Rapid Population Growth and Resource Utilization: A Review of Theories

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Abstract

The management of resources sustainably and responsibly, and the encouragement of sustainable consumption patterns are all necessary to address the environmental effects of population pressure. For the long-term wellbeing of both human civilizations and the environment, it is essential to strike a balance between population increase and resource consumption. While humans are the demanding agents, the environment on the other hand is relied upon to supply the resources. This interplay creates a demand and supply function between humans and the environment which is vital to sustainable use of environmental resources. The balanced demand with supply of resources creates an equilibrium. Excess demand is created when consumption exceed capacity of the environment to supply needed resources. While excess supply is when consumption falls below supply from the environment. Malthusian, Neo-Malthusian, Cornucopian, Technological Optimism, Ecological Economics, Boserup, Geertz Theories amongst others have tried to narrate the interplay between population and resource use. Malthusian and Neo-Malthusian theories point at the impact of disequilibrium between population growth and resource use, while Cornucopian and Technological Optimism theories opine how technology can be used to offset impact. The demand and supply equilibrium might not be attained, despite technological advancements and interventions, if measures to slow down population increase and consumption are not put in place. Without adequate measures, population growth and consumption have the potential to surpass technological advancement. Degradation of the environment and loss of biodiversity amongst others, will be caused by rising resource consumption and population increase. Human creativity will create chances that will offer remedies to challenges while creating new challenges.

Keywords: *Environmental Provisioning, Demand, Supply, Environmental Resource, Population Growth, Consumption.*

Introduction

Ecosystem services make human life possible by, for example, providing food and clean water, regulating climate, supporting the pollination of crops and soil formation, and providing recreational, cultural and spiritual benefits. These goods are some of the material benefits people obtain from ecosystems called ´provisioning services´. Many provisioning services are traded in markets. Rural and urban households pay for these services according to level of affluence. However, in many regions, rural households directly depend on provisioning services for their livelihoods. In this case, the services value may be much more important than is reflected in the prices they fetch in local markets. Agriculture, forestry and fisheries are influenced and influence all types of ecosystem services. Agriculture, forestry and fishery activities modify the environment to allow for increased or reduced productivity and interaction that bolster ecosystem services. Living species in an ecosystem rely on the environment for resources such as food and shelter. Environments serves the bases on which ecosystems blossom by providing the conditions for growing, hunting and all other interaction that are obtained in an ecosystem. Natural ecosystems (aquatic or terrestrial) play a vital role in maintaining biodiversity.

Every living organism including humans exist and operate within a space which is called their environment. The environment is understood as the immediate surrounding of an organism or individual. Environment covers biotic and abiotic components in the atmosphere, hydrosphere, and lithosphere. Environmental factors affect human existence as well as choice of settlement and in turn, humans also modify the environment to suit its purpose. This interplay accounts for the concepts of environmental determinism and environmental possibilism respectively. The term environment is so vast and encompassing that virtually every science studies a section of it.

There exist a mix of varieties of living things which depend on each other in a complex manner. This mix of living things is called biodiversity. Rawat and Agarwal (2015), defined biodiversity as the variety of different forms of life on earth, including the different plants, animals, micro-organisms, the genes they contain and the ecosystem they form. Biodiversity is a comprehensive umbrella term for the extent of natures variety or variation within the natural system. Biodiversity makes part of the numerous resources obtainable within the environment. Environmental resources in their various forms serve a major part of human life support system. Several scholars such as Singh et al. (2006); Brauman, and Daily (2014); Ervin et al (2014); Rawat and Agarwal, (2015); Kull, Arnauld de Sartre, and Castro-Larrañaga (2015) Cohen-Shacham et al (2016) supports the fact that without these resources which also come as ecosystem services, life will not be meaningful and sustainable.

Reverend Thomas Robert Malthus (13 February 1766 – 23 December 1834), wrote his essay titled "An Essay on Population" in 1798 and modified some of his conclusions in the next edition in 1803 (Mellos, 1988; Effiong, 2019; Warburton, 2021). He supposedly realised how unsustainable life will be without these services and the delicate relationship between human population and environmental resource (in this case "food"), and went ahead to propound what is now known as the Malthusian theory. In his theory, he explained that while population was growing at a geometric speed, food which is a needed item for human sustenance was growing at an arithmetic speed. This implies that human population depends on the environment and that one day the environment may not be able to adequately cater for the fast-growing population if unchecked.

Thomas Malthus in Mahees and Bandara (2021), states that environmental crisis aggravates when population goes up.

The Malthusian theory as proposed by Reverend Thomas Malthus, suggests that population growth will outpace the availability of resources, leading to inevitable poverty, famine, and social unrest. While Malthus's theory has garnered both support and criticism over the years, it has served as a fulcrum on which several other theories have emerged. Some of the key objections to the Malthusian theory as relates to this subject matter include:

1. Failure to take into account technical progress: One of the main criticisms of the Malthusian hypothesis is that it does not take into account technological development and how it affects the availability of resources. The enormous advances in agriculture, medicine, and technology that have greatly boosted food production and resource extraction capacities were not anticipated by Malthus. Technology advancements have made it possible for us to lower concerns about scarcity and raise living standards, refuting the Malthusian viewpoint.

2. Neglecting the role of economic factors: Critics argue that Malthus overlooked the role of economic factors in resource distribution and production. They contend that poverty and inequality are not solely a result of population growth but are often influenced by social and economic systems, such as unequal distribution of wealth and inadequate infrastructure. By focusing primarily on population growth, Malthus's theory neglects the complexities of economic systems and their impact on resource allocation.

3. Limited consideration of social and political factors: Malthus's theory tends to overlook the role of social and political factors in shaping population dynamics and resource availability. Critics argue that issues like government policies, conflict, corruption, and social inequalities can exacerbate resource scarcity and poverty. By focusing solely on population growth, Malthus's theory neglects the broader context in which population dynamics unfold.

The Malthus theory has been heavily criticized, but it has also impacted later theories and discussions on population increase, resource scarcity, and sustainability. Modern discussions frequently take a more nuanced approach that takes into account a wider array of variables outside of Malthus' initial framework. There are several other theories to the Malthusian theory that explore the relationship between population growth and resources:

1. Neo-Malthusian Theory: Neo-Malthusianism builds upon the ideas of Thomas Malthus but incorporates additional factors such as environmental degradation and resource depletion. Neo-Malthusians argue that population growth, combined with unsustainable consumption patterns, can lead to ecological crises and environmental degradation. They emphasize the need for population control measures and sustainable resource management to avoid catastrophic consequences.

Evidences have shown ecological degradation as a result of increasing resource use and agricultural production. The Green Revolution significantly influenced the dominant ideologies in contemporary agricultural practice and established intensive agricultural production practices around the world. Since the 1950s, there has been a steady rise in global yields, with more food produced per person than ever before. The Green Revolution's intensification tactics have been criticised for causing ecological degradation and unsustainable resource usage, even though they are mostly acknowledged with helping prevent the large-scale food shortages that were predicted in the post-World War II era (Gladek et al, 2017).

2. Cornucopian Theory: The Cornucopian theory of population is based on the idea that the natural resources and technology that we have at our disposal are unlimited and will continue to grow and develop (Quickonomics, 2023). In contrast to the Malthusian perspective, the cornucopian theory asserts that human ingenuity and technological progress will continuously create new resources and solutions to sustain a growing population. Cornucopians argue that human innovation and technological advancements will overcome any resource constraints. They believe that population growth stimulates innovation and leads to increased efficiency and resource abundance. A cornerstone argument of the cornucopian position is a denial of English Economist Thomas Malthus's assertion that human population growth will always tend to outrun the supply of food and natural resources. The Cornucopian Theory failed to note the existence of renewable as well as unrenewable resources. So far, technology have neither eradicated hunger nor the ecological degradation from technological intensification of resource exploitation and agricultural production

3. Demographic Transition Theory: The demographic transition theory describes a consistent pattern of population change as societies undergo economic development. It suggests that population growth initially accelerates due to improved living conditions and reduced mortality rates, but eventually stabilizes or declines as fertility rates decrease. The theory posits that factors such as industrialization, urbanization, improved healthcare, and education contribute to declining birth rates. The theory tried to associate developing countries with high population and rapid growth. It explains how changes occur due to economic development rather than changes in population due to hunger, starvation and other factors outlined by Thomas Malthus.

4. Technological Optimism: This perspective emphasizes the role of technology in solving resource scarcity challenges. Proponents of technological optimism argue that human creativity and technological advancements will continue to address and overcome resource constraints. They believe that innovation, renewable energy sources, and sustainable practices will allow for the sustainable use of resources, supporting a growing population.

No doubt food production has been increased without increasing agricultural lands through mechanization, irrigation, use of fertilizers, improved seedlings. Hydroponic farming has proven to be another means of expanding agricultural output without increasing land size. However, the applicability of hydroponic farming to all crop type is still in question. Maharana and Koul (2011) in Rakesh and Pareek (2020) listed crops that can be grown in hydroponic farming as cereals, fodder crops, vegetables, leafy vegetables, fruits, condiments and medicinal crops.

In other aspects, human creativity is helping to overcome resource constraints through recycling, material and energy recovery processes. The use of energy now involves an energy mix between renewable and non-renewable energy resources. Still, the ecological degradation and damage caused is only being slowed rather than eliminated.

5. Ecological Economics: Ecological economics is an interdisciplinary field that integrates ecological and economic principles. It recognizes the finite nature of resources and emphasizes the importance of ecological sustainability. Ecological economists explore concepts such as carrying capacity, ecological limits, and the need for a steady-state economy. They advocate for sustainable resource management and emphasize the importance of balancing human needs with ecological constraints.

6. Boserup Theory: The Boserup theory states that humanity will develop new agricultural practices to support the increase in population. Ester Boserup's theories primarily revolve around agricultural intensification and the relationship between population growth and food production.

7. Geertz Theory: Clifford Geertz postulated the theory of agricultural involution in which a unit of labour (input) yielded a unit of production, a case of stagnation in which the population is fed but surpluses are absent (Geertz, 1963 in National Research Council, 2014).

These theories offer different perspectives on the relationship between population growth and resources. While some theories, like the neo-Malthusian and cornucopian perspectives, present contrasting viewpoints, others, such as the demographic transition theory and ecological economics, incorporate a more nuanced understanding of the interplay between population dynamics, resource availability, and sustainability. Population growth can exacerbate pressure on ecosystems and raise demand for natural resources like energy, water, and land. More land is required when the population rises for infrastructure, agriculture, and housing, which can result in deforestation, habitat loss, and soil degradation. Additionally, when there are more people, there will be more garbage produced, which can lead to pollution and environmental damage.

Paul Ehrlich and John Holdren in the 1970s propounded the IPAT theory (Impact = Population, Affluence and Technology) (Ehrlich and Holdren, 1971). In this theory they posit that population plays a role in environmental impacts in addition to other factors. Following the acronym chronologically, one could say Paul Ehrlich and John Holdren placed population as having topmost impact by placing it first (ahead of affluence and technology). Though it is crucial to remember that the effect of population growth on the environment depends not only on the total number of people but also on their consumption habits. While population plays a huge role as the vehicle, affluence is the accelerator. In addition, changes in policy and technology can have an impact on how effectively resources are used and how those decisions affect the environment. However, population growth has remained a potent and seemingly undefeated force to reckon with, in analysing ecological relationship and interaction between humans and the environment.

Literature Review

Mittal and Mittal (2013), asserts that the environment on earth is suffering from the growth of global population. The growth of population puts larger demands on our already limited resources. The rapid increase of human population is putting an incredible strain on our environment. The demands that this growth places on our global environment is threatening the future of sustainable life on earth. One of the largest environmental effects of human population growth is the problem of global warming. Some scientists fear that global warming will lead to rising sea levels and extreme weather conditions in the future. In order to support the growing population, forests are being destroyed at an alarming rate. Humans also continue to put a great demand on the natural resources of our planet. Many non-renewable resources are being depleted due to the unrestrained use of fuel and energy. Many parts of the world also suffer from a shortage of food and water. Mittal and Mittal (2013) state that depletion of resources and biodiversity, the production of waste, and the destroying of natural habitat are serious problems that must be addressed in order to ensure that life on earth will be sustainable throughout the next century.

George (2018) noted that increased human population has greatly affected the environment and especially these natural resources which support both human and other life forms. Rapid population growth especially in a developing country like Kenya has put pressure on the available resources like water, forests and land in general. Increased population translates to increased demand for food and space for settlement. As a result, people engage in intensive agriculture with application of inorganic fertilizers that affect the environment negatively.

Sam, et al (2014), based on findings from their research stated that overpopulation has a negative impact on the conservation of biological diversity in Boki local government area of Cross River State, Nigeria. Obaisi (2017) highlighted that humans must understand that overpopulation is a threat to sustainable agriculture and food security. All over the world there are 3.7 billion undernourished and malnourished District humans. The adequate feeding of these ones constitutes a major concern, in the face of the rapidly growing population.

Baus (2017) assertion supports the statement of Obaisi (2017), he stated that over-population is a great problem to many countries, especially African countries. It damages the economy by increasing the consumption. As result, available resources are not enough. It also causes many environmental problems. The more the population is, the more the need arises for living space by cutting forests.

Maja and Ayano (2021) in their review of population impact on natural resources stated rapid population growth continues to be a major underlying force of environmental degradation and a threat to sustainable use of natural resources. It reduces the quality and quantity of natural resources through overexploitation, intensive farming and land fragmentation. Regions with high population pressure face scarcity of arable land, which leads to shortened/removed fallow period, declining soil fertility and farm income due to farm subdivision.

Debel, Tilahun, and Chimdesa (2014) analyzed impact of population growth on forests in Haro Limu, East Wollega, Ethiopia. The result of their analysis revealed that population growth has huge impact on forestry development by conversion of forested lands to agricultural lands and expansion of agricultural lands, using wood as energy sources and satisfying the input requirements in agricultural activities.

Obienusi, Ekezie, and Onwuka (2014) investigated yam supply situation and population increase in Awka, Anambra State, Nigeria and revealed that in the study area that there exist a significant relationship between population increase and yam supply and that there is a significant relationship between the income of the consumers and yam consumption. The increase in the population in Awka urban has led to a decrease in food production causing the people to look outward for food supply.

Man-Environment Resource Interaction

The environment interacts with humans in a way which should be symbiotic, but has rather turned parasitic. This is because humans exploit the environment to a detrimental dimension. This can be attributed largely to the growing population, life style and importantly the nature of the resources we depend on, as some are exhaustive while others are inexhaustive but can still be degraded in terms of quality and ability to yield maximally. We are living in an era of unprecedented population growth. Since the middle of the twentieth century, the world's population has more than tripled in size, reaching almost 8 billion people in 2023. This 8billion people has to be carted for, in terms of food, shelter and other life supporting materials. Fortunately, the environment is relied upon to provide these materials either directly or indirectly as raw materials for production of finished products. It is safe to say that majority of the items needed to meet human needs (if not all) are sourced from the environment. This creates a demand and supply interaction between humans as the demanding agents and the environment as the supply agent. This demand and supply interaction has displayed a pattern that can be called man-environment demand and supply interaction. Where environmental provisioning and supply is high and abundant, human population/consumption tend to grow either by reproductive means or migration. Demand and consumption of essential resources therefore increases as human population increases or with improvement in standard of living which occasions a change in lifestyle. On the other hand, the increase in human population/consumption then translates into increased supply of resources, to meet with demand.

Demand in this context means the desire for and utilization of resources to satisfy human want/need. While supply in this context, is the availability and exploitation of resources to satisfy those in demand for it, either by direct use or by using it as a raw material for production of other required goods. Figure 1, shows an illustration with the assumption of a fixed resource base.

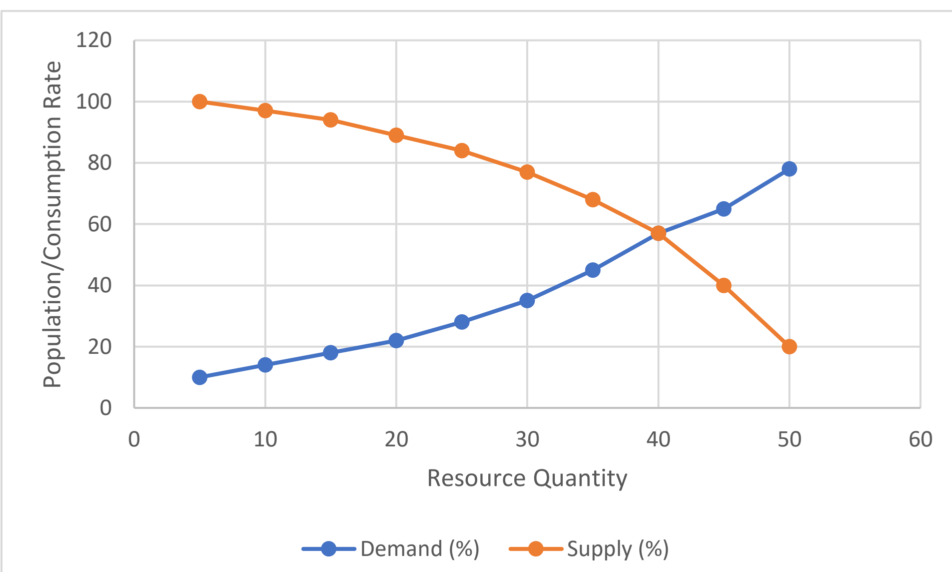

Figure 1: Human demand and environmental supply illustration

Figure 1 shows that at low population/consumption, demand is equally low while ability of the environment to maintain maximum supply is retained. However, with increased population/consumption the capability of the environment reduced. For instance, at 20million people (demand), ability of the environment to meet demand (in essence supply) was 50% while it decreased to 40% at 60million people and further decreased to 30% at about 80million people. Similarly, an earlier illustration by Bartlett (nd), using his Exponential Expiration Time (EET) formula proffered answer to a question such as "If a non-renewable resource would last, say 50 years at present rates of consumption, how long would it last if consumption were to grow say 4% per year?". This involves using the formula in which the quotient (R/r_0) is the number of years the quantity R of the resource would last at the present rate of consumption, r_0. The results of this simple calculation are shown in Table 1.

Lifetimes of non-renewable resources for different rates of growth of consumption. Except for the left column, all numbers are lifetimes in years.								
		LIFETIME OF RESOURCE IN YEARS						
ANNUAL GROWTH RATE	**0%***	**10**	**30**	**100**	**300**	**1000**	**3000**	**10,000**
	1%	9.5	26	69	139	240	343	462
	2%	9.1	24	55	97	152	206	265
	3%	8.7	21	46	77	115	150	190
	4%	8.4	20	40	64	93	120	150
	5%	8.1	18	36	56	79	100	124
	6%	7.8	17	32	49	69	87	107
	7%	7.6	16	30	44	61	77	94
	8%	7.3	15	28	40	55	69	84
	9%	7.1	15	26	37	50	62	76
	10%	6.9	14	24	34	46	57	69
	** 0% annual growth = "at current rate of consumption"*							

Table 1: Lifetime of resources at different rates of consumption
Source: Bartlett (nd)

Bartlett (nd) explained table 1 using three scenarios, as follows:

Scenario 1. If a resource would last 300 years at present rates of consumption, then it would last 49 years if the rate of consumption grew 6% per year.

Scenario 2. If a resource would last 18 years at 5% annual growth in the rate of consumption, then it would last 30 years at present rates of consumption. (0% growth)

Scenario 3. If a resource would last 55 years at 8% annual growth in the rate of consumption, then it would last 115 years at 3% annual growth rate.

At any point where available resources conveniently meet with consumption demand an equilibrium point is established, which can be termed as optimum population/consumption. That is where carrying capacity, ability to supply meet with demand for environmental resources without pressure or negative feedback from the environment. There could be cases of excess supply, that is when population demand/consumption is far less than what the environment is able to supply. This situation is depicted when consumption is low. Excess demand occurs when the population/consumption is high leading to high demand, in which environmental supply is unable to meet or carter for the high level of demand creating a supply deficit.

Supply is very closely related to and goes hand in hand with demand. When supply of a resource exceeds the demand of the people, the worth, value falls. In some cases, abuse of that resource is likely to occur if no legislation is put in place. On the other hand, when the demand for a resource exceeds supply due to increase in population/consumers seeking that particular resource, scarcity sets in. The scarcity of the resource leads to discomfort, reduced standard of living (if it is an essential resource), environmental degradation in pursuit for more, wars and conflict over the exploitation of such resource. This supports the position of Neo-Malthusian theory which posit that unsustainable consumption in the face of unbridled population growth will lead to crisis.

Contrarily, technological optimism has set a path to the perspective that technology could solve or avert the crisis as stated by proponents of Malthusian and Neo-Malthusian theories. Obaisi (2017) stated that Science and technology has to rise to the occasion to save the day if we are going to make it through these difficult times created by skyrocketing growth in population/consumption. There is no doubt that human ingenuity and technological progress has created new solutions to agricultural production of food, in terms of GMF (genetically modified food), green houses, mechanization, hydroponic farming, aeroponics, and other methods. It is still not safe to declare it a walk in the park, as evidences of the positions of Malthusian and Neo-Malthusian theories on impact of population growth abound. As noble as it may be, none of the new technologies are without issues nor has it satisfactorily solved the issues that led to exploring new methods of food production and alternatives resources. This is because the continuous rapid increase in population/consumption has the capacity to surpass the means for catering for the demand. This will then lead to a situation of excess demand on the environment for the supply of materials required for survival. The case is different when the ability of the environment to supply is not matched by demand, this creates a situation of excess supply.

However, as long as the equilibrium point is maintained (i.e., a situation where consumption/population growth matches with ability of environment to provide ecosystem services to humans without negative feedbacks), ecosystem provisioning services will remain at optimum output. Any push in supplies by growing population or consumption will lead to additional pressure to provide more and therefore could reduce supply or lead to degradation. The depletion/degradation will suffice until an equilibrium is reached again at some point or intervention is made. This is however not applicable to deeply impacted non-renewable resources.

Factors that Determine Demand and Supply in this Context

One way that population growth can affect ecosystems is through increasing pressure on them and increasing demand for natural resources like energy, water, and land. As the population increases, more land is required for infrastructure, agriculture, and housing, which can result in deforestation, habitat loss, and deteriorated soil. Additionally, more people produce more garbage, which can contribute to pollution and the destruction of the ecosystem. It is a fact that affluence/life style is a major determinant of human demand of resources but population seem to remain a more potent force. The following factors determine human demand and environmental supply.

Demand

- Population: the number of persons demanding the supply of any environmental service or function.
- Affluence/life style: the ability to pay the cost for the supply of desired environmental services. Affluence influences the average consumption rate of individuals within the population.
- Essentiality of the resource/material: the value or importance of the environmental service.
- Frequency of use: rate at which an environmental service is utilized.
- Availability of alternative: existence of substitutes would create room choice.

Supply

- Demand for the resource
- Size of resource reserve/reservoir
- Impact of exploiting the resource
- Government policy/decision
- Technological capability to exploit
- Cost of exploitation

Responses to Excess Demand on the Environment

Where human demand exceeds environmental supply excess demand is created. In response to excess demand which is a factor attributable to the many factors responsible for environmental degradation, hunger, migration, and poverty, humans have learnt to technologically navigate through the muggy waters as posited by the Cornucopian and Technological Optimism theories. Some measures taken to meet human demand of environmental resources for comfort and preservation include:

To meet demand for food: Global and localized population growth has led to introduction and consumption of genetically modified foods (GMFs), use of agrochemicals such as fertilizers, agricultural mechanization, greenhouse farming, newer farming techniques such as hydroponic and aeroponic farming. Cloud seeding a weather modification technique aimed at enhancing precipitation from clouds, could possibly be used for agricultural application in addition to its weather modification function. Manida and Ganeshan (2021), listed new agricultural technologies in modern farming aimed at increasing yield to include use of indoor vertical farming, farm automation, precision agriculture, modern greenhouses, artificial intelligence, soil and water sensors, amongst others. Manida and Ganeshan (2021) stated that new headways in advancements going from mechanical technology and robots to PC vision programming have totally changed present day agribusiness. Gautam and Kumar (2014), had earlier acknowledged that agriculture needs technology infusion to accelerate production so that food is accessible to all. According to the estimates of the Food and Agricultural Organization (FAO) as citied by Gautam and Kumar (2014), agricultural production would need to grow globally by 70 per cent by 2050 and more specifically by almost 100 per cent in developing countries, to feed the growing population alone.

To meet demand for water: Water is an indispensable compound that sustains life, supports ecosystems, regulates climate, facilitates various human activities, and provides a multitude of benefits for the planet and its inhabitants. Water is needed for human consumption, domestic use, industrial use, and agricultural use. As population increases so also the pressure on water sources. Improvement in standards of living creates a change of lifestyle ushering in utilization of sophisticated gadgets which has high water requirement e.g., cloth and dish washers, sprinklers. To meet the high demand for water, various techniques have been employed, such as: wastewater recycling, water desalination, frost harvesting, improved technologies for groundwater, rain and storm water harvesting. Over two billion people live in countries experiencing water stress. About 1.6 billion people face ‘economic’ water scarcity, which means that while water may be physically available, they lack the necessary infrastructure to access that water. An estimated four billion people live in areas that suffer from severe physical water scarcity for at least one month per year (UNESCO, 2021). According to UNESCO (2021) global freshwater use has increased by a factor of six over the past 100 years and continues to grow at a rate of roughly 1% per year since the 1980s. Much of this growth can be attributed to a combination of population growth, economic development and shifting consumption patterns. In affirmation Wada et al (2016) noted that water demand has been increasing and continues to grow globally, as the world population grows and nations become wealthier and consume more. The global population more than quadrupled in the last 100 years, currently exceeding 7billion people. Growing food demands and increasing standards of living raised global water use by nearly 8times from 500 to 4000 km^3yr over the period 1900–2010. How to relieve water shortage has become a hot topic in recent years and is expected to be a serious issue in the next few decades. Goal 6 of the Sustainable Development Goals (SDGs) proposed by United Nations in 2015 also highlights the high demand for safe water accessibility, especially in regions where water shortage is severe (Chen, Tao, and Shi, 2022). Water resources that are not readily accessible, such water vapour and seawater, have come under scrutiny as a means of essentially meeting the demand for fresh water. Thus, in recent decades, technologies that extract water from the atmosphere or oceans have been created and shown to offer a potential response to the global water crisis (Youssef, Al-Dadah, and Mahmoud, 2014; Elashmawy, 2020; Jarimi, Powell, and Riffat, 2020; Chen, Tao and Shi, 2022).

To meet energy demand: From the era of the industrial revolution when energy demand began to surge, coal, fossil fuels and other forms of exhaustive, non-renewable energy resources were utilized. In recent times, a shift or expansion of energy sources occurred, chiefly due to its exhaustive, non-renewable nature and issues of pollution manifesting in effects like global warming and climate change. The expansion of energy sources has seen the utilization of new sources as nuclear energy, hydro-electric energy, wind energy, solar energy, and geothermal energy. Essentially due to industrialization, population increase and increased incomes among the poor and near-poor, energy demand has increased too much for the energy infrastructure that is now in place. The wealthy and developed nations use nuclear power as fossil fuel sources are running out. Production and consumption of nuclear and fossil fuels are strongly correlated with environmental deterioration, which endangers human health and quality of life, disrupts ecological equilibrium, and reduces biodiversity. Therefore, it is obvious that there must be global effort to exploit energy that should not endanger the lives of current and future generations and should not exceed the carrying capacity of ecosystems if the rapidly growing global energy needs are to be met without causing irreparable environmental damage. Renewable energy sources such as solar energy, wind power, biomass and geothermal energy are abundant, inexhaustible and widely available. These resources have the capacity to meet the present and future energy demands of the world (Asif and Muneer, 2007).

To meet demand for shelter and comfort: Urban expansion is another major driver of land cover change. Construction of buildings and other artificial surfaces contributes to the loss of sensitive ecosystems and fragmentation of natural habitats. Globally, an area the size of the United Kingdom (244,000 km^2) has been converted to built-up areas between 1990 and 2014 (OECD, 2018). Lutzenberger, Brillinger, and Pott (2014) stated that from 1992-93 to 2000, settlement areas in Africa grew by around 282.68%. This represents an increased area of 20,941km^2. From 1992-93 to 2000, settlement areas in America grew by around 0.42 %. This represents an increased area of 425km^2. From 1992-93 to 2000 settlement areas in Asia and Australia grew by 18.83% (+11.523km^2). In 1995 total settlement areas covered around 3.5 % (780,106 km^2) of the land surfaces in Europe. From 1995-2005 the surface built-up and populated by humans grew by around 8% (67,675km^2) and increased to an area of 847,781 km^2. Ray and Roy (2018) stated that world population projected to be 9.6 billion by 2050, can only be properly sheltered by adequately utilizing land. This means bare and vegetated lands will have to be converted to built-up areas. The rapid rate of land consumption will result in a horizontal and vertical expansion of places. In order to provide shelter to such huge population it is essential for engineers to keep on building more innovative mega tall skyscrapers. There has been wide diversification of materials for construction purposes with additional discoveries underway. The use of wood (FAO, 2009; Khademibami, and Bobadilha 2022), glass and metal has increased in recent times. Zou et al (2019), Kamali et al (2019), and Huang et al (2020), noted that rapid urbanization and population growth has resulted in soaring consumption of building materials. Zou et al (2019), Kamali, Hewage, and Sadiq (2019), Huange et al (2020) highlighted that global consumption of building materials tripled from 6.7 billion tons in 2000 to 17.5 billion tons in 2017; concrete, aggregates, and bricks are the most commonly used building materials.

Implications of Excess Environmental Demand

Like the postulations of Cornucopian and Technological Optimism theories, human innovation has seen modern techniques providing alternatives to some environmental functions. Boserup stated that humans will always evolve new ways to increase agricultural production to cater for growing population. As much as this assertion is true, virtually all the measures employed have become an albatross of some sort. The deployment of technological means to tackle rising demand have resulted in:

1. Deforestation and Habitat Loss: As the population grows, there is increased demand for land for agriculture, housing, and infrastructure. This leads to deforestation, the conversion of natural habitats into human settlements, and the fragmentation of ecosystems. Loss of forests and habitats threatens biodiversity, disrupts ecological balances, and contributes to species migration or extinction.
2. Resource Depletion: The increasing demand for natural resources, such as water, minerals, fossil fuels, and timber, can lead to overexploitation and depletion of resources. Population pressure can exacerbate the strain on water supplies, result in overfishing, and contribute to the depletion of non-renewable resources which are known to be exhaustible.
3. Land and Soil Degradation: Population pressure often leads to intensive agricultural practices to meet the growing demand for food. Unsustainable farming methods, such as excessive use of chemical fertilizers and pesticides, overgrazing, and improper land management, can lead to soil erosion, degradation, and loss of soil fertility. This affects agricultural productivity and reduces the capacity of the land to support ecosystems.
4. Water Stress: As the population grows, the demand for water increases, leading to water stress in many regions. Overextraction of groundwater, pollution of water sources, and inadequate water management practices can deplete water supplies and harm freshwater ecosystems. Water scarcity and competition for water resources can trigger conflicts and social tensions.
5. Pollution and Waste Generation: A growing population generates more waste and pollutants. Increased industrial activities, energy consumption, and transportation contribute to air and water pollution. Improper waste management and inadequate infrastructure for waste disposal can further pollute the environment, impacting ecosystems, human health, and the quality of air, water, and soil.
6. Biodiversity loss: The ever-increasing amount of land that needs to be used for production and consumption, such as for agricultural, raw material extraction, forestry, or buildings and infrastructure, means clearing the land and removing all natural trees and vegetation. This destroys the biodiversity of the plant life on that land, and also harms animal and insect life through the loss of their habitats. The consequences of this biodiversity loss are dire and are already damaging the life-supporting systems of food, water and air on which all living things on Earth depend.
7. Climate Change: Population growth contributes to increased greenhouse gas emissions, primarily through increased energy consumption and industrial activities. The burning of fossil fuels and deforestation release carbon dioxide, a major contributor to climate change. Climate change leads to rising temperatures, changes in precipitation patterns, sea-level rise, and impacts on ecosystems and vulnerable communities.

Worthy of mention is the fact in this Anthropocene era, when environmental sustainability is of much concern, technological innovations owe it as a duty to be environmentally friendly. So far, technological interventions have not come without consequences that have continued to impact on the climate and other aspects of the environment. The Growing demand for environmental supplies including food has remained a key driver of global environment change.

Higher consumption demands occasioned by growing human population and/or improved standard of living will make progressively more difficult for the environment to keep pace with supply of resources. To ameliorate the concerns raised by Thomas Malthus, technological intervention has partly been successful. However, despite technological inventions and intervention, the demand and supply equilibrium may not be reached if measures are not in place to check rapid population growth. Population growth has the capacity to outpace technology without measures to slow the growth of population. According to Global Footprint Network, (2012); Moomaw, et al (2012), If current population and consumption trends continue, humanity will need the equivalent of two Earths to support it by 2030.

Technological innovations have shown to be a means to an end rather than the end itself. This assertion is proven by the existence of prevailing hunger, resource depletion, and environmental impact. It is therefore safe to say that rapid growth in population and consumption will topple technological innovations if population and consumption continues to grow rapidly. The famous one-hour lecture titled “Arithmetic, Population, and Energy: Sustainability 101” was delivered by Professor Bartlett. He said in the opening remark of his hour-long speech that the greatest failing of humanity, according to Professor Albert Bartlett (2002), is our inability to comprehend the exponential function. After that, he provided a brief overview of the arithmetic behind steady growth, including an explanation of the effect of doubling time. He discussed the effects of constant, unwavering expansion on the populations of the entire planet. He explored the effects of constant growth in a finite environment, and saw how this growth affected the consumption of fossil fuels, whose lifespan is far shorter than the estimates that are frequently used. According to Professor Bartlett (2002) “You cannot sustain population growth and/or growth in the rates of consumption of resources”.

Conclusion

The ecosystems of the planet produce a variety of necessary services, such as the production of food and wood, soil restoration, and energy sources, that support and enhance human life. No society can completely replace the breadth and magnitude of advantages that the environment provides, despite the fact that many cultures have evolved the technological capacity to create alternatives for some functions. Given its significance and capacity to provide life support systems that cannot be obtained through any other means, the environment is therefore an asset deserving of careful consideration and investment. The carrying capacity of the earth can be strained by the rapidly growing human population, thereby impeding significant investments towards environmental protection and sustainability.

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