World of The Environment

A Book Series issued by the Zayed International Foundation for the Environment

Environment Friends Guide

How to live an Environmentally Friendly Life?

Dr. Ayoub Issa Abu Dayyeh

مؤسسة زايد الدولية للبيئة

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How to live an Environmentally Friendly Life?

Dr. Ayoub Issa Abu Dayyeh
Amman – The Hashemite Kingdom of Jordan

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Dr. Ayoub Issa Abu Dayyeh

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Introduction

of Environment Friends Guide

The Zayed International Foundation for the Environment has published so far 36 books in the “World of Environment” book series all in Arabic language.

This book marks the first English publication by the Zayed International Foundation for the Environment, contributing to the prestigious “World of Environment” book series.

The series is dedicated to spreading the core knowledge and scientific insights of esteemed scholars and experts, presenting them in a manner that is both comprehensible and engaging for diverse audiences.

These works are designed to foster youth education, cultivate environmental awareness and stewardship, and equip individuals with the critical understanding needed to make informed decisions in planning and development.

Thanks to Dr. Ayoub Abu Deyya, who wrote this book in Arabic language and the foundation translated it into English for the benefit of the large non-Arabic population in the UAE and abroad.

He really covered all aspects of our life and indicated exactly how to become Environment Friendly.

Let us all enjoy reading and spread the message.

Prof. Mohammad Ahmed Bin Fahad
Editor-in-Chief – World of Environment Book Series
Chairman of Zayed International Foundation
for Environment

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Introduction

After a long discussion on how to live an environmentally friendly life, my friend Peter admits that he has left noticeable traces of carbon, methane and other greenhouse gases in nature during his lifetime in the United States. The time has come, Peter says, speaking with a stutter of shame and embarrassment: these irresponsible and unconscious actions towards Mother Nature must be replaced by conscious practices that are kind to the environment through various means.

Peter gazes at me with a deliberate air of provocation, seemingly seeking a reaction to his shame and attempting to alleviate the psychological strain he is currently experiencing. He mentions, almost as a justification, that he has ceased consuming red meat for this very reason. Then, he poses a pointed question: “Is this sufficient to atone for my ethical guilt toward the global environment?”. With this inquiry, it feels as though he has thrust the weight of moral accountability upon me, eagerly awaiting my response with palpable anticipation

Peter’s question compelled me to reflect profoundly on the issue at hand, a matter of significant complexity. It symbolizes the repayment of a long-overdue debt humanity owes to nature—a debt stemming from the profound impact of human existence on the natural world.

This impact has been evident since the beginning of organized societies, amplified by the knowledge gained during the great scientific revolution of the seventeenth century and further intensified with the industrial revolution of the late eighteenth century, marked by the advent of the coal-powered steam engine. The consequences of these developments, notably rising global temperatures, became apparent in the latter half of the twentieth century and have continued to escalate.

Since the first industrial revolution that began at the end of the eighteenth century, humanity has burned fossil fuels, starting with wood, followed by coal, and then our consumption increased at the end of the nineteenth century when oil was discovered, then the invention of the internal combustion engine in 1872 and the discovery of electricity in 1879, which made our energy consumption much greater, especially since these events coincided with the expansion of capitalism in the world, as well as with the piracy practiced by colonial countries to plunder the wealth of poor countries from gold, silver, human trafficking, and others.

Since the onset of the Industrial Revolution in the late eighteenth century, humanity has increasingly relied on the combustion of fossil fuels, beginning with wood, followed by coal. Consumption surged toward close of the nineteenth century with the discovery of oil, further accelerating with the invention of the internal combustion engine in 1872 and the discovery of electricity in 1879. These innovations significantly amplified energy consumption, particularly as they coincided with the global expansion of capitalism. This period also witnessed the exploitative practices of colonial powers, who engaged in the plunder of resources from poor nations, including gold, silver, human trafficking and others.

Consequently, global carbon dioxide emissions escalated by approximately twentyfold in 2000 compared to 1900, primarily due to the combustion of fossil fuels. The average global temperature of the Earth's biosphere increased by at least 1°C by 2020, with the average temperature of the world's sea surfaces rising by a similar magnitude [exceeding 1.5 degrees end of 2024].

In response to the rise in temperatures, known as global warming, and the subsequent climate change, the efforts of the United Nations Framework Convention on Climate Change culminated in the Paris Agreement of 2015. This agreement aimed to limit the global temperature increase to well below 2°C, with an enhanced commitment to reduce it to 1.5°C by the end of the century to avert severe consequences. This decision is being revised, particularly following the 2021 Conference of the Parties to the United Nations Framework Convention on Climate Change in Glasgow, Scotland, where additional measures were discussed to limit the temperature rise to 1.5°C, if feasible, voluntarily.

With the United States' irresponsible decision to withdraw from the Framework Convention on Climate Change under the leadership of former President Trump, the American public, including my friend Peter, bears responsibility for altering consumption patterns, modes of transportation, and other behaviors that prevailed during that period. However, the shift in U.S. policy following the administration of President Biden represents a positive and constructive step in the right direction towards achieving balance in addressing these challenges.

Let's start with the priorities, which begin with the most polluting human activities first, then move to the least harmful to the environment.

It is agreed that the US per capita greenhouse gas emissions in 2015, for short-term household consumption, according to the Global Footprint Network, ***were as follows:***

- Personal transportation 24%
- Housing (electricity, heating..., 22%)
- Services (restaurants, sports, educational institutions, government services..., 21%)
- Food (food and beverages) 17%)
- Goods (electronics, clothing..., 15%)

In 2014, according to data from the World Bank, Qatar had the highest per capita carbon emissions, producing 45.42 tons per person annually. In comparison, the United States emitted 16.49 tons per capita, while Jordan's emissions stood at 3 tons. Conversely, Somalia recorded the lowest emissions, with only 0.05 tons per capita. It is noteworthy that a person in Qatar produced more than 900 times the amount of carbon emissions as an individual in Somalia.

To put these figures into perspective, Peter, an American citizen, would need to plant approximately 1,000 trees annually, assuming that a single mature tree absorbs about 16 kilograms of carbon dioxide per year, to fulfill his aspiration of repaying his environmental debt to the planet, which he regards as a nurturing mother. However, this approach is not a feasible solution for him. Therefore, he must undergo a fundamental transformation in his lifestyle. This change involves not only ceasing the consumption of red meat but also seeking environmentally friendly transportation alternatives. Additionally, he must reconsider his choices regarding housing, services, and the goods he purchases and consumes. If he is sincere in his intentions, he will not achieve any substantial environmental impact, unless he implements these changes immediately.

The aim of this book, titled ***"How to live an Environmentally Friendly Life?"*** is to encourage individuals to adopt similar strategies to reduce their greenhouse gas emissions. This can be achieved by embracing a new lifestyle that prioritizes environmental sustainability, yet allows individuals to enjoy the pleasures of life and meet their essential needs.

Chapter One

Food

Chapter "1"

Food

Approximately 70% of the world's safe water is consumed for agricultural purposes. Meanwhile, the global production of meat, vegetable oil, and other highly polluting food items continues to rise at an accelerating pace within a globally open capitalist world. This increase responds to the growing individual consumption of limited needs and unlimited desires (in terms of calories). Furthermore, it is estimated that 25-30% of the total food produced worldwide is wasted, spoiled, or discarded by consumers, thereby squandering the energy spent on its production.

Globally, around two billion people are classified as overweight, while 821 million individuals lack access to adequate food. Additionally, 151 million children face malnutrition, and 613 million women aged 15 to 49 suffer from iron deficiency, a vital component in the formation of red blood cells (International Panel on Climate Change [IPCC] report). [(1)]

In the field of agriculture, it is essential to prioritize organic and smart agricultural practices that minimize water consumption. Smart agriculture refers to advanced technologies and data-driven approaches to enhance productivity and efficiency within the agricultural sector. A wide array of techniques and tools is employed in smart agriculture to optimize operations, reduce waste, and improve crop yields, thereby contributing to more sustainable and effective agricultural practices.

There is also a need to prepare for the production of agricultural crops that can withstand drought and those that can withstand salt water, such as rain-fed tomatoes, parsley, and others. There is also a need to develop new, more sustainable varieties that are more adaptable to the harsh climate that the Earth is exposed to in light of the phenomenon of global warming and the resulting climate change.

Significantly, reducing the consumption of red meat yields environmental benefits, as its production is among the most energy- and water-intensive. Furthermore, the processes involved in producing, storing, refrigerating, and transporting red meat result in the release of considerable quantities of greenhouse gases, as demonstrated in the figure (1).

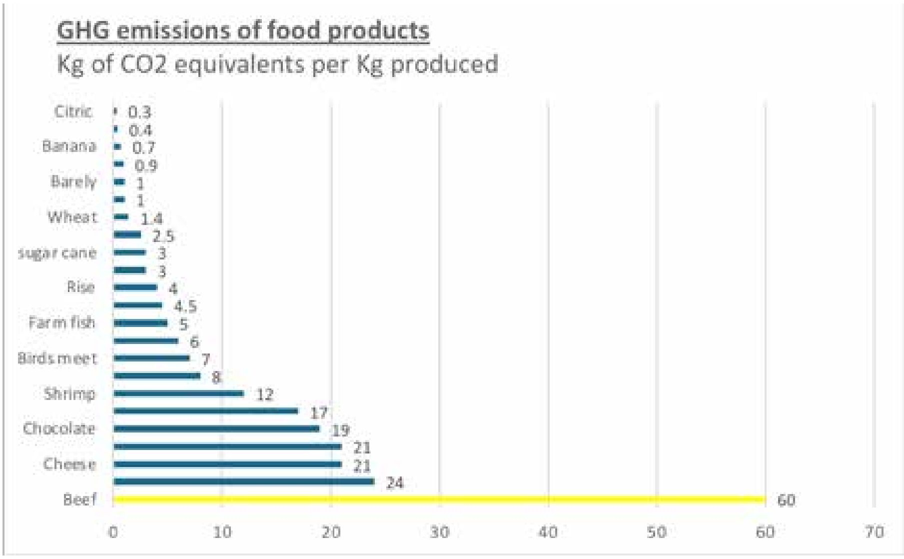

Figure (1)

Carbon dioxide production rate per kilogram for different types of food [(2)]

Figure 1 presents that meat is the most environmentally polluting food, with red meat, particularly beef, ranking as the highest contributor. This is followed, though to a lesser extent, by lamb, cheese, fish, coffee, palm oil, wheat, poultry, olive oil, sugar cane, eggs, barley, rice, milk, banana, and, lastly, fruits, citric and vegetables, which are the least polluting. But why does red meat have such a substantial impact on environmental degradation?

The primary reason is that meat production requires the clearance of extensive land areas for grazing. In many regions, forests, including rainforests, are being destroyed to make way for pastures, resulting in considerable environmental harm. Furthermore, red meat production necessitates vast quantities of water, feed, and energy, while releasing significant amounts of greenhouse gases through processes e.g. animal belching and intestinal peristalsis.

The next aspect to consider is the food production, preservation, and distribution chain, which encompasses several stages, including slaughtering, skinning, washing, cutting, cleaning, storage in refrigerated vehicles or warehouses, packaging, and long-distance shipping. Land transportation, in particular, is one of the most environmentally harmful modes of transport, the subject examined in greater depth in Chapter 3 on transportation.

Each of these operations requires considerable amounts of energy and water, while also contributing to environmental pollution. Moreover, a significant quantity of meat is often spoiled and discarded. As illustrated in image1, large amounts of meat are wasted and disposed of without benefiting humans. These discarded materials serve as sources of environmental pollution, contaminate water resources, facilitate the spread of epidemics, and give rise to various other related concerns.

Organic meat production mandates feeding animals exclusively with 100% organic feed. Techniques such as cloning and embryo transfer must be strictly avoided, and the use of hormones or antibiotics limited to instances of absolute necessity. Furthermore, ensuring the physical and psychological welfare of the animals is paramount. This entails providing adequate housing, appropriate population densities to reduce stress, ensuring access to fresh air and sunlight, delivering high-quality medical care, and attending to other essential needs and services.

To highlight the environmental impact of red meat consumption, consider the following comparison. The greenhouse gas emissions generated by the production process of one kilogram of beef are equivalent to those emitted during a 176-kilometre journey in a conventional fossil-fuel-powered vehicle.

Figure 2 illustrates the differences in emissions between short-distance domestic flights and long-distance international flights, where total emissions decrease from 295 (102 + 193) grams per kilolmetre to 254 (133 + 121) grams per kilometre for international flights.

Travelling in a conventional vehicle with only the driver is almost as environmentally detrimental as air travel, with emissions reaching 171 grams per kilometre. In contrast, a bus significantly reduces emissions to 104 grams per kilometre. However, the most environmentally friendly option is carpooling with four passengers in a single vehicle, which minimizes emissions to just 43 grams per person per kilometre(3).

The considerable environmentally sustainable modes of transportation include walking and cycling, followed by trains and buses. Among trains, modern models exhibit the lowest levels of pollution. For example, the Eurostar emits merely 6 grams of carbon dioxide per person per kilometre, positioning it as the most environmentally efficient choice. This is followed by buses, with emissions of 27 grams per person per kilometre, and traditional trains, which emit 41 grams.

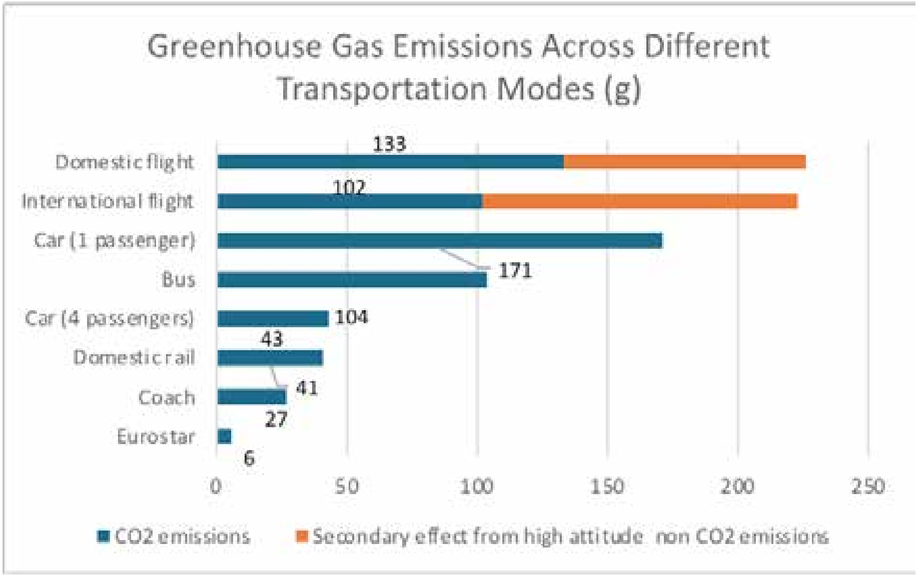

Figure (2)

Emissions from various means of transport per passenger and per kilometer [4]

Adopting environmentally responsible practices involves refraining from consuming food products transported by air. Air freight is a significant contributor to greenhouse gas emissions, primarily due to the extensive combustion of fossil fuels. It produces 254 grams of greenhouse gases per kilometre—121 grams from the flight itself and an additional 133 grams from related processes, as illustrated in Figure 2. By contrast, conventional local freight trains generate only 41 grams of greenhouse gases per kilometer, making them a considerably more sustainable alternative.

Avoid consuming non-local or out-of-season fruits and vegetables, such produce often necessitates resource-intensive practices, including the construction of greenhouses, reliance on supplemental irrigation, and the application of artificial growth stimulants. Furthermore, these produce typically involves extended refrigeration, which demands substantial amounts of electricity. Prolonged storage not only exacerbates enviΔΔronmental impact but also diminishes the nutritional quality of the food, it negatively impacts human health.

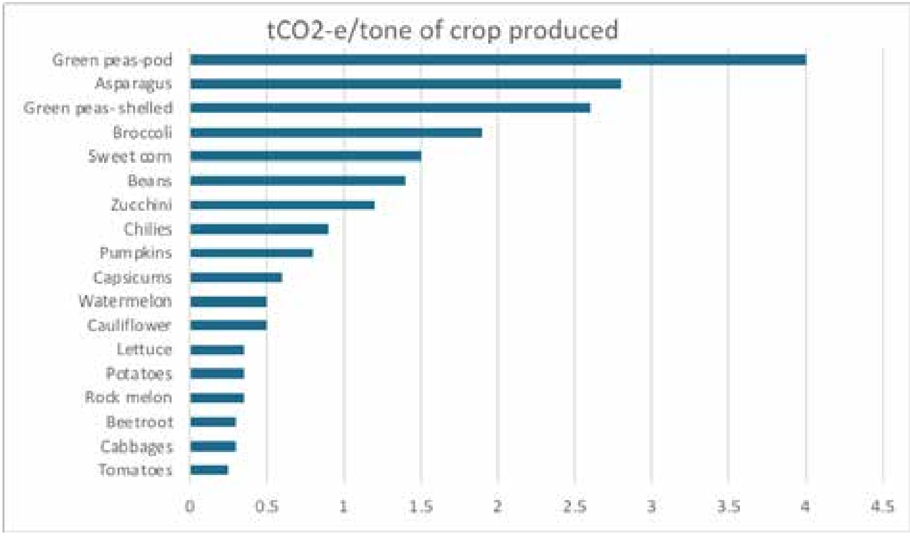

Figure (3)

Carbon dioxide emissions from the production of one ton of the produced crop [5]

Figure 3 displays the emissions associated with the production of one ton of various crops. Green peas are the most environmentally harmful vegetable, producing approximately 4 tons of carbon dioxide equivalent to per ton of output. They are followed by asparagus plants (around

3 tons), sweet corn, beans, watermelon, lettuce, potatoes, beetroot, cabbage, tomatoes peas, carrots and other crops.

Reducing food waste is essential, particularly at private and public events such as banquets, conferences, and other gatherings, including those hosted by hotels. Such wasteful practices are prevalent in multiple parts of the world, including Arab countries, as shown in image (1).

Addressing this issue is vital for minimizing unnecessary environmental impacts.

Image (1)

Disposal of food waste [6]

Why not cultivate our food at home gardens, and courtyards as a genuine form of environmental responsibility? This approach is not novel to humanity. During World War II, the widespread cultivation of food in private gardens, known as Victory Gardens, became prevalent. Additionally, the preservation of food through canning became highly popular, reaching its peak in 1943 with over 4.1 billion jars of canned fruits and vegetables stored in glass containers to contribute to the war effort.

Modern production methods offer sustainable alternatives, such as aquaculture for marine species in fresh, salty, or seawater. Permaculture practices and minimal-soil agriculture, including hydroponics—using water mixed with minerals and nutrients—or aquaponics, where fish farming water nourishes vegetable crops, are also promising. These methods reduce freshwater consumption, boost productivity, and minimize environmental pollution. We will explore these and other organic farming techniques in greater detail in Chapter 21; Green Behavior.

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Chapter Two

Drinking

Chapter "2"

Drinking

Drinking a glass of water is seldom accompanied by contemplating the extensive and intricate processes required to render it potable. The significant quantities of energy and water consumed in its production are rarely considered. However, when the fact that the freshwater consumed originates from finite surface water resources or non-renewable subterranean aquifers is reflected upon, it becomes evident that a drinking water crisis is imminent. This concern is particularly acute in Yemen, where the adverse effects of global warming and climate change compound the depletion of freshwater resources. These effects are manifested in the increasing scarcity of potable water, the salinization of existing water sources, and the exacerbation of drought in certain regions of the world [(1)].

Energy is indispensable. Whether the water is drawn from the depths of the earth, extracted from rivers and lakes, purified to remove impurities and pathogens, or desalinated to render saline water fit for use, each stage demands substantial energy inputs. Following treatment, the water must be transported to consumers through extensive networks of clean pipelines. In the United States, for example, the water sector—encompassing treatment, purification, and transportation—accounted for approximately 12.6% of the nation's total electricity consumption in 2013. Similarly, in Jordan, a country characterized by extreme water scarcity with an annual per capita water share below 100 cubic meters, the water sector consumed 15.3% of the nation's electricity in 2019 [(2)] - a considerable proportion for a small country.

The journey of fresh water from its source to the consumer is arduous and energy-intensive. The electricity utilized in this process is frequently derived from a mix of energy sources, including fossil fuels such as coal, oil, and natural gas, as well as nuclear and renewable energy. However, when electricity production relies heavily on fossil fuels, it results in the emission of significant quantities of carbon dioxide and other greenhouse gases, such as methane, nitrous oxide, and chlorofluorocarbons. These emissions exacerbate environmental degradation and contribute to global climate change.

Equally concerning is the environmental impact of plastic water bottles. These bottles represent a major source of pollution due to the substantial effort and raw materials required for their production. The manufacturing process consumes vast amounts of water and energy, and the disposal or recycling of these bottles presents additional challenges. Each year, tens of billions of plastic bottles are discarded into the environment, where they persist for centuries before decomposing. This persistent pollution inflicts profound and enduring harm upon ecosystems. For instance, producing a single plastic bottle consumes more water than the bottle's capacity, underscoring the inefficiency and environmental cost of this practice.

Figure (4)

The time required for the decomposition of various types of plastic [3]

In Australia, approximately three million tons of plastic are produced annually, with a mere 12% being recycled. The global scale of plastic production and its improper disposal, particularly in economically disadvantaged nations, exacerbate environmental harm. For example, plastic items such as toothbrushes, baby diapers, and coffee pads require 450-500 years to decompose, while thinner plastic bags take about 20 years. During this prolonged decomposition process, plastic waste poses significant risks to wildlife, including grazing animals and marine species.

Water consumption is not limited to drinking; it extends to other daily activities such as washing, where wastewater enters sewage systems. The treatment of this wastewater—whether through mechanical, biological, or chemical processes—demands considerable energy, primarily in the form of electricity. When this electricity is generated from fossil fuels, it further amplifies the carbon footprint of wastewater treatment, releasing methane and other greenhouse gases into the atmosphere.

Thus, the seemingly innocuous act of drinking a glass of water sets in motion a complex chain of environmental consequences. The process imposes significant strain on natural resources, from the extraction and treatment of water to its eventual recycling. It stresses the need for individuals to carefully consider their drinking water sources, its sustainability, its packaging and transportation methods, and the proper handling and recycling of containers—all essential for fostering an environmentally responsible lifestyle, as reflected in this book.

Similarly, when consuming fruit juice, one must reflect upon its origins. The journey of juice begins with the agricultural lands and orchards that produce the fruit, often at the expense of deforested areas. The subsequent transportation of these fruits to factories, sometimes by environmentally detrimental means such as air freight, further compounds the ecological footprint. Once at the factory, fruits are washed, juiced, packaged, and cooled—processes that demand substantial water and energy.

The lifecycle of fruit juice production does not conclude at the factory. Packaging, transport, refrigeration, and delivery to consumers.

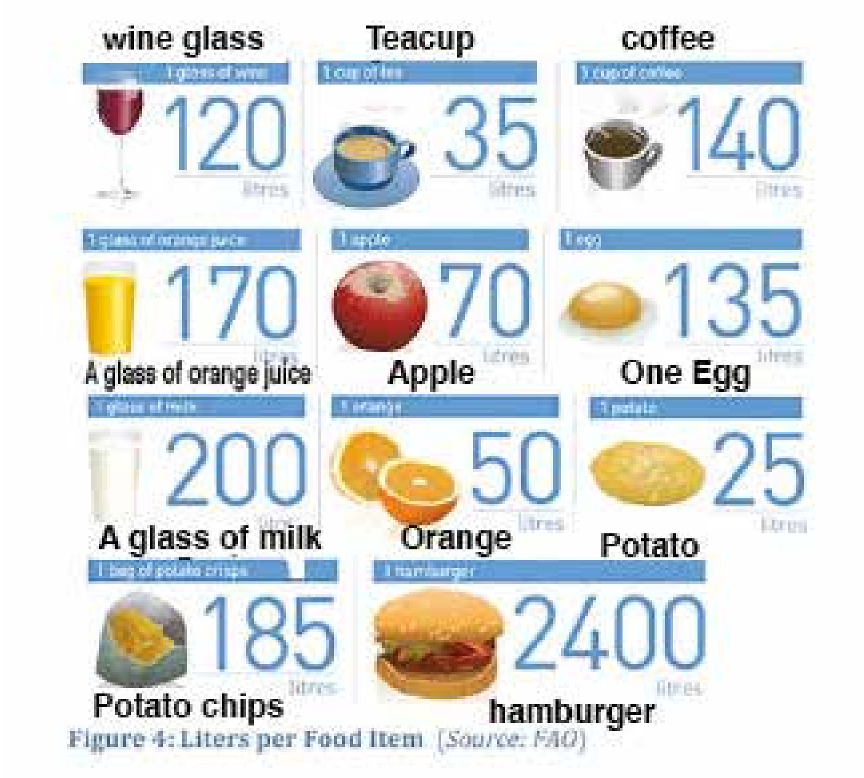

Figure (5)

The depletion of water caused by various food materials during their production stages [4]

Producing a small plastic bottle of water requires over five liters of water. Additionally, a single glass of orange juice consumes approximately 170 liters of water—a figure that encompasses the water required for cultivation, manufacturing, and packaging. Similarly, producing a glass of wine requires 120 liters of water, while a single hamburger necessitates an astonishing 2,400 liters. These figures illustrate the extensive resource demands of food and beverage production (see Figure 5).

The environmental impact of these industries extends beyond their direct water usage. The machinery employed in production relies on electricity, and the manufacturing of this machinery itself has a historical record of water and energy consumption. Consequently, the chain of environmental depletion perpetuates itself, underscoring the urgent need for sustainable practices at every stage of production.

In conclusion, the seemingly simple acts of drinking water or consuming food and beverages are indistinguishably linked to a broader environmental narrative. To mitigate the detrimental impact of these activities, individuals and societies must adopt sustainable practices, prioritize resource conservation, and strive to minimize their ecological footprint.

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Chapter Three

Transportation

Chapter "3"

Transportation

The advent of fossil fuel utilization, particularly following the invention of the steam engine in the late eighteenth century, marked a significant turning point that contributed to the rise of greenhouse gas emissions in the Earth's atmosphere. For much of the following centuries, the global community remained largely oblivious to the repercussions of this development, such as the increase in mean atmospheric temperatures, glacial melting, and other critical environmental indicators. It was not until the twentieth century that the serious implications of these changes became apparent, prompting a growing urgency to mitigate emissions. The recognition of the potential consequences—most notably a dramatic rise in global temperatures and severe climate disruptions—has raised alarms about the planet's capacity to sustain human life by the close of the twenty-first century.

This brings forth an essential inquiry: how can we, as individuals, ensure that life on this planet remains viable while fostering an environment that preserves it for future generations, particularly in relation to transportation?

To address this, it is crucial to assess the scale of emissions generated by the global transportation sector. In 2016, the transport sector accounted for approximately

16.2% of total global greenhouse gas emissions, placing it third compared to other sectors such as electricity generation, industrial activities, land use, and heating and cooling.

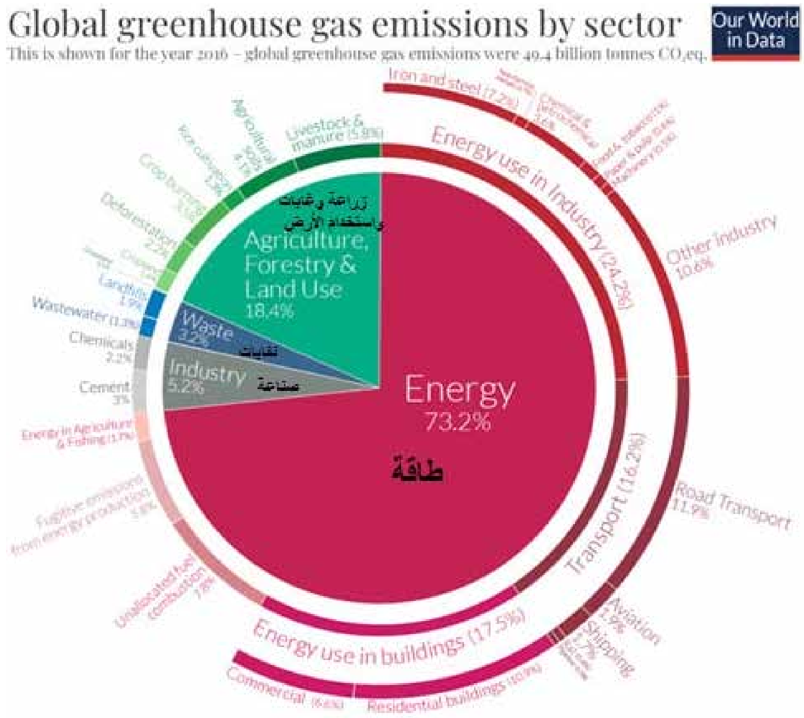


Figure (6)

Global distribution of greenhouse gas emissions by sector in 2016 [1]

The energy sector, which encompasses various domains of use, contributed to 73.2% of total emissions. Within this context, the industrial sector was responsible for 24.2%, while the transport sector accounted for 16.2%, and the energy utilization in buildings and construction sectors contributed 17.5%. Notably, residential buildings emitted

10.9% of emissions, surpassing the 6.6% contribution from commercial buildings, underscoring the significance of adopting environmentally sustainable practices in our homes and workplaces.

Analysis of the data reveals that road transportation is responsible for the largest share of emissions within the transport domain, contributing 11.9%. In comparison, other land transport modes account for 1.9%, and maritime transport contributes 1.7%. Thus, it is imperative to identify which modes of transportation induce the highest levels of pollution, as illustrated in the subsequent figure 7.

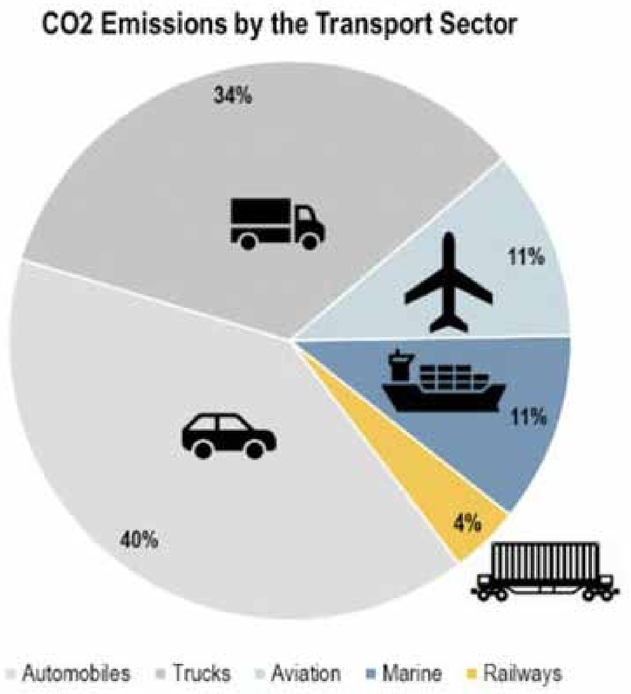
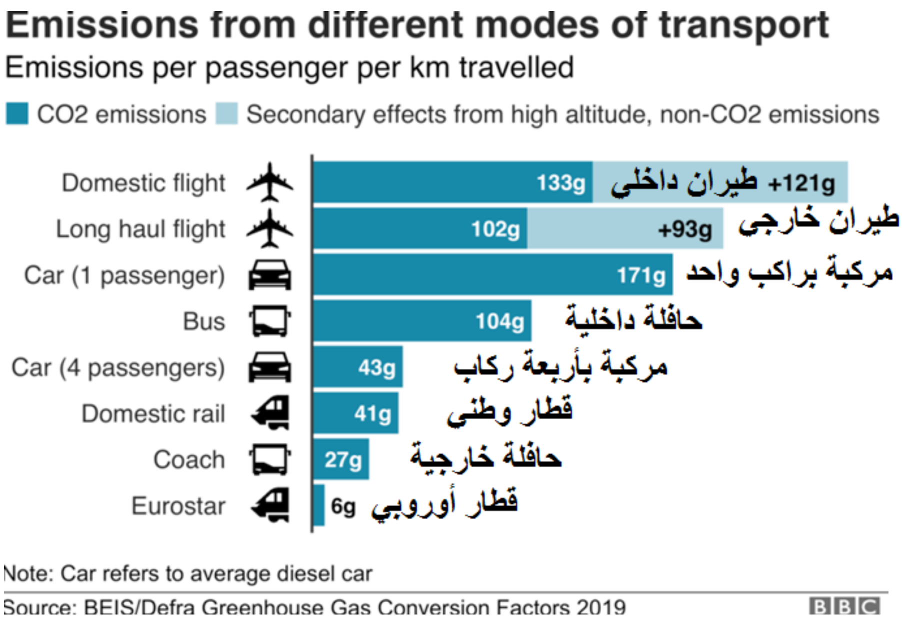


Figure (7)

Carbon Dioxide Emissions by Transport Sector: Breakdown by Various Modes of Transportation [2]

The findings indicate that private vehicles are the primary contributors to emissions within the transport sector, representing 40% of the total. Followed by heavy freight vehicles at 34%, and the aviation and maritime sectors each at 11%. In terms of environmentally responsible travel, trains emerge as the most sustainable option, contributes with only 4%.



Figure(8)

Emissions per Passenger per Kilometer across Different Modes of Transportation (3)

Recent data shows that the Eurostar, Europe's latest train model, achieves remarkable efficiency, emitting only 6 grams of carbon dioxide per passenger per kilometer.

This is significantly lower than other forms of transportation, including buses (27 grams), internal trains (41 grams), vehicles with four occupants (43 grams), long-haul flights (93+ 102,grams), and local flights, which combined can exceed (133 + 121) grams per passenger per kilometer.

Consequently, the environmentally conscious traveler should prioritize the Eurostar, followed by buses. If travel by personal vehicle is necessary, carpooling emerges as a commendable choice. By sharing rides, individuals can achieve emissions levels comparable to those of standard internal trains, thereby fostering a healthier environmental footprint.

The concept of vehicle sharing has extended to commercial endeavors, exemplified by platforms such as BlaBla Car. However, the onset of the COVID-19 pandemic in early 2020 hindered the widespread adoption of this practice. Nevertheless, there is renewed optimism for its resurgence and integration into both public and private sectors. For instance, government agencies, educational institutions, and corporate organizations could facilitate employee transport via shared vehicles rather than allowing individual commuting, thereby reducing both greenhouse gas emissions and road congestion.

When purchasing a vehicle, environmentally conscious consumers should first consider hydrogen-powered options, as their combustion produces only water vapor. Should hydrogen vehicles be unavailable, fully electric vehicles should be the next choice, provided they are charged with solar power. The subsequent alternative is hybrid vehicles, which utilize both electric and conventional fuel sources, incorporating regenerative braking and momentum to recharge their batteries.

If these options are not feasible, the bicycle emerges as an optimal choice for sustainable transportation, conditional upon the availability of appropriate infrastructure. The Netherlands, for instance, boasts a remarkable bicycle-to-resident ratio of 1.3, with 99.1% of its population engaged in cycling. Other countries with high cycling participation rates include Denmark (80.1%), Germany (75.8%), Sweden (63.7%), Norway (60.7%), Finland (60.4%), Japan (56.9%), the Czech Republic (48.8%), Belgium (48%), and China (37.2%). (4)

The evolution of electric bicycles has reached a stage where they now feature motors that recharge through pedaling, aiding cyclists in adverse conditions such as high winds or steep inclines. These electric bicycles can attain speeds of up to 45 km/h, with potential for even greater velocities in specific areas. (5)

The shift from traditional motorcycles to electric bicycles is increasingly being recognized as a viable strategy for minimizing environmental impact while meeting transportation needs.

In conclusion, walking is the most environmentally friendly mode of transport, followed by traditional bicycles, electric bicycles, and subsequently long-distance trains or buses. For those needing to purchase a personal vehicle, it is advisable to prioritize hydrogen-powered vehicles, followed by electric and hybrid options. When all those alternatives are exhausted, one should select a modern vehicle over an older model, taking into account emissions per kilometer. Notably, advancements in vehicle technology have led to reductions in carbon dioxide emissions; for instance, modern conventional vehicles have decreased their emissions from around 170 grams per kilometer to approximately 120 grams by 2018. Regulatory measures enacted in Europe in 2020 aim to lower vehicle emissions to 95 grams per kilometer, with similar targets established in Japan (105 grams) and China (117.5 grams).

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Chapter Four
Vacation

Chapter (4)

Vacation

During the contemplation for a vacation, an affluent individual who aspires for an environmentally conscious experience ought to prioritize domestic tourism. This approach not only minimizes travel distances but also allows for the meticulous selection of transportation modes that inflict the least harm upon our planet, as expounded upon in the preceding discourse on transportation.

Critical to the selection of vacation destinations are those environmental sites that exemplify a commitment to ecological preservation. Such sites should harness clean energy—derived from solar, wind, or other sustainable sources—thus ensuring their operational processes are environmentally benign. Moreover, these establishments diligently engage in the recycling of water and waste, all while honoring the delicate nature of their ecological surroundings. Efforts to enhance local ecosystems through the planting of trees, the protection of vulnerable species of flora and fauna, the preservation of vegetative cover, and initiatives to uplift local populations and their social environments are fundamental to their ethos.

This philosophy resonates with the principles of ecotourism, defined as responsible tourism practices aimed at conserving natural areas while simultaneously fostering the sustainability of local communities. In recognition of its significance, the United Nations proclaimed the year 2002 as the International Year of Ecotourism.

A model of harmonious environmental design can be exemplified by the Eco Nautilus Resort in the Philippines, whose architectural ethos reflects natural forms, notably through the application of the Fibonacci sequence, paralleling the inherent patterns found within living organisms e.g. shells and oysters.

This project further distinguishes itself by selecting eco-friendly building materials such as Bio Concrete, chosen based on a comprehensive assessment of the greenhouse gases emitted throughout their lifecycle—from extraction to disposal—thus minimizing environmental impact. The project adeptly harnesses the energy from ocean waves and solar sources, generating an excess that exceeds its operational requirements.

Image (2)

Eco-Friendly Resort Design in the Philippines: Embracing Environmental Harmony [2]

Furthermore, the financial gains manifested from this venture are earmarked for scientific research dedicated to environmental conservation within the region, which presently faces existential threats from climate change, including altered rainfall patterns, temperature increases, and rising sea levels. A portion of the resort's revenue will also be allocated to support the economic, social, and cultural vitality of the local population. This is particularly crucial for low-lying regions and islands, such as the Maldives and the Marshall Islands, which are imperiled by rising waters attributable to global warming and glacial melt—a phenomenon threatening to submerge coastal areas and foster environmental displacement. Consequently, tourism in these fragile locales not only aids local communities in fortifying infrastructure against the encroachment of seas but also supports their adaptive strategies in the face of inevitable ecological transformation, particularly as greenhouse gas concentrations continue to escalate within the Earth's atmosphere.

To further elucidate, the World Ecotourism Association articulates a definition of ecotourism as

"Responsible travel to natural areas that conserves the environment and improves the well-being of local people, enhancing public awareness of environmental issues and supporting necessary research to comprehend and propose effective solutions to these quandaries."

Undoubtedly, patronizing ecological reserves constitutes both a moral imperative and a national responsibility; these institutions play a pivotal role in safeguarding environmental resources. Research substantiates that ecotourism significantly contributes to the preservation of national parks, facilitating the protection of diverse species and their habitats while fostering responsible governance over their conservation against threats such as unsustainable construction practices.

National parks frequently encompass forests that are increasingly endangered, largely due to agricultural expansions and exploitative investments. Such environments necessitate protection against rampant wildfires, unchecked encroachments, excessive deforestation, and overgrazing, all of which are exacerbated by prevailing global capitalist paradigms. It is also imperative to acknowledge the perils associated with the feeding of wildlife within reserves; this activity often engenders a detrimental trust in humans among animals, rendering them susceptible to exploitation by poachers seeking fur, meat, or ivory. This naiveté undermines the intrinsic value of biodiversity, which is essential for maintaining the ecological balance and sustainability of their habitats.

Some examples of protected sites in Jordan include:

- Shomari Reserve.
- Al Majab Reserve.
- Fifa Nature Reserve.
- Azraq Wetland Reserve (see Image 3).
- Dana Reserve.
- Aqaba Marine Park.
- Ajloun Forest Reserve.
- Dibbin Reserve.
- Wadi Rum Reserve.
- Yarmouk Reserve.

Image (3)

Azraq Wetland Reserve – Jordan [4]

Among the most important nature reserves in the United Arab Emirates

- Sir Bani Yas Island Reserve.
- Marawah Reserve.
- Al Thaba Reserve.?????
- Ras Al Khor Reserve.
- Dubai Desert Conservation reserve.
- Jebel Ali Reserve.
- Al Maha Wildlife Reserve.
- Kalba Reserve.
- Batinah Island.
- Al Maram Reserve.???
- Al Dhulayma Reserve.??

Nature reserves in Saudi Arabia

- Mahazat Al Shaid Reserve.
- Umm Al Qamari Islands Reserve.
- Farsan Islands Reserve.
- Harrat Al Harra Reserve.
- Al Khunfah Reserve.
- Al Al Reserve.
- Al Tubaiq Reserve.

Nature reserves in Oman

- - Al Jabal Reserve
- Al Akhshar for Landscapes
- Al-Shalil Nature Reserve.
- - Bandar Al-Khiran Reserve.
- Al-Afar Reserve in Dhofar Governorate.
- Al-Daymaniyat Islands Reserve.
- Wildlife and Fungi Reserve.
- Oman Botanical and Tree Garden.
- Wadi Al-Sharin Reserve.

Nature reserves in Iraq

- Kashiba Reserve.
- Al-Reem Reserve.
- Najaf Reserve.
- Iraqi Rivers.

Nature reserves in Kuwait

- Shabah Al-Ahmad Nature Reserve.
- Mubarak Al-Kabeer Reserve.
- Umm Al-Qurain Reserve.
- Al-Rushteen Reserve.
- Al-Shaqaya Reserve.
- Al-Shalibiya Reserve.
- Al-Abdaliya Reserve.
- Al-Mutlaa Reserve.

Reserves in Bahrain

- Al-Areen Reserve.
- Har Islands Reserve.
- Mishtan Island Reserve.
- Dohat Arad Reserve
- Tabli Bay Reserve.
- Hair Balthama Reserve.

Reserves in Qatar

- Al-Shahaniya Reserve.
- Al-Froushia Reserve.
- Al-Mashhabiya Reserve.
- Al-Barra Reserve.
- Al-Shihi Reserve.
- Ras Ashirj Reserve.

Reserves that exceed 1,000 km2 in Egypt

- Jabal Elba Reserve.
- Shant Katherine Reserve.
- Wadi Al-Alaqi Reserve.
- Wadi Al-Rayyan Reserve.
- Qarun Reserve.
- Taba Reserve.
- Shiya Reserve.
- Al-Shahra Al-Bisha Reserve.
- Wadi Al-Gamal Reserve.
- Northern Red Sea Islands Reserve.
- Gilf Al-Kabir Reserve.

Reserves in Sudan

- Al-Dinder Al-Qimia Park.
- Dungonab Bay and Makar Island Reserve.
- Wadi Har Al-Tani Park.
- Al-Radom Al-Qimia Park.
- Shaken Archipelago Park.
- Jabal Al-Dayer Reserve
- Shanganib Island Marine Reserve.
- Jabal Al-Hashaniya Reserve.
- Jebel Marra Reserve
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Chapter Five

Choosing Your Clothes

Chapter 5

Choosing Your Clothes

When it comes to selecting clothing, the type of material is a primary concern. Are natural fibers such as cotton more eco-friendly than synthetic materials such as polyester?

A series of important questions should be considered:

- What harmful chemicals might be involved in clothing production?
- Are cotton farming regions encroached upon at the expense of forests or nature reserves?
- How easily can these materials be recycled after their useful life has ended?
- What were the labor practices in place during their production? Were workers treated ethically?
- Was the raw material sourced from distant locations, or were the clothes manufactured far away, necessitating air transport to reach consumers? Were they shipped using particularly polluting methods, such as large cargo ships?
- It's crucial to consider whether clothing was sourced from reputable thrift stores or purchased online from distant sellers, as both options may involve transportation methods that harm the environment.

These considerations are essential for anyone who aspires to embrace an eco-conscious lifestyle through their clothing choices.

Interestingly, a large portion of global clothing is made from synthetic fibers such as polyester, nylon, and acrylic, while only about 24% is crafted from cotton, see figure 10. The manufacturing process for cotton is notably water-intensive and contributes to environmental degradation. To illustrate, producing one kilogram of raw cotton can use around 10 to 20 cubic meters of water and involve the application of numerous chemicals, fertilizers, and pesticides to combat pests. This has adverse environmental effects and leads to a decline in vital green spaces as cotton cultivation often takes over forest land, which is essential for air purification, climate regulation, and soil erosion prevention.

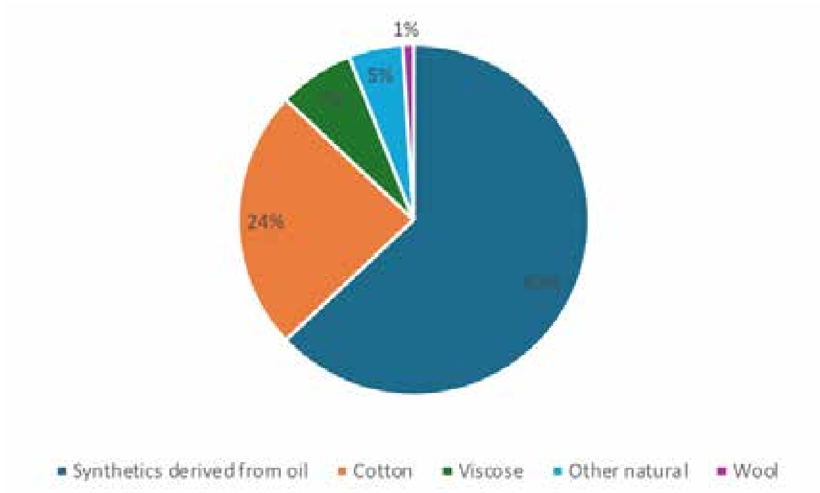

Figure (10)

The Role of Natural and Synthetic Fabrics in Global Clothing Production [1]

Although natural materials e.g. cotton, linen, and leather are valued, they consume considerable energy and water, impacting the environment negatively. In contrast, synthetic materials typically use less water in production. Clothes made from polyester tend to have a longer lifespan compared to their natural counterparts, which can mitigate their ecological footprint. As highlighted in Figure 10, a significant quantity of clothing is derived from petroleum-based sources.

Natural fibers like cotton require extensive water resources and involve pesticide and fertilizer usage, creating further ecological strains. The production of leather and fur also disrupts ecosystems by promoting the exploitation of specific animal species.

Research shows that the worth of unused clothing cluttering people's closets can surpass £30 billion; meanwhile, around 140 million pounds of textile waste are discarded in landfills each year, which translates to approximately 350,000 tons of clothing waste. Consequently, environmental advocates are promoting clothing recycling to extend garment longevity(2).

Buying new clothing entails substantial water and electricity usage during their creation, care, and maintenance. As clothing has a limited lifespan, following proper care instructions to extend their usability becomes essential to avoid premature degradation, particularly by avoiding high wash temperatures. Environmentally conscious individuals should also steer clear of purchasing garments that necessitate frequent ironing, contributing to higher energy bills.

In Table 1, we can observe that certain household appliances consume considerable amounts of electricity, such as irons (1000 watts), washing machines (500 watts), and clothes dryers (1000 to 4000 watts). By limiting the number of clothing items bought and selecting those needing less washing or ironing, one can effectively lower household energy consumption, which often comes from polluting energy sources e.g. coal and oil.

Table (1)

Household Appliances Energy Consumption[3]

HOME APPLIANCE	ENERGY CONSUMPTION (WATTS/HOUR)
22-INCH LED TV	17
55-INCH LED TV	116
REFRIGERATOR	40 - 80
CLOTHES DRYER	1,000 – 4,000
COMPUTER	100 - 450
ELECTRIC HEATER	2,000 – 3,000
MICROWAVE	600-1,700
IRON	1,000
WASHING MACHINE	500

To promote an environmentally sustainable lifestyle, it is advisable to adopt certain behavioral practices. For instance, selecting classic clothing styles that can be easily coordinated with various other pieces allows for extended usage and versatility. Additionally, opting for subdued and neutral colors rather than bright and bold ones enhances the practicality and longevity of garments. When clothing is no longer needed, it is recommended to recycle them by donating to individuals in need, rather than discarding them in waste bins.

Each year, significant amounts of clothing are disposed of as waste. Consequently, it has become imperative to adopt changes in human behavior and prioritize sustainability in the clothing industry. This can be achieved through mindful design and production processes, with a focus on extending the lifespan of garments, enhancing the quality of materials, and making thoughtful choices regarding the colors used in manufacturing.

The clothing industry has a significant environmental footprint. It contributes approximately 10% of global carbon dioxide emissions, consumes 6–8% of the world's water, and is responsible for polluting 20% of freshwater sources.[(4)]

Unfortunately, projections currently circulating is that the fashion industry will produce about 25% of carbon dioxide in the world by 2050[(5)], while emissions from this sector will increase by more than 60% by 2030. This emphasizes the urgent need for collective and individual action to mitigate the environmental impact of fashion and promote sustainable practices

The fashion industry uses about 93 billion cubic meters of water annually, including 20% of the wastewater produced from processing and softening different fabrics.

This industry also produces carbon emissions of about 10% of global emissions, more than double the carbon emissions resulting from land and sea transport combined, and it is expected that this contribution will increase by 50% by 2030, as stated by the World Bank. This is an important parameter and indicates the importance of considering the clothing sector when assessing environmental pollution on a global level.

Sustainable fashion represents a innovative approach to design and production that seeks to reduce the environmental impact of the clothing industry while promoting social responsibility and ethical practices. This involves minimizing waste, reducing carbon emissions, and using sustainable materials. It also includes adopting environmentally friendly production methods and encouraging recycling and remanufacturing of textiles.

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7.

Chapter Six

Choosing a Construction Site

Chapter (6)

Choosing a Construction Site

When aiming to lead a sustainable and environmentally conscious lifestyle, it is important to extend consideration beyond choices related to food, drink, clothing, transportation, and vacation destinations. One critical aspect is the selection of a residential location or the site for constructing a home for oneself and one's family. The selection of a construction site should align with environmental and sustainability principles while ensuring the well-being of the residents.

Environmental Considerations in Site Selection

The choice of a residential location must prioritize minimizing disruption to the natural environment. This includes avoiding areas such as nature reserves, protected slopes, forests, or other ecologically sensitive zones. The sustainability of the site should also be evaluated in terms of its accessibility to public transportation, such as buses and trains, and the availability of infrastructure that supports walking and cycling.

Furthermore, the site should ideally provide access to essential services, including children's playgrounds, public parks, shopping centers, and medical facilities such as pharmacies and hospitals. Proximity to places of worship and educational institutions is also important. These amenities should be within walking distance wherever possible, as this reduces reliance on vehicles, conserves energy, and fosters a healthier and more efficient lifestyle in the short and long term.

Air Quality and Environmental Safety

The quality of air in the chosen area is a vital factor in ensuring a healthy living environment. Table 2 illustrates the air quality index and pollutant concentrations recorded in Amman, Jordan, on January 4, 2022. The general air quality index was 40, indicating acceptable air quality; however, ozone levels and particulate matter (PM10) were slightly elevated. Despite these minor concerns, other pollutants such as PM2.5, sulfur dioxide, nitrogen dioxide, and carbon monoxide (CO) were at excellent levels and did not require intervention.

Table (2)

Air Quality Index in Amman, Jordan on January 4, 2022 – Air Quality and Composition[1]

Air Quality	*Degree*	*Description*
Air Quality Index (AQI) -	Acceptable - 40	The air quality is generally acceptable for most individuals. However, prolonged exposure may trigger mild to severe symptoms in people with allergies.
O_3 (Ozone Gas)	Acceptable - 84 µg/m³	Ozone in the lower layers of the atmosphere can exacerbate respiratory diseases and cause throat irritation, headaches, and chest pain.

PM 10 (Particulate Matter up to 10 µm)	Excellent 28 µg/m³	Particulate matter (PM) consists of inhalable pollutants less than 10 micrometers in diameter. Larger particles can accumulate in the respiratory system, causing irritation, coughing, and breathing difficulties. Prolonged exposure may worsen asthma and lead to severe health issues, emphasizing the need for air quality management to reduce pollution-related risks.
PM 2.5 (Particulate Matter up to 2.5 µm)	Excellent 6 µg/m³	Fine particulate matter (PM2.5) consists of pollutant particles under 2.5 micrometers that penetrate the lungs and bloodstream, causing serious respiratory and cardiovascular issues. Exposure can lead to coughing, breathing difficulties, severe asthma attacks, and worsened chronic respiratory diseases, particularly affecting the lungs and heart, increasing long-term health risks.
(Sulfur Dioxide)	Excellent 8 µg/m³	Sulfur dioxide exposure can cause throat and eye irritation, exacerbate asthma, and contribute to chronic bronchitis. However, the current air quality is excellent, and no further precautions are necessary.

(Nitrogen Dioxide)	Excellent 5 µg/m³	High concentrations of nitrogen dioxide increase the risk of respiratory issues, leading to coughing, asthma, and, in severe cases, respiratory infections. However, the current air quality is excellent, requiring no additional measures.
CO (Carbon Monoxide)	Excellent 105 µg/m³	Carbon monoxide is a colorless and odorless gas. When inhaled in high concentrations, it can cause headaches, nausea, dizziness, and vomiting. Prolonged exposure may contribute to heart disease. However, the current condition is excellent, and there is no cause for concern.

Table 2 indicates that the air quality index, measured on Tuesday, January 4, 2022, in the Jordanian capital, Amman, was 40 degrees overall, signifying satisfactory air conditions. The table also provides detailed data on the concentrations of gases and fine suspended particles, measured in micrograms per cubic meter of air. It reveals that ozone (O_3) and suspended particles (PM2.5)were slightly elevated but still within acceptable levels. Meanwhile, other elements, such as fine particulate matter (PM2.5), sulfur dioxide, nitrogen dioxide, and carbon monoxide, were rated as excellent and did not require any reduction measures.

Given these findings, the selection of a residential location should prioritize the atmospheric quality of the area.

It is essential to ensure that the area is sufficiently distant from hazardous industries, radioactive materials, polluted water sources, and waste disposal sites. Additionally, it is crucial to avoid regions prone to natural disasters, such as floods or severe earthquakes.

Beyond environmental factors, the social environment of the area should be carefully evaluated to ensure its suitability for raising children. Consideration should be given to the potential influence of the local community on children's upbringing. Special attention must be paid to ensuring that children are not exposed to violence, bullying, or harm in any form.

Finally, selecting an appropriate school for children is equally important. The school should ideally be located near the home and provide a social, cultural, and educational environment aligned with the family's economic, moral, psychological, and spiritual values.

An individual striving to live a healthy and environmentally conscious life seeks to avoid sources of physical and mental pollution. This includes residing at a distance from highways, airports, and other areas with high-speed vehicles, as such environments contribute to increased physical pollution. It is equally critical to avoid areas exposed to natural disaster risks, such as earthquakes, volcanoes, hurricanes, and tsunamis, as well as areas prone to radiation exposure. Proximity to sites where radioactive waste is buried or to nuclear power plants that emit ionized gases into the atmosphere poses significant risks to health and safety.

Noise pollution is another crucial factor. Excessive noise levels can lead to serious health conditions and, in some cases, premature death. According to the World Health Organization, noise levels should not exceed 55 decibels (dB) to maintain optimal health. However, extreme winter climates also contribute to significant health risks. In Europe, for instance, harsh winter conditions have been linked to 12,000 premature deaths in a single year, with 48,000 individuals hospitalized due to their impact, including heart-related issues[(2)].

The European Environment Agency (EEA) estimates that 22 million people in the European Union experience severe discomfort due to winter conditions, while 6.5 million suffer from sleep disturbances. Noise from air traffic alone has been associated with sleep difficulties for 12,500 students[(3)], negatively affecting their academic performance.

Research further highlights the detrimental effects of noise pollution from transportation, vehicle alarms, construction activities, and aircraft on humans, animals, and ecosystems. Less developed countries are particularly vulnerable, as they tend to experience more severe noise pollution.

Figure (11)

Noise Pollution Intensity in Decibels (dB) from Various Sources [4]

The data highlights that airplane noise ranks highest among sources of environmental noise pollution, often causing not just irritation but also severe health issues, such as sudden strokes and heart attacks. Annoyance typically begins at noise levels of 60 decibels or more, though sensitivity varies among individuals. For instance, while the sound of a ringing phone is mildly annoying, the noise from large machines, excavators, or loud bands is significantly more disturbing.

On the lower end of the scale, sound levels below 55 decibels, such as falling raindrops, low-pitched conversation, or the ticking of a wristwatch, are less intrusive and are generally considered calming.

When selecting a building site, attention must be given to the soil's characteristics to avoid potential structural issues. Certain clay soils prone to swelling require additional construction precautions, such as protective screens and walkways, to prevent damage caused by fluctuating soil moisture levels during seasonal changes. This alternation between swelling in wet conditions and shrinking in dry conditions can lead to severe structural damage(5).

Excavating extremely hard rock requires the use of heavy machinery, which generates significant amounts of dust that negatively impact the environment. The excavation process causes environmental pollution, leaving dust particles suspended in the air. These particles can obstruct breathing, lead to tracheal inflammation, impair vision, and cause various health problems affecting the respiratory system and sensory organs.

Relatively large dust particles, typically exceeding 2.5 micrometers in size, can settle in the airways and result in serious health complications. Exposure to these particles may cause irritation to the eyes and throat, persistent coughing, or difficulty in breathing. In severe cases, such exposure can lead to the development of intense asthma symptoms.

Additionally, fine particles suspended in the air pose even greater risks. These particles can penetrate deep into the lungs and enter the bloodstream, leading to critical health issues. The most severe effects are observed in the lungs and heart. Prolonged exposure to such particles may result in chronic coughing, difficulty breathing, severe asthma, and an increased severity of existing chronic respiratory conditions. The health risks associated with these particles emphasize the need for effective mitigation measures during excavation activities to minimize their environmental and human health impact.

The presence of trees also influences the soil and foundation stability of buildings. While trees provide shade, certain species, such as poplars, absorb significant amounts of soil moisture through their roots, which can lead to cracking in building foundations. Tree roots often extend to considerable depths, sometimes reaching twice the tree's height, depending on the species, soil conditions, and climate. This extensive root system can disrupt the soil's moisture balance, causing changes in its volume and movement in the foundations, ultimately resulting in structural cracks.

Finally, the choice of a home's location and construction methods is a moral responsibility, reflecting a commitment to living an environmentally conscious life. Such choices may involve challenges and hardships, but they contribute significantly to preserving the planet, preventing ecological harm, and fulfilling humanity's shared goal of sustaining a clean and fertile environment for future generations.

Image 4 illustrates the substantial thickness of poplar tree (Tree Poplar) roots, which extend to considerable depths in their search for moisture. In some cases, these roots can penetrate to depths equal to twice the height of the tree, or even more. The extent of root penetration depends on various factors, including the species of the tree, the characteristics of the soil, the prevailing climate, the rate of rainfall, the availability of groundwater, and other environmental conditions(6).

Image (4)

Deep-Rooted Poplar Tree Penetrating the Foundation Soil of a Building (7)

Consequently, the effort to live an environmentally sustainable life, particularly when selecting a suitable location for residence, represents a profound moral obligation that encompasses all aspects of human existence. This undertaking demands a deep awareness of its significance and a steadfast commitment to adopting environmentally friendly practices throughout one's lifetime. While such an endeavor may involve challenges and sacrifices, it ultimately serves to preserve the planet from the threat of ecological collapse. Furthermore, it fulfills humanity's aspirations for a clean, healthy, and sustainable environment, ensuring a better quality of life for present and future generations.

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Chapter Seven

Houses Orientation

Chapter (7)

Houses Orientation

Why should an individual committed to an environmentally sustainable lifestyle concern themselves with the orientation of their house in relation to the movement of the sun throughout the year? Is it merely about following the sun's rays, aligning with prevailing winds, enjoying scenic views, or enhancing the aesthetic appeal of the building's design?

In temperate and cold regions of the Northern Hemisphere, it is generally recommended that the longer side of the building, along with the most frequently used rooms—such as living rooms and kitchens—face east or south. This orientation optimizes the benefits of solar energy during winter, contributing to energy efficiency and ensuring thermal comfort for the building's occupants. However, in regions where summers are particularly hot, such as the Arab world and North Africa, additional measures must be taken to mitigate excessive solar exposure. In these cases, providing adequate shading for external openings is essential to block direct sunlight when necessary and to maintain indoor thermal balance during the summer months.

As illustrated in Image 5, a window situated on the eastern façade of a building in a cold region, such as Amman, Jordan, is effectively shaded using external blades. These shading elements are designed to obstruct direct sunlight in the morning when the sun rises at a low angle during summer, thereby preventing excessive heat gain through the glass. This shading technique is particularly applicable to windows on the eastern and western façades of a building. These blades may be positioned vertically or tilted at an angle to regulate the amount of solar radiation entering the space, ensuring adequate natural lighting while preventing overheating.

Additionally, these shading elements serve a dual function in moderating wind movement. In winter, they help retain warm air within the building by reducing heat loss, while in summer, they minimize the impact of hot external winds, thus enhancing indoor comfort and reducing reliance on artificial cooling systems.

Image (5)

Shading Patterns for Eastern and Western Facades in Warm Climates [1]

Regarding the side façade, a different approach to shading is required. Unlike the previous case, where shading elements are positioned at an angle, the side façade necessitates the use of horizontal awnings. This is due to the fact that, at noon, the sun’s angle on the side of the building is significantly higher, necessitating horizontal shading elements to effectively block direct sunlight.

Image (6)

Shading of a Southern Facade in Hot Climates (2)

The configuration of these horizontal awnings depends on the dimensions of the windows and the specific solar exposure. As illustrated in Image 6, when windows are particularly wide, multiple closely spaced horizontal awnings may be necessary to provide sufficient shading. Conversely, if the height of the window is moderate, typically not exceeding 1.5 meters, a single awning may be sufficient. The optimal shading design is determined by factors such as the angle of solar incidence and the height of the external opening, ensuring maximum efficiency in controlling solar heat gain while maintaining adequate natural lighting.

Regarding the northern façade, shading is generally unnecessary. However, the number and size of external openings on this façade should be minimized to reduce heat loss during winter and to regulate heat penetration into the interior during warmer periods. Additionally, northern openings can be strategically utilized for natural ventilation, depending on the geographical and climatic conditions of the area.

The orientation of a house plays a crucial role in maximizing the benefits of prevailing wind patterns. Winds striking the façade of a building create a high-pressure zone, which can be harnessed for effective natural cooling if windows are appropriately positioned. This is particularly beneficial in extremely hot climates, where enhancing airflow significantly improves indoor air quality and thermal comfort. Effective ventilation also helps mitigate indoor air pollution and contributes to a more pleasant indoor climate, particularly when cool northern winds occur during the early hours of the day.

In hot regions, it is preferable for the long sides of a building to face east and west, where the intensity of solar radiation is relatively lower during sunrise and sunset. However, this orientation necessitates additional shading measures, including the use of vertical shading elements for the eastern and western façades, as well as horizontal shading for side openings, as demonstrated in Figures 5 and 6.

As illustrated in Figure 12, a vertical airflow current can form between clusters of tall and slender trees. This phenomenon occurs because tall trees may obstruct sunlight during winter. To prevent excessive shading, deciduous trees should be planted, or trees should be positioned at an adequate distance from the building.

Furthermore, it is essential to ensure that solar panels remain unobstructed by tree shadows throughout the year. This applies to both photovoltaic panels used for electricity generation and solar water heaters, which require direct sunlight for optimal performance.

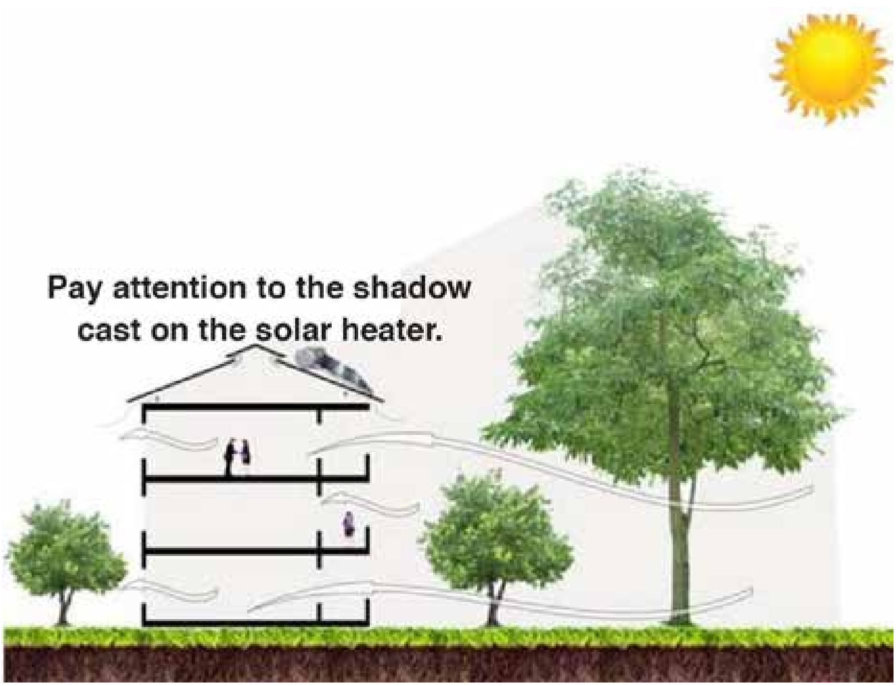

Figure (12)

Shading buildings with trees at different heights [3]

The significance of a building's orientation extends beyond energy conservation and thermal comfort; it also plays a crucial role in shaping the visual experience of its occupants. Thoughtful orientation can maximize exposure to scenic natural landscapes or, conversely, minimize undesirable views. This can be achieved through strategic placement of windows, the incorporation of trees as visual barriers, or the intentional angling of windows to control sightlines. For instance, a window may be designed at an inclined angle relative to the wall, either perpendicular or slanted, forming a pyramidal shape that directs the view toward a desirable focal point.

In specific cases, an individual may wish to maintain a clear view of the main entrance from the kitchen window, allowing them to observe visitors or monitor activity in front of the house. Conversely, one may seek to obstruct an undesirable view—such as a cemetery—by reorienting windows to overlook a lush forest or a majestic mountain range.

Thus, building orientation serves as a vital design consideration that harmonizes aesthetic appeal with practical functionality. It facilitates a balance between visually pleasing and less desirable elements of the surrounding environment, taking into account topography, demographic factors, and climatic conditions. This equilibrium does not compromise efforts to maintain a healthy and sustainable living environment; rather, it enhances the overall well-being and comfort of the building's occupants.

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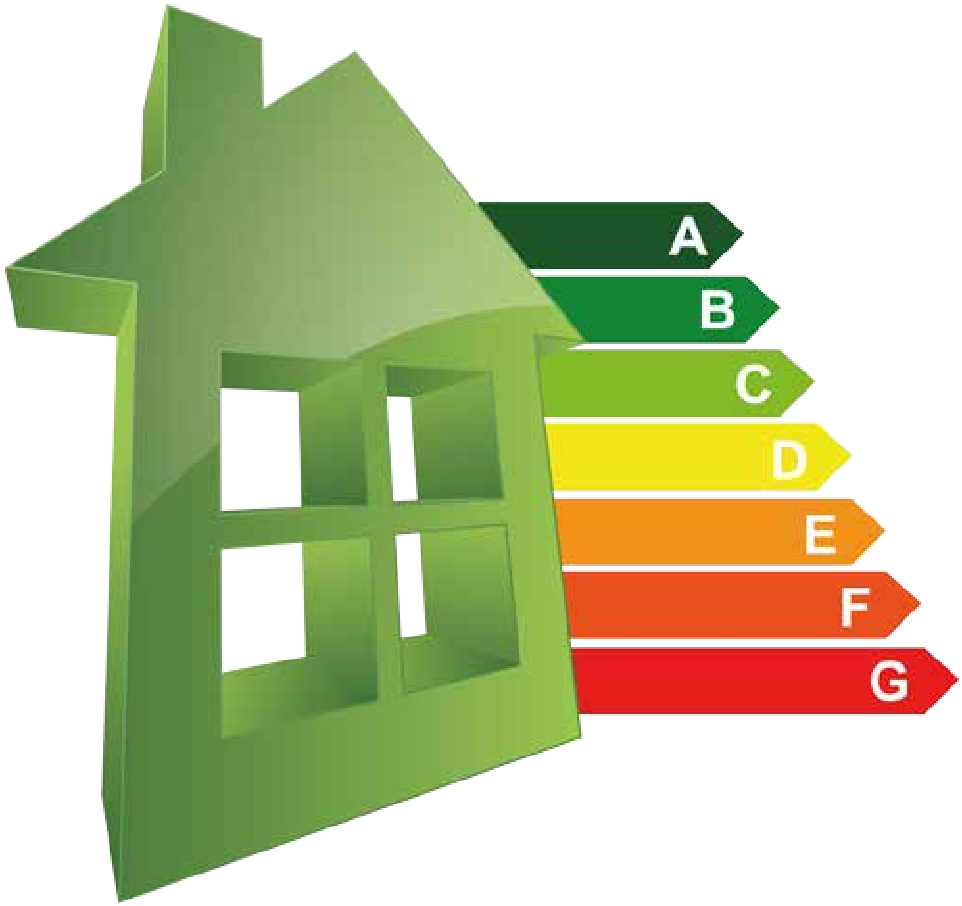
Chapter Eight

Passive Architectural Design

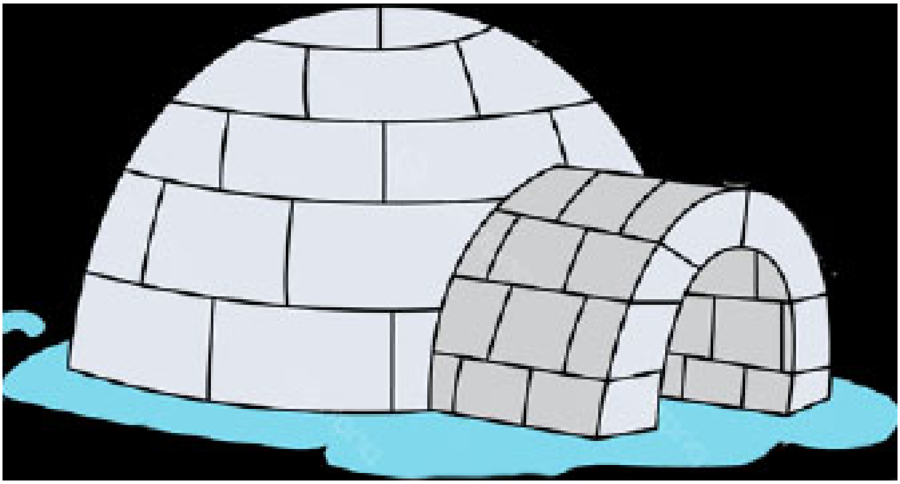


Chapter (8)

Passive Architectural Design

The climatic design of a building goes beyond the issue of orienting the building to include taking care of its shading, studying its shape, the ratio of the area of its external walls to its overall size, natural lighting, appropriate ventilation, and the quality of the ventilation inside it, etc., noting that the most suitable area of the external walls to the size of the building is the geometric shape of a ball, and therefore we find the Eskimo house (igloo) a dome of snow as seen in Figure 13.

The climatic design of a building extends beyond mere orientation considerations to encompass various critical factors, including shading, form analysis, the proportion of external wall surface area relative to the building's overall volume, natural lighting, optimal ventilation, and the quality of indoor air circulation. It is noteworthy that the most efficient geometric configuration, in terms of the ratio of external surface area to volume, is the sphere. This principle is exemplified in the traditional dwellings of the Inuit, where the igloo—a dome constructed from compacted snow—demonstrates an effective adaptation to harsh climatic conditions, as illustrated in Figure 13.



Figure(13)

The Dome Structure of Eskimo Houses as an Ideal Design for Minimizing Internal Heat Loss [1]

The architectural design of Inuit dwellings provides valuable insights into the significance of thermal insulation in building construction. The effectiveness of the external thermal envelope plays a crucial role in regulating indoor temperatures, as a well-insulated structure significantly reduces the energy required for heating or cooling.

Furthermore, the engineering principles observed in Inuit architecture highlight the importance of preventing the infiltration of cold external air. To achieve this, residents construct a specialized entrance resembling a tunnel, which acts as a buffer zone, shielding the interior from harsh winds and external elements (as illustrated by the entrance to the ice house in Figure 13). This design consideration underscores the necessity of selecting appropriate materials for external openings and strategically positioning them to minimize air penetration into internal spaces.

Within the Inuit dwelling, even minimal heating—such as burning a seal-fat candle—can cause the inner surface of the snow walls to melt slightly, forming a thin layer of water. However, upon brief exposure to the cold air when the door is opened, this water layer refreezes, effectively sealing any gaps between the ice blocks. This natural process exemplifies an adaptive design that ensures airtight insulation, prompting further reflection on strategies to prevent air infiltration in modern buildings. Similar principles can be applied to sealing structural elements such as window frames, electrical outlets, and other potential air leakage points in a building's exterior envelope.

Table 3 presents data on air permeability in cubic feet per minute per square foot for various types of windows. Notably, the highest air infiltration occurs through traditional sash windows. However, the addition of air-sealing strips significantly improves their resistance to air leakage, reducing the absorption rate from 2.5 to 1.0 cubic feet per minute per square foot. In contrast, fixed windows, which do not open, exhibit minimal air permeability, with a rate of just 0.1 cubic feet per minute. This indicates that fixed windows are ten times more resistant to air infiltration than the least efficient sash windows, highlighting the importance of appropriate window selection in ensuring thermal efficiency and airtight construction.

Table(3) [2]

Air leakage rate through various windows

Air leakage cubic feet per minute	Window type
0.1 cfm/sqft	Fixed windows or curtain wall
2.5 cfm/sqft	Sliding Windows
1.0 cfm/sqft	Weatheripped sliding windows

In terms of internal thermal comfort, the heat generated by the human body through radiation, conduction, and convection, combined with the thermal energy produced by a small seal-fat candle, is sufficient to warm an Inuit dwelling. This is particularly effective when the occupants wear fur clothing and use warm blankets for bedding. What lessons can be drawn from their living conditions and architectural choices?

The effectiveness of warm blankets in retaining body heat highlights the importance of thermal insulation, a fundamental aspect of climate-responsive architectural design. In sustainable architecture, this principle is extensively addressed in Chapter 16: Thermal Insulation of green building design literature. However, beyond insulation in furnishings, an essential question arises: how does the snow structure itself function as an effective building material?

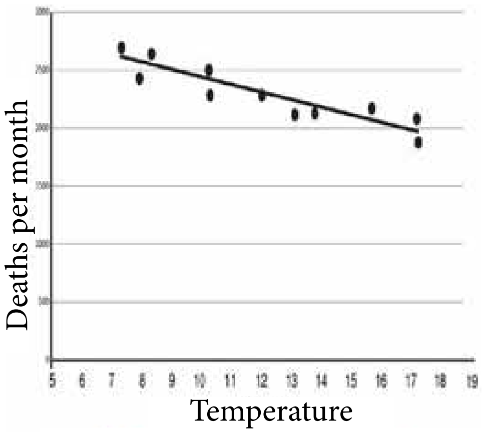
Snow, though seemingly an unconventional construction material, possesses excellent insulating properties due to the air bubbles trapped within its structure. These air pockets serve as natural thermal insulators, allowing the interior temperature of an igloo to reach approximately 0°C (32°F), even when the external temperature plummets to -50°C (-58°F). This remarkable insulating capability ensures a reasonable level of thermal comfort in extreme climates.

In modern buildings, thermal insulation materials embedded within walls and ceilings serve a similar function, replacing the air pockets found in snow structures. These materials are designed to minimize heat transfer in both directions, effectively maintaining indoor temperatures during both summer and winter.

The efficiency of a building's thermal envelope is directly influenced by its architectural complexity—structures with excessive angles, curves, and intricate designs tend to be less energy-efficient. Additionally, larger buildings require greater heating and cooling energy to maintain thermal comfort.

Natural lighting, while essential for reducing dependence on artificial illumination, can paradoxically increase energy consumption by introducing unwanted heat gain, thereby raising cooling demands. Similarly, increased air absorption through the roof necessitates higher cooling efforts during summer while also requiring greater heating in winter.

Proper internal ventilation is another crucial factor in maintaining a healthy indoor environment. Insufficient ventilation can lead to poor air quality, affecting the well-being of the occupants. Conversely, excessively high indoor temperatures contribute to thermal discomfort, increasing the risk of heat-related illnesses, including heatstroke and respiratory complications. Vulnerable populations, such as children and the elderly, are particularly susceptible to these adverse effects, underscoring the need for thoughtful climate-responsive design in modern architecture.



Mortality rate vs. temperature

Figure (14)

Death rates vs indoor temperature (3)

A study published by the University of Otago in New Zealand highlights the critical importance of maintaining healthy indoor conditions in buildings, particularly in the context of green architecture. The study emphasizes that human well-being and indoor environmental quality are essential factors in sustainable design. As illustrated in Figure 14, a direct correlation exists between lower indoor temperatures during winter and increased mortality rates. Consequently, healthy buildings should maintain an internal temperature above 18°C in cold regions to safeguard occupant health. However, achieving thermal comfort requires more than just maintaining a minimum indoor temperature. Additional factors, such as the temperature of internal surfaces, indoor air circulation, wind speed, occupant behavior, and clothing choices, also play a significant role in determining overall comfort levels.

Effective climate-responsive architectural design must integrate strategies for optimizing shading and thermal efficiency. External shading devices should be designed to block excessive solar radiation in the summer, preventing overheating in indoor spaces, while allowing sunlight penetration during winter months to contribute to passive heating. These principles align with previous studies on climate-adaptive design strategies.

Beyond thermal performance, sustainable architectural planning must also consider topographical modifications at construction sites. Excessive alterations to natural landforms can generate environmental pollutants, such as silt deposits, which negatively impact ecosystems. Additionally, the formation of urban heat islands (UHIs) caused by the widespread use of impermeable surfaces such as asphalt, concrete, and dark roofing materials—exacerbates temperature extremes in urban areas. To mitigate these effects, designers should prioritize materials with high solar reflectance and integrate green spaces into the built environment. This approach is particularly vital in regions with hot climates, where increasing vegetation coverage helps regulate humidity levels and moderate extreme summer temperatures.

The table below presents a selection of materials and colors along with their solar absorption properties, offering insights into their effectiveness in controlling heat gain within built environments.

Table (4)

Absorption coefficient of the surfaces of different materials for sunlight [(4)]

The surface of the material and its type	*Absorption coefficient*
Aluminum paint	0.18
Cement filling	0.29
Light yellow oil paint	0.45
Limestone	0.53
Concrete	0.65
Red Oil Paint	0.74
Asphalt slurry	0.91

Sustainable Water Management in Climate-Responsive Architecture

In climate-responsive architectural design, careful consideration is given to sustainable resource management, including rainwater harvesting, water recycling, and the utilization of renewable energy sources such as solar and wind power. Additionally, the potential for cultivating fruit-bearing trees, vegetables, and legumes is explored to enhance food security for building occupants, ensuring access to scarce food resources for extended periods.

Waste management is another critical aspect of sustainable design. Recycling household waste and producing methane gas for domestic use—where feasible—can significantly enhance energy efficiency. As demonstrated in Figure 7, a dedicated tank can be installed in the garden to process black water for irrigation purposes instead of methane gas production.

Image (7)

A Tank for Collecting and Fermenting Household Waste for Methane Gas Production [5]

When incorporating green spaces into architectural designs, priority should be given to plants that are native to the local environment and adapted to minimal irrigation requirements. Many fruit-bearing and ornamental plants thrive on natural rainfall alone, reducing the need for supplementary watering. Examples of such drought-resistant species include cactus, lavender, and rosemary (as depicted in Image 8). These species contribute to the sustainability of urban landscapes while conserving water resources.

Image (8)

Local, endemic plants that tolerate drought, such as lavender and rosemary [5]

Greywater refers to wastewater generated from sinks, washing machines, showers, and kitchen activities. Avoid watering vegetables, it can be repurposed for irrigation of trees, such as lilies and olive trees. These species possess natural filtration mechanisms that prevent heavy metals and harmful chemicals from entering the food chain.

As illustrated in Figure 15, greywater constitutes a significant portion of household water consumption in the UK. Shower water accounts for 35%, while laundry water contributes 20%. By excluding wastewater from toilets, kitchens, and household cleaning, greywater collection can cover up to 55% of domestic water consumption. This recycled water can be effectively utilized for flushing toilets—which alone consumes 30% of household water—and can potentially provide surplus water for agricultural irrigation and external cleaning.

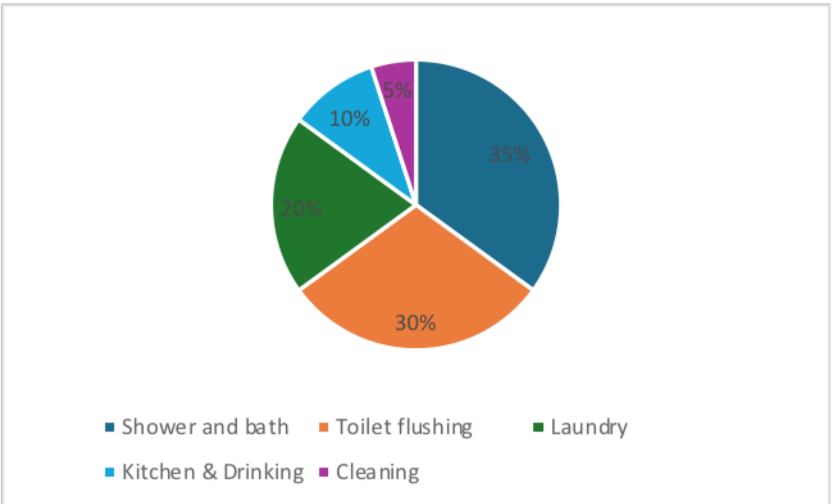


Figure (15)

Water Usage Distribution in UK Homes (6)

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Chapter Nine

Building Shading

Chapter (9)

Building Shading

Shading in architectural design can be achieved through natural and artificial methods, both of which serve the purpose of regulating sunlight penetration within buildings. Sunlight is allowed to enter internal courtyards during winter to provide warmth, while in the hot summer months, shading techniques are employed to prevent excessive heat gain and ensure thermal comfort for occupants.

Natural shading can be accomplished through careful building orientation, ensuring optimal exposure to sunlight based on seasonal requirements. Additionally, shading can be achieved by leveraging existing environmental features, such as the shadows cast by adjacent tall buildings, forests, or mountainous terrains. These natural elements serve as passive cooling mechanisms, reducing the need for artificial shading solutions. On the other hand, artificial shading is implemented through architectural and landscaping strategies designed to mitigate heat exposure. Common methods include the use of umbrellas, pergolas, climbing plants, and strategically planted trees. In some cases, shading is achieved through permanent building elements, such as staircases, roof structures, and water tanks, which can provide additional thermal protection.

As illustrated in Figure 16, structural components like roof frameworks, staircases, and water tanks create shaded zones on the roof. This shading effect helps reduce the external temperature of the roof during the summer months, thereby minimizing the impact of heat waves that penetrate the building envelope. By limiting heat absorption through walls and ceilings, artificial shading enhances indoor thermal comfort, ensuring a more habitable environment for the building's occupants.

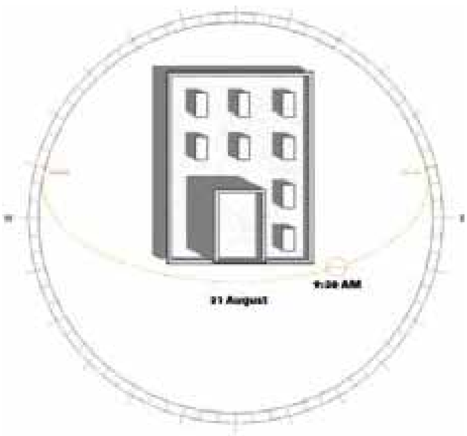

Figure (16)

Shades on roofs at 9:30 a.m.

- On August 21 in relatively hot areas such as Amman, Jordan (1)
- The Role of Shading in Climate-Responsive Architecture

Shading plays a crucial role in moderating external temperatures during hot summer months, making it an essential component of climate-responsive architectural design, particularly in regions with high-temperature climates. The Roof plan illustrated in Figure 16 demonstrates how various architectural elements contribute to shading by casting shadows on the roof. These elements include staircase structures, roof frameworks, and water tanks, which are integral components of the building itself.

When appropriately oriented, these shaded areas significantly reduce the roof temperature during hot summers. By minimizing heat absorption through the roof, shading helps regulate ambient temperatures, creating a cooling effect that enhances thermal comfort inside the building. This, in turn, reduces heat transfer into internal courtyards, preventing excessive temperature increases and ensuring a more comfortable indoor environment for occupants.

Methods of Shading External Openings

Shading external openings can be achieved through permanent or adjustable systems.

Permanent shading solutions include concrete overhangs, fixed stone, wood, or metal canopies, and structural elements designed to provide continuous shading.

Adjustable shading solutions offer flexibility in controlling sunlight exposure. These include movable umbrellas, retractable awnings, and deciduous trees—which provide shade during summer while shedding their leaves in winter to allow for solar gain.

Image (9)

Vertical shading of the eastern façade [2]

When installing awnings on the eastern or western façades of a building, they should not be positioned vertically, as illustrated in Image 9. Instead, to effectively provide shade, their placement must be carefully adjusted. Conversely, when shading windows located on the sides of a building, awnings or curtains should be positioned horizontally, as depicted in Image 10—a principle previously discussed in Chapter 7: " Orientation of Houses."

Shading strategies, whether natural or artificial, are implemented to regulate the entry of sunlight into a building. In winter, controlled solar access is essential to allow sunlight penetration into internal courtyards, providing necessary warmth. In contrast, during the hot summer months, shading solutions are crucial to blocking excessive solar radiation, thereby preventing heat buildup and ensuring thermal comfort for occupants. By integrating effective shading techniques, architectural design can enhance energy efficiency and improve the overall livability of indoor spaces.

Image (10)

Horizontal shading of the southern facade - to the left - [3]

Effective shading strategies ensure that direct sunlight is blocked from internal courtyards while maintaining a reasonable level of natural illumination within indoor spaces. To facilitate solar penetration through windows during winter, it is essential to carefully plan vegetation placement around the building. Tall trees should be planted at a distance to prevent excessive shading, while smaller shrubs can be positioned closer to the structure to allow for filtered light entry.

For enhancing air circulation, particularly in kitchen areas, trees should be strategically arranged to create open passages that allow wind to flow through while naturally cooling and humidifying the surrounding environment. This method is particularly beneficial in hot and arid climates, as illustrated in Figure 12, which is referenced in Chapter 7: “Orientation of Houses.”

In regions with hot climates, additional architectural elements can be incorporated to reduce heat absorption on the building’s roof. One effective strategy is the installation of rooftop shading structures, such as tents or pergolas, which not only minimize heat gain but also create comfortable outdoor sitting areas during hot weather.

Furthermore, green roofs—where vegetation is planted—serve as natural insulation layers, helping to cool the building by reducing solar radiation absorption. Additionally, external pathways can be designed to optimize shading, improving overall thermal comfort. As depicted in Image 11, grape arbors or trellises can be installed along the rear sections of the roof, forming shaded zones that contribute to a more pleasant and energy-efficient environment.

Image (11)

Shading the facades and external courtyards with grape plants [4]

A study conducted in Malaysia revealed that shading external openings significantly enhances thermal comfort within residential buildings. The findings indicated that, in the absence of internal ventilation, shading external openings increased the number of hours during which occupants experience thermal comfort by 26%[5]. Furthermore, when ventilation was introduced—such as by opening a window—the number of thermally comfortable hours increased by an additional 4.7%[5].

These results underscore the critical importance of effective shading strategies in hot climates. Properly designed shading systems not only mitigate heat gain but also enhance the overall indoor living environment, reinforcing the necessity of implementing climate-responsive design solutions in architecture.

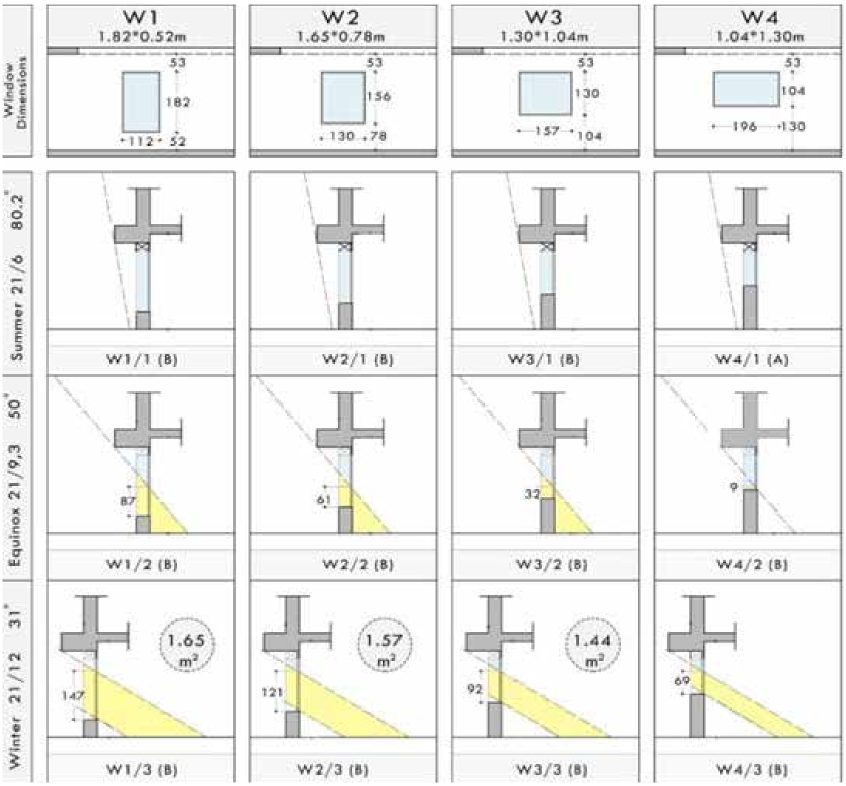

Figure (17)

Various forms of window shading and their effect on thermal comfort inside buildings [6]

Figure 17 illustrates four window models of identical surface area but with different shapes, demonstrating their varying effectiveness in controlling sunlight penetration. In the first scenario (W1), the canopy successfully blocks direct sunlight from entering through the window during summer. However, as winter approaches, the impact of window height and shape on solar gain becomes evident. The taller and smaller window in the fourth case allows sunlight to reach a larger floor area of 1.65 square meters, making it the most effective in maximizing solar heat gain during the colder months.

These findings indicate that W1 is the least effective when the goal is to maximize solar exposure for winter heating, making it unsuitable for colder climates, such as the high-altitude regions of the Levant. Conversely, in warmer climates, such as the Arabian Gulf, selecting W3 or W4 would be more appropriate, as they provide better shading and help reduce excessive heat gain, thereby enhancing thermal comfort in hot environments.

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Chapter Ten

Choosing Windows

Chapter 10

Choosing Windows

To achieve a healthy and environmentally sustainable lifestyle, careful attention must be given to the quality of materials used in construction. This includes not only the shapes and dimensions of external openings—as discussed in Figure 17—but also the environmental impact of window materials. A crucial question arises: which materials are the most sustainable in terms of energy consumption, water usage, and pollution generated during extraction and manufacturing? Additionally, it is essential to evaluate the total environmental footprint of each material, considering its entire lifecycle, from its origins as raw material to its final stage of recycling.

Evaluating Window Materials and Thermal Efficiency

The first consideration in sustainable construction is the material composition of the window and its environmental impact. The second is an analysis of glass types and their thermal performance, enabling a well-informed decision on optimal material selection. Figure 18 provides a comparative analysis of greenhouse gas emissions (CO2e equivalent) generated by different window materials.

The data reveals that the energy consumption required for wood production is significantly lower than that for glass, steel, and aluminum manufacturing. Furthermore, recycled wood produces only 25% of the carbon emissions compared to newly harvested wood, making it a more environmentally friendly option.

Conversely, aluminum production has the highest environmental impact, followed by copper, rubber, steel, paper, glass, and finally, wood. The findings emphasize the necessity of choosing materials wisely to reduce carbon emissions and enhance energy efficiency in architectural design. Sustainable choices in window materials and external openings contribute significantly to mitigating climate change and promoting environmentally responsible construction practices.

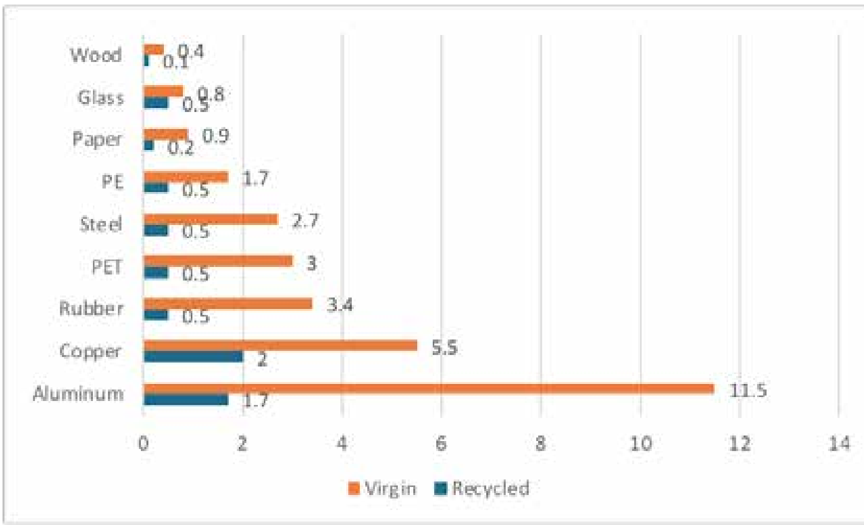

Figure (18)

Carbon Emission Intensity in the Production of Materials from Raw and Recycled Sources [1]

Figure 18 highlights the significance of using recycled materials in window manufacturing. For instance, recycled aluminum generates less than 15% of the greenhouse gas emissions compared to newly manufactured aluminum, reducing its carbon footprint from 11.5 kg to 1.7 kg of CO_2 equivalent per kilogram of material. This underscores the environmental benefits of selecting recycled materials in sustainable building design.

Comparison of Window Frame Materials

The primary materials available for window frames include wood, metal, vinyl (PVC), fiberglass, and composite materials. Their environmental impact varies significantly:

Recycled Wood – This is the most environmentally sustainable option, particularly when sourced from certified forests managed under sustainable forestry practices, where trees are replanted at the rate of harvesting.

Fiberglass – Ranked second in environmental performance due to its ease of recyclability and high thermal insulation properties at the end of its operational life.

Composite Materials – A combination of different materials offers a balance between sustainability and performance, placing it in third place.

Vinyl (PVC) – Less environmentally favorable due to its harmful chemical composition and negative long-term effects on sustainability.

Metals (Aluminum and Steel) – These materials have the highest environmental impact, as their manufacturing process releases significant amounts of greenhouse gases and contributes substantially to global carbon emissions.

When considering thermal performance, two layers of glass provide double the thermal resistance compared to a single layer. However, if a layer of silver oxide is applied to the surface of one of the panes in a double-glazed window (known as low-emissivity glass), its efficiency becomes significantly lower compared to single-pane glass. If an inert gas is introduced between the layers of glass, the efficiency improves to four times that of a single layer.

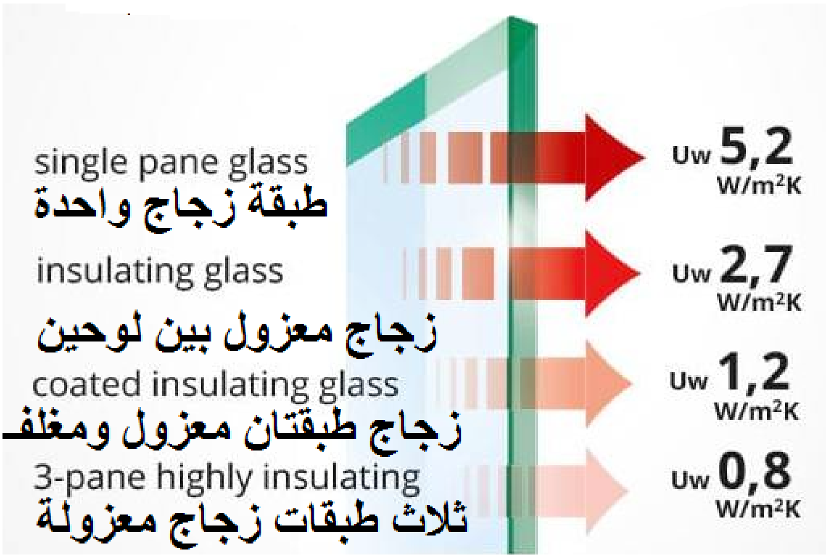

Figure (19)

Improvement of thermal efficiency of windows (2)

Thermal Efficiency through Window Glazing and Shading Systems

Figure 19 presents a comparative analysis of thermal transmittance values (U-values) for different window configurations, illustrating their impact on energy efficiency. The findings indicate that a single-glazed window has a thermal transmittance (U-value) of 5.2 $W/m^2{\cdot}K$. By adding a second layer of glass, heat transfer is reduced to 2.7 $W/m^2{\cdot}K$, significantly improving insulation. Further enhancement is achieved by incorporating a third layer of glass, which decreases the U-value to 0.8 $W/m^2{\cdot}K$, offering superior thermal resistance.

In addition to multiple glazing layers, the application of low-emissivity (Low-E) coatings further optimizes thermal performance. When a Low-E layer is added to a double-glazed window, the U-value is reduced from 2.7 $W/m^2{\cdot}K$ to 1.2 $W/m^2{\cdot}K$, representing a substantial improvement in energy efficiency. This demonstrates the effectiveness of Low-E coatings in minimizing heat transfer while maintaining optimal indoor thermal conditions.

The Role of Shutters in Thermal Insulation

Beyond glazing enhancements, shutters—whether installed internally or externally—serve as an effective shading and insulation solution. However, the positioning of the shutter box plays a crucial role in preventing thermal inefficiencies.

For optimal performance, shutter boxes should be placed externally, as illustrated in Figure 20. This placement reduces thermal bridging and minimizes air leakage into the internal courtyard, thereby improving indoor comfort. During winter, properly sealed shutters help prevent cold air infiltration, reducing heat loss and improving energy efficiency.

In hot climates, well-installed shutters act as a barrier against hot air and dust infiltration, maintaining cooler and cleaner indoor environments. Their strategic use enhances thermal regulation, reducing the reliance on mechanical heating and cooling systems, and ultimately contributing to a more sustainable and energy-efficient architectural design.

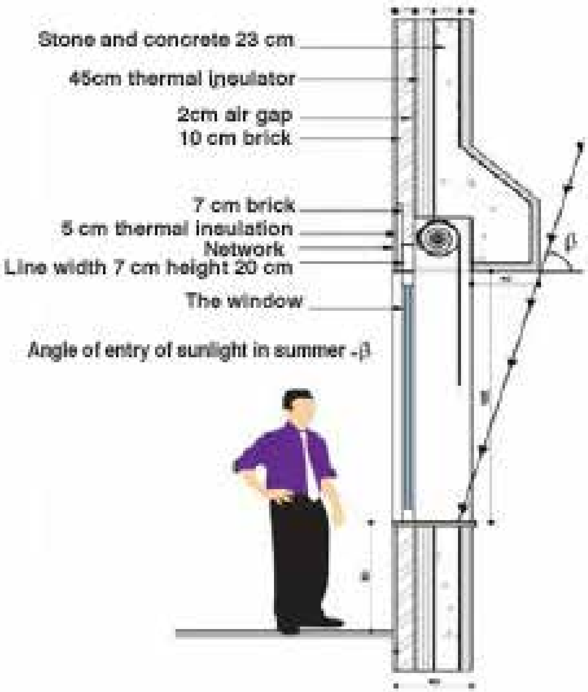

Figure (20)

Cross-Section of an External Wall Indicating the Placement of the shutter box to outside [3]

The shape of the window is not rectangular, as illustrated in Figure 21. Window W1 achieves the largest area of sunlight falling on the floor of the room and also allows for the greatest volume of air to be warmed by the sun's rays. It's important to note that the areas of the three windows are approximately the same. Additionally, the canopy effectively blocks sunlight during hot summer days. To ensure maximum efficiency in allowing sunlight into the room, attention should be given to the height of the canopy in relation to the window lintel.

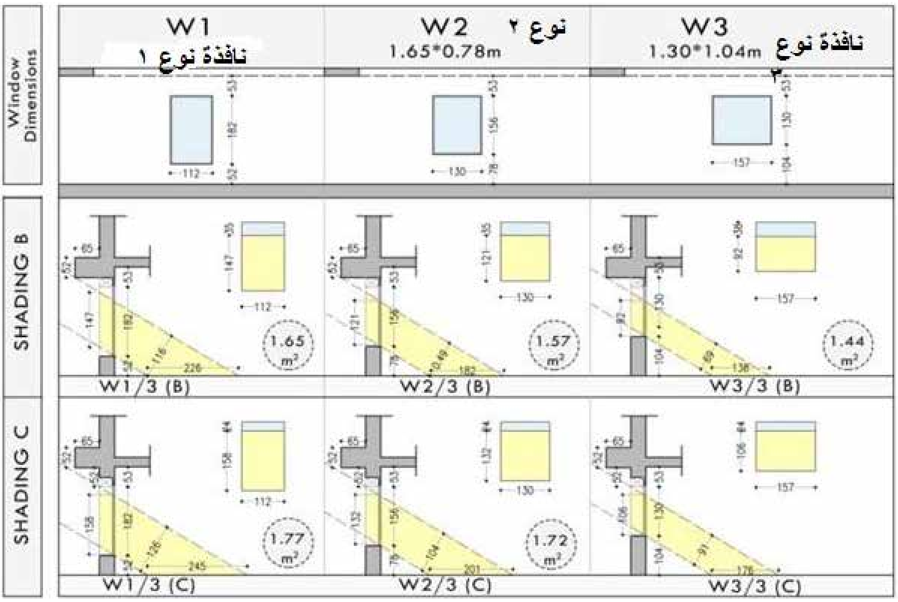

Figure (21)

Case Study of Various Window Shapes with a Uniform Area [4]

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Chapter Eleventh

Choosing the Right Colors

Chapter (11)

Choosing the Right Colors

The selection of appropriate colors for a building is influenced by several key factors. Foremost among these is the harmonization of colors within the architectural composition, ensuring a cohesive aesthetic. Additionally, the chosen colors should complement the surrounding environment, taking into account cultural preferences, geographic location, and climatic conditions. The influence of time, place, and environmental context further shapes the decision-making process, highlighting the need for thoughtful and context-sensitive color selection.

Beyond aesthetic considerations, the quality of paint plays a crucial role in sustainable building design. It is essential to prioritize environmentally friendly paints that do not contain harmful substances, such as volatile organic compounds (VOCs), which contribute to air pollution and pose risks to human health.

The Role of Color in Heat Absorption and Reflection

The thermal properties of paint—specifically its ability to absorb, emit, or reflect heat—are significant factors in regulating a building's temperature and energy efficiency. Each type of paint has a distinct solar reflectance and absorption capacity, which directly impacts heat retention on building surfaces.

Paints with a high solar reflectance reduce heat absorption, keeping surfaces cooler and enhancing thermal comfort within the building.

Conversely, materials with a high solar absorption coefficient retain more heat, leading to higher surface temperatures and increased heat transfer into the building interior.

Strategic color selection, therefore, not only enhances the visual appeal of a building but also contributes to its energy efficiency and environmental sustainability by influencing heat gain and loss.

Table (5)

Emittance and Absorption of Various Construction Materials to Sunlight (1)

Substance	*Emissivity of material at 35C*	*Absorption coefficient of the material for sunlight*
Matte black color	0.98	0.94
Glass	0.92	0.83
Concrete and plaster	0.91	0.65
Aluminum coating	0.5 – 0.3	0.18
Silver	0.01	0.18

Table 5 demonstrates that the most suitable roofing materials are not necessarily those with the highest heat absorption but rather those with the lowest weight and optimal thermal properties. Materials that absorb most of the incident thermal radiation tend to emit a significant portion of this energy back into the external environment (with an emissivity of 0.98). This raises the question: Is selecting Low heat-absorptive materials a wise choice?

One example is white Paint, which, despite having a low solar absorption coefficient of 0.12, possesses a high thermal transmittance of 0.90 (90%). This results in excessive heat loss during winter, as the material emits more heat to the exterior, reducing indoor thermal retention. Therefore, white Paint is not an ideal roofing choice, especially for regions requiring effective heat conservation.

Even less effective is shiny aluminum, which performs poorly due to its aluminum coating having a thermal transmittance of only 0.3 – 0.5 and a solar transmittance coefficient of merely 0.18. In contrast, silver is an optimal choice due to its nearly negligible heat emission (0.01) and low solar absorption coefficient (0.18). Meanwhile, glass, with a heat emissivity of 0.92, allows significant heat loss.

To mitigate heat loss in cold climates, a thin silicon oxide coating is applied to the interior glass surface to prevent heat dissipation to the outside during winter. Conversely, in hot climates, this coating is applied to the exterior glass surface to reduce heat penetration into indoor spaces.

This principle was previously discussed in relation to glass thermal efficiency, where adding a low-emissivity (Low-E) layer improved the U-value from 2.7 $W/m^2 \cdot K$ to 1.2 $W/m^2 \cdot K$, significantly enhancing thermal insulation. Additionally, this silicon oxide layer serves a secondary function by blocking ultraviolet (UV) radiation, thereby preventing interior fading and protecting furniture, curtains, artwork, and electronic appliances from UV-related degradation.

Types of Glass and Their Thermal Properties

- Various types of glass are manufactured for different architectural and energy efficiency purposes, each possessing distinct thermal and optical properties:
- Solar Transmittance – The ability of glass to allow solar radiation to penetrate.
- Solar Reflectance – The ability to reflect solar radiation, reducing heat gain.
- Solar Absorbance – The capacity of glass to absorb solar heat, influencing indoor temperature.
- Visible Light Transmittance – The extent to which visible light can pass through glass.
- Visible Light Reflectance – The proportion of visible light that is reflected away rather than transmitted.
- Shading Coefficient – A measurement of the glass's ability to provide shade, reducing glare and heat.
- Ultraviolet Rejection – The glass's capacity to block UV radiation, preventing damage to interior furnishings.

By carefully selecting appropriate glass types and roofing materials, architects can optimize thermal comfort, energy efficiency, and environmental sustainability, ensuring buildings perform effectively across different climatic conditions.

Table (6)

The various properties of glass types as stated in the manufacturer's catalogue [2]

Solar properties	**%**
Solar transmittance	86
Solar Reflectance	7
Solar Absorptance	89
Visible Light Transmittance	9
Winter Median U Value	1.14
Shading Coefficient	99
Ultraviolet Rejected	95
Total Solar Energy Rejected	14

Glass Technology in Sustainable Architecture

Table 6 presents the properties of a specific type of glass manufactured by LLumar®, demonstrating its optical and thermal performance. This glass allows 89% of visible light to pass through while blocking 14% of solar energy due to specialized surface coatings applied externally. The manufacturer has the ability to modify these physical and thermal properties to align with the specific requirements of buildings, geographical locations, and climatic conditions.

For instance, in colder climates, the glass can be engineered to increase the penetration of thermal solar radiation, maximizing indoor heat gain. Conversely, in warmer regions, the same glass can be optimized to block unwanted solar radiation, such as ultraviolet (UV) rays. As shown in Table 6, this particular glass type rejects 95% of UV radiation, significantly reducing fading and deterioration of furniture, artwork, and interior finishes.

The Integration of Glass in Renewable Energy Systems [2]

The advancements in glass technology have led to its integration with photovoltaic (solar) cells, enabling glass surfaces to generate electrical energy while simultaneously improving solar reflectance and shading efficiency. This innovation is particularly beneficial in hot climates, where it helps to reduce heat gain through external openings, thereby enhancing thermal comfort and energy efficiency.

Furthermore, glass-integrated photovoltaic cells have expanded beyond architectural applications and are now being implemented in road infrastructure to generate electricity. This vision suggests a future where road surfaces transform into clean energy-producing platforms, replacing traditional asphalt roads, which absorb significant amounts of solar radiation and contribute to the urban heat island effect.

By shifting to solar-integrated glass surfaces, cities can effectively lower ambient temperatures, mitigate heat islands, and simultaneously generate clean electricity. This technology has the potential to reduce fossil fuel dependency while providing power for electric vehicles, which are becoming increasingly prevalent worldwide. The implications of this transition are promising, paving the way for sustainable energy solutions in urban planning, as illustrated in Figure 12.

Image (12)

Photovoltaic cells on the roads [4]

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Chapter Twelfth

Choosing Housing Materials

Chapter (12)

Choosing Housing Materials

The primary selection of construction materials should prioritize those naturally occurring in the environment, aligning with the practices of early civilizations that constructed dwellings using clay, bricks, and natural stone. Additionally, an alternative approach involves utilizing anthropogenic materials, which, if not subjected to appropriate recycling processes, contribute to environmental pollution. Such materials include discarded vehicle tires, glass, plastic, and non-corrosive metals, among others.

In adhering to conventional construction methodologies, it is imperative to conduct a thorough analysis of the environmental ramifications associated with each building material. This necessitates a comparative evaluation based on the volume of greenhouse gases emitted throughout its entire life cycle. Extending from its initial extraction or production—its inception—through its functional lifespan and ultimately to its phase of reuse or recycling.

Image (13)

A depiction of ancestral dwellings as they stand in this village, characterized by its uniform and harmonious architectural style [1].

When evaluating the total energy required for a wooden window throughout its entire life cycle. From the initial extraction of raw materials to its eventual disposal or recycling. It experiences multiple distinct phases, including:

- The harvesting of timber from trees and subsequent transportation.
- The processing and treatment of the wood.
- The fabrication of the window frame.
- The preliminary manufacturing procedures, including painting and surface finishing.
- The assembly of the complete window unit, installation of the glass, and its transportation to the construction site.

- The installation of the frame within the building structure.
- Periodic maintenance throughout the window's functional lifespan.
- The thermal energy losses occurring through the window during its operational life.
- The eventual disposal of the window upon reaching the end of its service life.
- The energy expenditure associated with either recycling the window or disposing of it in a landfill.

Cumulatively, the total energy consumption for producing a wooden window is estimated to be approximately 995 megajoules. By contrast, a window utilizing a polyvinyl chloride (PVC) frame requires significantly more energy, amounting to approximately 2,980 megajoules. This value further escalates in the case of aluminum-framed windows, reaching approximately 6,000 megajoules. Consequently, aluminum windows impose the greatest environmental burden relative to other materials.

Despite the advantages of aluminum in terms of its recyclability, the recycling process itself is associated with the release of hazardous and toxic byproducts, including aluminum oxides, sulfides, phosphides, and other environmentally persistent compounds (2). Which, if not adequately managed, contribute to ecological contamination.

Table (7)

Comparison of Various Window Types Based on Thermal Conductivity, Environmental Impact, and Longevity [3]

Material	*Environmental Dimension (Energy consumption in Production (MJ))*	*Thermal conductivity*	*Life expectancy*
UPVC From derivatives of polyvinyl chloride	MJ 2980	0.8 – 1.5 W/m2k	25 – 35 years
Aluminum	6000 MJ	1 - 1.9 W/m2.k	56 – 65 years
Wood	995MJ	0.7 - 1.2 W/m2.k	68 – 80 years
Aluminum and Wood	1460 MJ	0.8 - 1.6 W/m2.k	71 – 80 years

Regarding maintenance requirements, wooden windows necessitate more frequent upkeep compared to other types of window materials. From an environmental perspective, wood offers the advantage of being both recyclable and replenishable through reforestation efforts, thereby mitigating resource depletion. Conversely, the production of alternative materials involves processes that introduce significant environmental concerns. For instance, the manufacturing of unplasticized polyvinyl chloride (UPVC) entails the release of chlorine gas, while aluminum production generates substantial and hazardous pollutants, including aluminum oxides, sulfides, and phosphides phosphides, as previously discussed. Although aluminum is relatively easy to recycle, its processing still poses ecological risks.

In terms of thermal insulation properties, wood exhibits the highest insulating capacity among window materials, followed by UPVC, with aluminum offering the least insulation. Nevertheless, incorporating double or triple glazing across all window types significantly enhances their overall thermal insulation efficiency, contributing to improved energy conservation and indoor climate control.

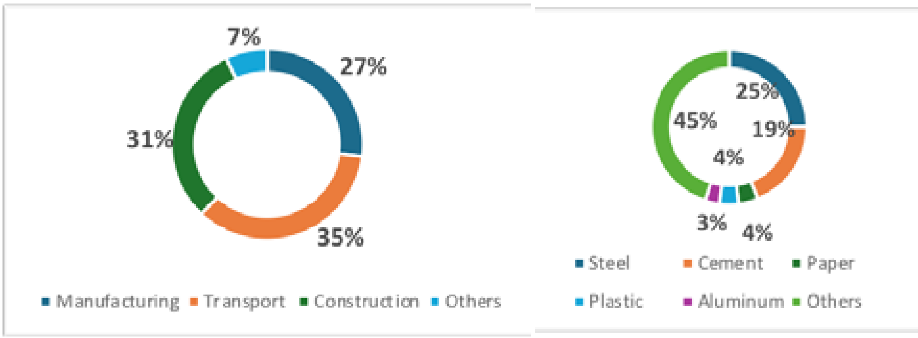

Figure (22)

Environmental pollution due to various construction materials (4)

As illustrated in Figure 22, the construction sector accounts for approximately 31% of the global energy sector’s total greenhouse gas emissions. This percentage surpasses the sector’s share of global manufacturing consumption, which does not exceed 27%. Additionally, Figure 22 highlights the contribution of greenhouse gas emissions from various industrial sectors, including the paper industry 45%, the steel industry (25%), the cement industry (19%), the plastics industry (4%), and the aluminum industry (3%).

The steel industry, being one of the highest environmentally polluting sectors, presents opportunities for reducing steel consumption in construction through the use of lightweight materials for permanent loads, as well as efficient structural designs that minimize steel waste. For instance, lightweight thermal insulation materials may be employed in place of cement mortar for ceilings, lightweight aggregates can be incorporated into concrete mixtures, and gypsum partitions can replace heavy plaster walls. Furthermore, high-tensile steel can be utilized to enhance structural efficiency while reducing material consumption.

Similarly, the demand for cement can be curtailed by employing lightweight concrete, which not only reduces material usage but also enhances thermal insulation properties for walls, ceilings, and floors. Reinforced concrete incorporating steel filaments or other fiber-reinforced composites may also serve as a viable alternative. In certain applications, cement usage can be entirely eliminated, such as in the construction of external walkways, where sand alone may suffice, as depicted in Image 14.

Image (14)

Paving external corridors using sand [5]

Thus, this environmentally conscious approach can be extended to all building materials, ensuring that construction practices align with sustainability principles. If these criteria are meticulously adhered to, this method represents an exemplary model of environmentally friendly construction.

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Chapter Thirteenth

Selecting Energy Sources

Chapter 13

Selecting Energy Sources

Life Cycle Analysis (LCA) is a widely recognized and effective method for assessing greenhouse gas (GHG) emissions associated with materials and activities in the construction industry. Encompassing all stages from production to disposal, commonly referred to as "cradle to grave."

For instance, when evaluating the greenhouse gas emissions generated by coal combustion over the life cycle of a coal mine, the assessment extends beyond the direct burning of coal in power plants. It also includes emissions resulting from the construction of coal mines, alterations to the land, coal extraction processes, and mining operations. Furthermore, it accounts for emissions associated with coal transportation, the construction, operation, and maintenance of power plants, as well as the energy consumption required for decommissioning outdated facilities, recycling their components, and rehabilitating the affected area. Additionally, the analysis considers emissions generated through the transmission and distribution of electricity produced by coal-fired power plants to consumers.

Coal mining, irrespective of the type of coal being extracted, releases significant quantities of methane—a potent greenhouse gas—trapped within the geological layers of the mine. This methane is released into the atmosphere upon the commencement of drilling operations, thereby contributing to the rise in global temperatures.

The combustion of coal produces various gases, including carbon dioxide, sulfur hexafluoride, and nitrogen oxides (NO_x), among others. These gases have a significant greenhouse effect, with some possessing a radiative forcing impact that is several times greater than that of carbon dioxide, as illustrated in Table 8.

Table (8)

The effectiveness of some gases in the greenhouse effect [1]

Greenhouse gases (GHG)	*Global warming potential*	*Lifetime in Atmosphere (years)*
CO_2	1 year (Base)	Thousands of years
CH_4	28-36	10
N_2O	265 - 298	100
HFCs	14,800	270
PFCs	7,390 – 12,200	50,000
NF_3	17,200	740
SF_6	23,500	3,200

Methane gas exhibits a heat-trapping capability that is 28 to 36 times greater than that of carbon dioxide, while nitrous oxide (N_2O) possesses a heat-trapping potential that is hundreds of times greater. Chlorofluorocarbons (CFCs) exhibit an even higher capacity, measured in the thousands, whereas sulfur hexafluoride (SF_6) demonstrates an extraordinary global warming potential, being 23,500 times more potent than carbon dioxide. Despite their substantial capacity for heat retention, the overall concentration of these gases in the atmosphere remains relatively low compared to that of carbon dioxide. Were these gases present in significantly greater quantities; the Earth's atmospheric temperature would experience an extreme and unsustainable increase.

Another critical factor that is often overlooked is the atmospheric lifespan of these greenhouse gas molecules. While carbon dioxide remains in the atmosphere for thousands of years before it naturally decomposes, methane persists for only approximately ten years. In contrast, sulfur hexafluoride has an atmospheric residence time of approximately 3,200 years, while perfluorocarbons (PFCs) remain for as long as 50,000 years, as illustrated in Table 8. Due to these varying atmospheric lifespans, greenhouse gas emissions are frequently converted into carbon dioxide equivalents (CO2e) to facilitate direct comparison of their environmental impact.

The use of coal or charcoal as an energy source has severe environmental consequences and should be discouraged as an unsustainable consumption pattern. Instead, coal-based energy production should be systematically compared to alternative energy sources. Additionally, the carbon dioxide emissions from electricity generation vary significantly based on the energy source, with fossil fuels emitting considerably more than renewables. The key emission levels for different energy sources are as follows [(2)]:

Lignite (low-grade coal): Up to 1,300 g CO_2/kWh

Oil: Approximately 900 g CO_2/kWh

Natural gas: 380–1,000 g CO_2/kWh

Solar energy: 13–190 g CO_2/kWh

Wind power: 3–41 g CO_2/kWh

Hydroelectric power: 2–20 g CO_2/kWh

Consequently, renewable energy—particularly hydroelectric power—is among the least polluting energy sources in terms of greenhouse gas emissions. However, it must be noted that global water resources are finite, and most hydroelectric potential has already been exploited, especially in developed countries. Thus, adopting an environmentally sustainable lifestyle necessitates a shift towards renewable energy sources wherever feasible. In certain regions, consumers have the option to select their preferred electricity source via smart meters installed in their homes. While some renewable energy sources may incur higher costs, ethical and environmental considerations often drive individuals to opt for cleaner energy alternatives despite the added expense.

Exacerbating this challenge is the fact that some nations justify their continued reliance on coal by arguing that, as smaller economies, their overall contribution to global emissions is negligible when compared to larger, industrialized countries. However, this perspective has been criticized as an unsustainable and morally indefensible position. During the 2019 Pacific Islands Forum, former New Zealand Prime Minister Jacinda Ardern addressed this issue, asserting that supporting such a stance is unethical, as it disregards the collective responsibility of smaller nations in combating climate change. She emphasized that every country, regardless of its size, has the capacity to make a meaningful contribution to mitigating environmental degradation, underscoring the importance of collective action [3].

Another critical socio-economic and environmental concern is the reliance on imported coal. The transportation of coal by rail, road, or sea not only results in additional greenhouse gas emissions but also heightens the risk of environmental disasters, including the dispersal of radioactive coal dust. Furthermore, the common assertion that nuclear energy is entirely free from carbon dioxide emissions is a widespread misconception. The figures often presented to support this claim significantly underestimate the actual environmental impact of nuclear power. Emissions from processes such as uranium mining, milling, enrichment, transportation, and waste disposal are frequently disregarded.

Research conducted by Mudd and Diesendorf estimated that, by the end of the twentieth century, the nuclear energy life cycle produced approximately 168 grams of carbon dioxide per kilowatt-hour of electricity generated, based on specific calculations of uranium concentrations in natural deposits. However, this figure is expected to rise dramatically over time due to the ongoing depletion of high-grade uranium ores, which necessitates the extraction and processing of lower-quality deposits[4].

These evaluations frequently fail to account for the adverse impacts of radioactivity on biodiversity, the depletion of freshwater resources, and the contamination of both groundwater and surface water.

Beyond its environmental implications, coal imports have significant economic consequences. The continued reliance on coal as an energy source deprives smaller nations of employment opportunities in the rapidly growing renewable energy sector. Conversely, countries that extract and export coal benefit from an increase in employment in coal mining and processing industries. Comparisons between job creation in renewable energy and fossil fuel industries indicate that renewable energy investments generate more employment opportunities. For instance, an investment of one million dollars in renewable energy has been shown to create approximately 8.4 full-time jobs, compared to 7.1 jobs for the same investment in fossil fuel industries [5].

Therefore, a sustainable and environmentally responsible future necessitates prioritizing clean, renewable energy sources. Not only are these alternatives less costly in the long term, but they also generate fewer greenhouse gas emissions and provide greater economic benefits by fostering employment growth in emerging green industries. This issue will be examined in further detail in Chapter 17, which explores the potential and implementation of renewable energy solutions.

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Chapter fourteenth

Recycling

Chapter (14)

Recycling

Recycling refers to the process of reusing materials and tools that have reached the end of their functional lifespan. This involves collecting, processing, and transforming waste materials into reusable forms. For instance, plastic utensils can be recycled through a systematic process that includes collection, shredding, and reshaping into granules, which can then be reprocessed into new plastic products. A similar approach is applied to the recycling of aluminum and other metals and minerals, whereby materials are shredded and repurposed for further use.

The efficiency of recycling can be enhanced through the systematic segregation of waste at various locations, including households, educational institutions, offices, and industrial facilities. This process involves categorizing waste into different containers to facilitate proper recycling and reuse. For example, biodegradable waste, such as food scraps, can be placed in designated containers for composting and conversion into organic fertilizers. Similarly, plastic waste should be separated into distinct containers, as should metal, paper, and cardboard, to ensure that each material is processed and repurposed independently. Such practices contribute to the effective management of waste and the conservation of natural resources.

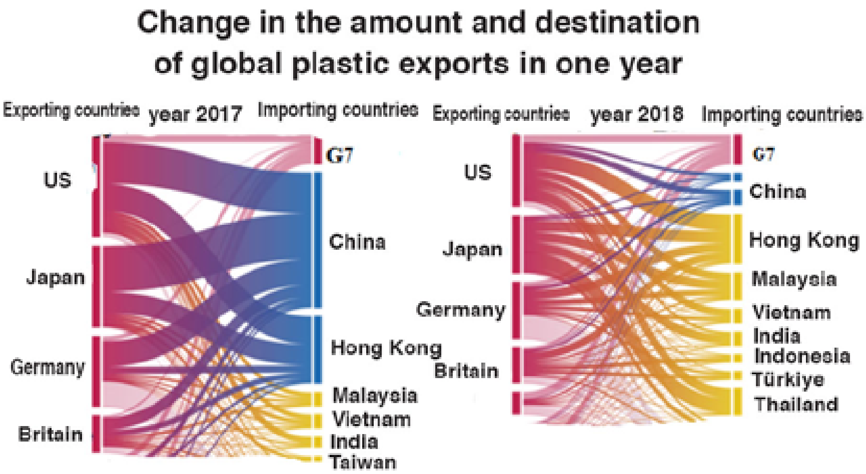

Figure (23)

How the global recycling process deteriorated in 2018 (1)

Figure 23 illustrates the decline in global waste recycling following China's announcement at the end of 2017 that it would reduce its waste imports, citing environmental concerns regarding the negative impacts of imported waste. As a result, the volume of waste imported by China significantly decreased, while waste accumulation increased in producing countries or was redirected to alternative destinations.

In 2017, the United States exported approximately 950,000 tons of waste; however, this figure declined to 667,000 tons in 2018. Notably, countries such as Malaysia, Vietnam, Taiwan, and Thailand, along with other Asian nations, began absorbing a greater proportion of global waste, while China's waste imports dropped dramatically from 1,258,000 tons in 2017 to merely 70,000 tons in 2018 (2).

The exchange, recycling, and reuse of waste currently face a global crisis, necessitating the development of a long-term strategy that leverages advanced technologies to optimize waste management. This includes transforming waste into energy or raw materials that can be reintegrated into industrial processes. Furthermore, it is crucial to differentiate between waste reduction, reuse, and recycling, as these concepts play distinct roles in sustainable waste management.

Recycling is not limited to solid waste but also extends to wastewater treatment and reuse. For instance, black water can be treated and repurposed for agricultural irrigation and, in some cases, even for potable use. Similarly, grey water, which includes wastewater from sinks and kitchens, can be collected and directly utilized for irrigation in gardens or undergo treatment for secondary uses e.g. flushing toilets. These practices align with sustainable water management principles, as previously discussed in the context of the limitations of positive climate design and as will be further examined in discussions on “water consumption.”

Additionally, construction waste can be repurposed as mulch for driveways, patios, and parking lots, contributing to resource efficiency in infrastructure projects. Wood chippings and byproducts from carpentry can be mixed into soil to enhance plant growth and soil moisture retention. Furthermore, empty glass containers can be repurposed for decorative applications; reshaped into traditional artisanal products, demonstrating the potential for creative and sustainable material reuse.

Image (15)

Empty plastic bottles and a cement mixer wheel used as bird nests [3]

As illustrated in Image 15, the structure appears to have been intentionally constructed using recycled plastic bottles. These bottles were repurposed to build a bird tower, with nests fashioned from a reclaimed concrete mixer wheel. The structure itself was constructed using a composite of clay and lime, sourced from materials available on-site, including remnants of old electricity poles. Collectively, this design contributed to the aesthetic appeal of the garden while also attracting a unique assemblage of bird species.

Similarly, the wall constructed from repurposed empty bottles, as depicted in Image 16, exhibits high thermal insulation efficiency. This is primarily due to the air pockets enclosed within the sealed glass containers, which act as insulating barriers. If the bottles were left open, their thermal insulation properties would be significantly reduced. Additionally, the use of bottles in the wall design allows for natural lighting while simultaneously minimizing the size of traditional windows. This design choice helps regulate indoor temperatures by reducing excessive heat absorption in summer and minimizing heat loss during winter, thereby improving overall thermal performance.

Image (16)

Walls built from empty bottles [4].

The implementation of this construction approach can be widely adopted in rural areas for the development of barns and enclosures for poultry and livestock. Its feasibility is particularly enhanced when the project site is located near sources of recycled construction materials, thereby minimizing transportation costs and environmental impact. A relevant example is Image no. 17, which has successfully repurposed discarded vehicle tires to construct structural reinforcements aimed at mitigating soil erosion. This demonstrates the potential of utilizing recycled materials in sustainable and functional architectural solutions.

Image (17)

A wall to prevent soil erosion from used tires [(5)].

The wall depicted in the image can serve multiple functional purposes, including the construction of windbreaks to reduce wind impact, barriers to mitigate desert encroachment, and protective retaining walls to prevent soil erosion. Additionally, it can be utilized for the development of enclosures and shelters for various applications. To maximize its structural integrity and thermal efficiency, it is essential to ensure that all gaps between the tires are fully sealed and that the most suitable infill material is selected. This approach enhances both the durability and insulation properties of the structure, optimizing its overall performance.

Image (18)

A rubber tire, glass containers and cement as a garden [6]

Materials derived from restricted activities and designated for recycling can be repurposed to enhance garden aesthetics. For instance, a discarded vehicle tire can be reinforced internally with a cement mixture and embedded with fragments of recycled glass containers to create a durable and visually appealing outdoor table, as illustrated in Image No. 18. This approach not only contributes to sustainable waste management but also promotes innovative and functional design solutions for outdoor spaces.

Image (19)

Walls of buildings made of used tires [7]

Used tires can also be repurposed to construct enclosed spaces suitable for various applications, such as greenhouse structures for agriculture or temporary worker accommodations at construction sites, as depicted in Image 19. Once the construction project is completed, these materials can be transported to a new site and reused multiple times without compromising their structural integrity or functionality.

One of the simplest forms of recycling involves directly repurposing materials for everyday use. For example, plastic containers can be utilized in home gardening or as bird feeders, as illustrated in Image 20. Additionally, some recycled materials can be adapted for indoor applications, such as creating decking or other functional elements within residential spaces. This approach not only promotes resource efficiency but also supports sustainable and cost-effective design solutions.

Image (20)

Reusing plastic containers to grow plants in the garden and make bird feeders [8]

The volume of materials consumed in daily life is substantial, and its environmental impact is considerable. According to World Bank statistics, global solid waste production exceeds two billion tons annually, yet only 7.7% is recycled (9). This low recycling rate contributes significantly to environmental pollution, highlighting the urgent need for improved waste management strategies and sustainable resource utilization.

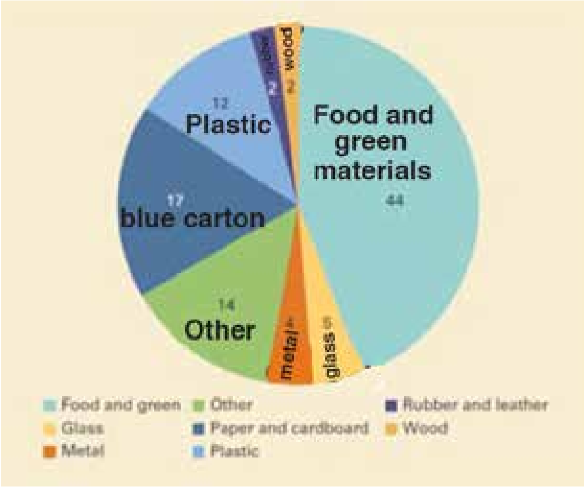

Figure (24)

Types and percentages of materials disposed of in the world [9]

Figure 24 illustrates the global distribution of waste by type, with the largest proportion consisting of food and green waste (44%), followed by paper and cardboard (17%), plastic materials (12%), glass (5%), metals (4%), and other miscellaneous materials.

The composition and volume of waste vary significantly between high-income and low-income countries, influenced by economic conditions, consumption patterns, and the availability of natural resources. In lower-income nations, the proportion of recyclable materials is significantly lower, comprising only approximately 20% of total waste (10). This disparity is primarily attributed to limited investment in waste management and recycling infrastructure, as financial resources are often prioritized for essential services, infrastructure development, and other pressing economic needs.

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Chapter Fifteenth

Building-Integrated Farming

Chapter (15)

Building-Integrated Farming

While the presence of grass surrounding buildings is often regarded as aesthetically pleasing due to its lush greenery and distinctive fragrance, it is essential to recognize the environmental and structural drawbacks associated with its cultivation. A comprehensive understanding of these challenges is crucial when considering the development of environmentally sustainable buildings and the implementation of eco-friendly practices.

The widespread assumption that green vegetation contributes to the sustainability of buildings—whether through the creation of green terraces or rooftop gardens—stems from the belief that these surfaces absorb less solar radiation compared to traditional dark-colored building materials. This reduction in heat absorption is thought to mitigate the urban heat island effect, thereby lessening the impact of global warming and regulating ambient temperatures. However, while grass can contribute to lowering surface temperatures to some extent, it is insufficient to classify a building as environmentally sustainable, particularly in regions suffering from water scarcity.

Grass is highly water-intensive, particularly in arid and semi-arid climates. On a hot, sunny day, it can transpire between 4 to 5 liters of water per square meter [1]. During extremely hot and dry conditions, evaporation rates increase, further depleting soil moisture and exacerbating water shortages. This raises significant concerns about the viability of grass as a sustainable landscaping choice in water-stressed environments.

The Unsuitability of Grass as a Green Practice

Given these considerations, planting grass should not be considered an environmentally responsible practice for the following reasons:

Excessive Water Consumption and Structural Damage Grass requires substantial amounts of water to maintain its greenery. In regions with limited water resources, this leads to inefficient water use. Additionally, over-irrigation can result in excessive moisture accumulation, causing cracks in building foundations, paved walkways, and external surfaces. Prolonged exposure to moisture can further lead to structural deterioration and the infiltration of dampness into buildings.

Impact on Soil Stability and Structural Integrity Lawns and grassy areas can alter the movement of rainwater and irrigation water, slowing runoff and increasing water infiltration into the soil beneath pathways and foundations. This is particularly problematic in regions with clayey soils, which are prone to expansion and contraction depending on moisture levels. As the soil swells or contracts, structural elements such as foundations and pavements become vulnerable to cracks and subsidence, compromising the stability of buildings over time.

Exploring Sustainable Alternatives

In summary, the cultivation of grass as a means of greening buildings in water-scarce regions is not only unsustainable but also contributes to structural degradation. Instead of emulating landscaping practices from high-rainfall regions of the Northern Hemisphere, it is crucial to explore alternative approaches that align with the local climate and water availability.

Are there native plant species that can provide the benefits of greenery while requiring minimal water consumption? Can sustainable landscaping techniques be employed to enhance building sustainability without excessive water use? Addressing these questions will pave the way for more environmentally responsible and regionally appropriate green building solutions.

Image (21)

A dry garden in Amman that is only naturally irrigated with rainwater during the winter [2].

Establishing Ecological Garden with Minimal Irrigation

It is possible to cultivate a green, ecologically sustainable garden with a diverse array of beautiful flowers and ornamental plants without relying on artificial irrigation. By utilizing rainwater as the primary water source and supplementing with minimal irrigation only during extremely dry periods, such gardens can thrive in arid and semi-arid environments, as demonstrated in image 21. A successful example of this approach was implemented in Darat Al-Kamaliyah, near Amman, where various drought-resistant saplings were planted alongside red-flowered geraniums, a resilient plant that blooms throughout most of the year. Additional plant species, such as lavender and rosemary, were also integrated into the landscape, enhancing biodiversity while maintaining sustainability.

Strategies for Enhancing Soil Moisture Retention, to optimize water conservation, small stones were used to cover the soil surface, helping to retain moisture and capture dew, particularly during temperature fluctuations between hot days and cool nights (Image 22). Additionally, wild plants that naturally emerge in gardens—such as Hammam (Malva parviflora) and Qabara (Capparis spinosa)—were incorporated into the landscape. These species thrive by extracting moisture directly from the soil and can survive throughout the hot summer months with minimal external irrigation, from the onset of spring to the completion of their natural life cycle.

Alternatives to conventional green spaces, rather than planting, water-intensive lawns, a more sustainable alternative is the introduction of scattered drought-tolerant plants. These species, including sedges (Carex spp.), lavender (Lavandula spp.), geranium (Pelargonium spp.), and fescue (Festuca spp.), require significantly less water—typically needing only a few liters every two to three hours, depending on the local climate conditions.

Essential Steps for Soil Preparation

To ensure the successful establishment of a low-water garden, the following steps should be undertaken:

- ***Deep Root Planting:*** seedlings should be planted at a depth of at least 40 centimeters below the surface to encourage strong root development and enhance drought resistance.

- ***Soil Conditioning:*** the soil should be enriched with compost to improve its structure, particularly in cases where it is compact or clay-rich, allowing for better aeration and water absorption.
- ***Rainwater Storage & Erosion Prevention:*** the land must be prepared to retain the maximum possible amount of rainwater while simultaneously preventing soil erosion.
- ***Soil Surface Coverage:*** the application of stones of varying sizes to the soil surface helps reduce evaporation rates, thereby conserving moisture and improving plant survival during hot summer nights (Image 22).
- ***By implementing these techniques,*** it is possible to create a vibrant, sustainable garden that enhances biodiversity while minimizing water consumption, making it an ideal solution for water-scarce regions

Image (22)

Covering the surface of the soil with small stones and pebbles [3]

Stones contribute to moisture retention by capturing dew during humid and cool summer nights, as condensation forms on their relatively cooler surfaces and gradually seeps into the soil. Additionally, small stones and gravel, as shown in the Image 22, help minimize water evaporation by shielding the soil from direct sunlight. This coverage also inhibits the growth of unwanted weeds, which would otherwise compete with cultivated plants for available moisture and nutrients. By limiting weed proliferation, more water is preserved for plant roots, promoting healthier growth. Furthermore, stones help regulate soil temperature by mitigating extreme fluctuations, creating a more stable environment for plant development and supporting sustainable water conservation in arid conditions.

Carbon Storage Capacity of Trees

Figure 25 illustrates the carbon storage capacity of various tree species based on their age, represented here by trunk diameter. For instance, a Sugar Maple tree with a 20 cm diameter sequesters approximately 0.3 tons of carbon annually. This capacity increases significantly as the tree matures, reaching tons at 40 cm in diameter and approximately 5 tons at 60 cm. These findings highlight the importance of selecting tree species with high carbon sequestration rates for planting in gardens and urban landscapes to promote environmental sustainability. The greater the tree's ability to store carbon, the more effective it is in mitigating atmospheric carbon levels and contributing to ecological balance.

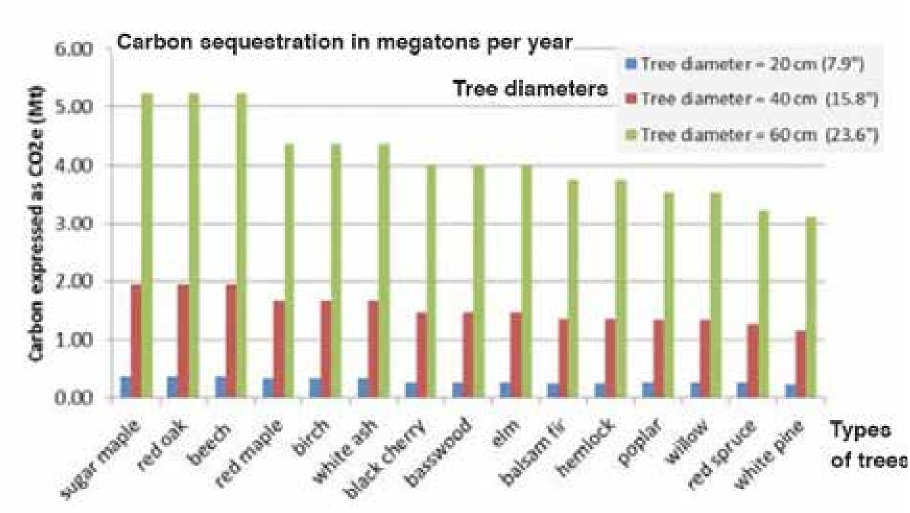

Figure (25)

Various types of trees and their ability to store carbon [4]

To contextualize the significance of tree-based carbon sequestration, it is useful to compare it with carbon emissions from vehicles. A single mature Sugar Maple tree stores an amount of carbon equivalent to the emissions produced by a vehicle consuming fuel at 21.4 miles per gallon, driving 11,318 miles per year—which amounts to approximately 4.75 tons of carbon annually. This comparison underscores the role of trees in offsetting vehicular emissions and highlights their potential in climate change mitigation strategies.

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Chapter Sixteenth

Thermal Insulation

Chapter (16)

Thermal Insulation

The function of a green building designed for a sustainable and healthy environment parallels the integrated functions of the human body. Just as the human body efficiently processes nutrients, absorbs essential elements, and expels waste that eventually enriches the soil, a green building should recycle and optimize its resource consumption. A truly sustainable building must be able to efficiently reuse energy and materials, minimizing waste and maximizing environmental benefits.

Climate has a profound impact on both humans and green buildings. Humans possess a unique adaptability to environmental changes, other species that struggle to survive in shifting climates. Numerous species, including the polar bear, Asian elephant, Siberian tiger, and mountain gorilla, are currently on the brink of extinction due to rising global temperatures.

Human adaptability, in contrast, stems from cognitive abilities, manual skills, imagination, strategic planning, and crisis management, all of which are unique among living organisms. Throughout history, humans have adjusted to climate fluctuations, developing protective clothing to insulate against extreme cold and modifying dietary patterns to maintain thermal balance. However, regardless of the thermal energy obtained from food, human survival in cold environments relies on external insulation such as fur, wool, and layered garments. Without adequate thermal insulation, heat loss can be fatal, leading to conditions such as hypothermia.

This principle of heat retention applies directly to green building design. In winter, thermal insulation in walls, roofs, and openings prevents the loss of heat energy, just as clothing retains body heat in cold climates. No matter how much external energy is supplied through conventional heating methods, buildings will remain inefficient and lose heat rapidly if they lack proper insulation. The solution lies in incorporating thermal insulation materials such as polystyrene, rock wool, glass wool, perlite(1), and polyurethane, or using locally sourced, natural insulating materials such as clay, reeds, straw, and palm fibers. When effective insulation is implemented, only a small amount of energy is required to maintain comfortable indoor temperatures throughout the year, reducing reliance on artificial heating and cooling systems.

These thermally insulated structures can be classified as “green buildings”, as they enhance thermal comfort, promote sustainability, and significantly reduce energy consumption. Effective insulation lowers harmful gas emissions, fosters a healthier living environment, and protects structural elements from damage caused by temperature-induced expansion and contraction. Among the most insulated structures are subterranean buildings, as exemplified by Roman architecture in North Africa and traditional Chinese dwellings in hot regions. Buildings integrated into mountainous landscapes, partially embedded in the ground, or covered with silt and vegetation also demonstrate superior insulation performance (see image 23). As architecture evolves towards sustainability, we transition from partially insulated buildings to completely self-sufficient, zero-carbon structures, marking the future of environmentally responsible construction.

Image (23)

A building that derives latent heat from the huge surrounding rocks (2)

The Impact of Building Shape on Energy Efficiency

Among above-ground building shapes, the most thermally efficient are circular structures, as they maximize enclosed volume while minimizing external surface area, thereby reducing heat transfer. This principle was previously observed in Inuit Huts, where design efficiency was achieved by optimizing form. However, architectural constraints often necessitate diverse building shapes. As a general rule, the closer a building's form is to a square, the less thermally efficient it becomes. Similarly, structures with numerous projections and curved surfaces have a larger external surface area, which increases heat loss in winter and heat gain in summer. Consequently, selecting an appropriate thermal insulation material for each specific building component is critical. Additionally, insulation must be protected from environmental factors, including water, sunlight, and vapor permeability, through the use of vapor barrier materials and safeguards against chemical and artificial damage.

While minimum thermal conductivity standards for walls, ceilings, and floors are established in most national building codes, exceeding these standards provides significant advantages in achieving sustainable architecture. This is particularly relevant in the context of the global energy crisis and increasingly stringent environmental regulations aimed at reducing atmospheric emissions that contribute to global warming, climate change, rising sea levels, soil salinity, and drinking water contamination. Despite the initial investment cost associated with higher-performance insulation, the long-term financial benefits are substantial, with energy savings making the investment profitable within a decade.

Beyond economic considerations, environmental pollution has emerged as a critical global issue that must be addressed at multiple levels. Internationally, frameworks such as the United Nations Framework Convention on

Climate Change (UNFCCC) have led to the implementation of agendas and projects aimed at mitigating climate change. At a cultural and ethical level, environmental stewardship is increasingly recognized as a moral obligation, emphasizing the necessity of reducing pollution to prevent excessive atmospheric warming, mitigate natural disasters, and preserve biodiversity. The continued disruption of energy and food chains due to climate instability poses a severe threat to the natural balance of life, reinforcing the urgency of sustainable building practices.

Thermal Stability and Comfort in Green and Heritage Buildings

The relationship between indoor temperature stability and human health is a crucial consideration in building design. Figure 26 illustrates that mortality rates increase as indoor temperatures drop during winter, highlighting the need for green buildings that maintain healthy living conditions. To ensure thermal comfort, indoor courtyard temperatures should remain above 18°C in cold regions and below 25°C in hot regions, creating a balanced and comfortable living environment.

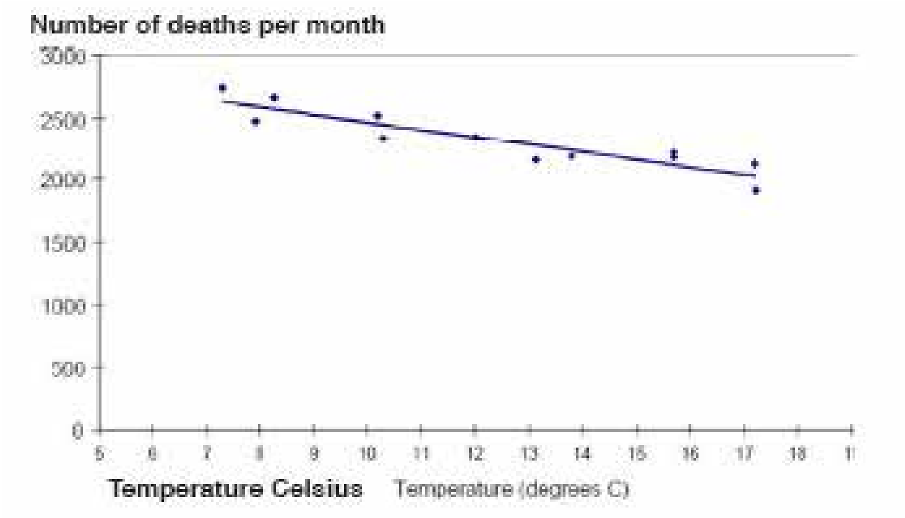

Figure (26)

A study showing the relationship between temperature, human health and the death rate versus the average temperature - New Zealand [3]

A key question arises: why do heritage buildings naturally achieve thermal comfort, while many modern buildings struggle to do so?

Green buildings, much similar to plants, maintain a stable temperature throughout the day and night. If we measure the temperature of a tree branch or a leaf, we find it remains relatively constant, despite fluctuations in atmospheric temperature. This is because a tree's root system, embedded deep in the soil, benefits from the stable geothermal conditions found underground. This natural principle can be applied to green buildings by utilizing thermally stable surfaces for passive heating and cooling, adapting to seasonal climatic conditions.

Heritage buildings share similar characteristics, with thick, thermally insulated walls that minimize heat loss in winter and reduce heat gain in summer. Additionally, these traditional structures often contained stored food materials, such as wheat, oil, lentils, and straw, which absorbed and retained heat during the winter months, moderating indoor temperatures and stabilizing the climate during summer.

These stored materials and structural elements function as a large thermal mass, effectively regulating indoor temperatures throughout the year. This thermal mass effect played a significant role in ensuring that ancestral homes remained comfortable living spaces in both hot summers and cold winters, reinforcing the im portance of sustainable architectural principles in modern construction.

Image (24)

Adobe mud and straw stores for storing grains, flour and other household food [(4)]

The same advantage applies during hot summers, where the moderate temperature in shaded areas helps maintain a comfortable indoor environment. All high-density materials present within the house contribute to thermal stability, enhancing the comfort of residents in green buildings. In contrast, modern buildings have largely eliminated high-density furnishings, replacing them with lightweight materials, such as hollow iron and coated wood, which do not retain heat effectively. Similarly, the outer framework of modern buildings is now constructed using lighter materials, further reducing the thermal mass necessary for effective temperature regulation, making these structures less efficient in maintaining indoor thermal comfort.

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Chapter Seventeenth

Renewable Energy

Chapter (17)

Renewable Energy

According to expert projections, global energy demand in 2030 is expected to increase by approximately 60% compared to 2002 levels. Various scenarios suggest that this growing demand will be met through the expansion and advancement of renewable and clean energy sources, including wind power, hydroelectric energy, solar energy, and geothermal energy. Concurrently, a reduction in the consumption of fossil fuels for energy production is anticipated, alongside a decline in nuclear energy generation—except in China. Moreover, investment in natural gas is expected to increase as a transitional energy source during this period.(1)

One of the primary challenges associated with renewable energy sources, particularly solar and wind power, is their intermittent nature. To address this issue, researchers have focused on developing energy storage solutions, particularly lithium-ion batteries. The cost of these batteries has been decreasing, and it is anticipated that they will soon dominate the energy storage sector, thereby mitigating the longstanding storage challenges associated with hydroelectric and wind power generation.

Hybrid energy systems that integrate solar and wind power have been employed for an extended period to mitigate power supply fluctuations caused by variable production conditions. Figure 27 illustrates the integration of wind and solar energy in Germany, which resulted in approximately 60% of the country's electricity needs being met on October 3, 2013, at approximately 12:00. More recent data indicate a substantial increase in the contribution of these energy sources to Germany's electricity production.

A similar trend has been observed in Denmark, which generated 140% of its electricity demand in 2015. The surplus electricity was subsequently exported to neighboring countries, including Germany, Norway, and Sweden.

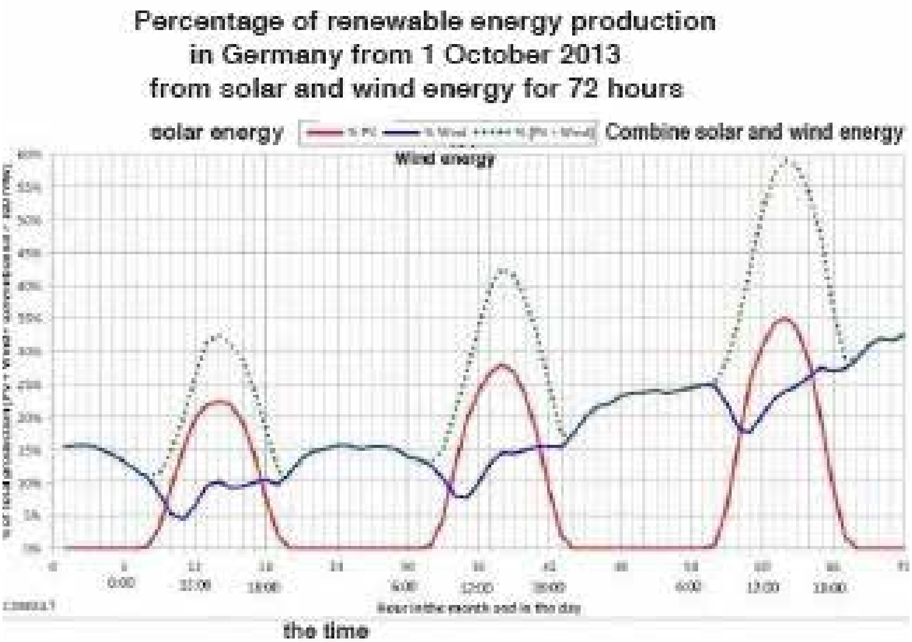

Figure (27)

refers to a hybrid system for generating electricity through the combined use of solar and wind energy. [2]

Historically, wind energy has been utilized in various applications, including the propulsion of sailing ships, the operation of waterwheels, grain milling, and parchment production. Technological advancements have led to the development of wind turbines capable of adjusting their orientation in response to changing wind directions while also incorporating mechanisms to temporarily halt operation to facilitate the passage of migratory birds. In regions that invest in advanced wind energy technologies and possess high, consistent wind speeds, wind power has become a cost-competitive alternative to conventional electricity generation from traditional energy sources.

Offshore wind farms, which benefit from stronger wind speeds and reduced natural barriers, represent a significant advancement in wind energy utilization. These farms are strategically located to minimize environmental impact while maximizing energy output. Future trends in wind energy development are expected to favor offshore installations to mitigate adverse effects on both natural ecosystems and aesthetic landscapes. Additionally, to address concerns related to visual (optical) pollution, and human-induced environmental disturbances, wind energy harvesting systems have evolved into structures resembling oscillating pillars that generate electricity through wind turbine-induced motion. The advancement of such technologies has made environmentally sustainable living increasingly accessible, provided there is adequate investment, interest, and technological innovation. Furthermore, the financial viability of these technologies is reinforced by their potential to yield substantial returns on investment.

Solar energy applications range from widely used solar water heaters to solar-powered cooking devices, land and marine transportation, and electricity generation for both urban and remote areas that lack access to conventional electrical grids. Additionally, solar energy is employed to power refrigeration systems, household electrical appliances, computers, calculators, and various other devices. Prominent applications of solar energy are its role in water heating, as seen in solar water heaters that supply residential and commercial buildings with hot water, facilitate home heating, and provide thermal energy for swimming pools, aquaculture facilities, farms, and industrial processes.

Advanced solar heating systems, such as hollow circular tube collectors, have been introduced globally, as illustrated in image 25, where they are installed on the rooftop of a building. These systems have become a significant contributor to water heating, making investment in them highly cost-effective. The financial returns on such investments can typically be recovered within two to several years, especially in light of rising oil prices since 2007 and during global crises, such as the ongoing war between Russia and Ukraine, which has led to a new energy crisis.

Moreover, solar energy is widely used in desalination processes, both for producing potable water and reclaiming saltwater for agricultural irrigation. Collectively, these applications contribute to the promotion of environmentally sustainable living.In industrial applications, however, the payback period for these systems can be remarkably short.

In some manufacturing facilities, the initial investment cost can be recovered within a single summer season, meaning that financial returns may be realized in as little as three to four months.

Image (25)

Evacuated circular solar water heaters [3]

The technology for converting solar energy into electricity has undergone significant advancements, particularly through the development of photovoltaic (PV) cells. Researchers have successfully reduced the cost of these cells to a level that has enabled them to compete with traditional fossil fuel-based energy sources for an extended period. Currently, photovoltaic technology stands as the most cost-effective method of electricity generation among all existing energy sources.

This technology is now widely accessible on a global scale, facilitating the supply of electricity to residential, commercial, and industrial sectors while addressing energy demands across various human activities, including the desalination of seawater. Moreover, several technologically advanced nations, including Japan, Germany, Spain, and China, have established themselves as global leaders in photovoltaic energy development, pioneering innovative applications and large-scale implementation to drive the expansion of renewable energy solutions.

Germany ranks as the global leader in electricity generation from photovoltaic (PV) cells relative to its population. A primary factor contributing to Germany's success in this domain is the government's policy of purchasing electricity from PV systems at preferential rates, thereby incentivizing investment and widespread adoption of solar technology.

Similarly, numerous developed nations have intensified their efforts to expand photovoltaic electricity production. China has emerged as a leading producer of clean energy, alongside Italy, Japan, and the United States. Notably, Japan surpassed Italy in photovoltaic electricity generation in 2014 following the Fukushima disaster, which prompted a strategic shift towards renewable energy sources to enhance energy security and sustainability.

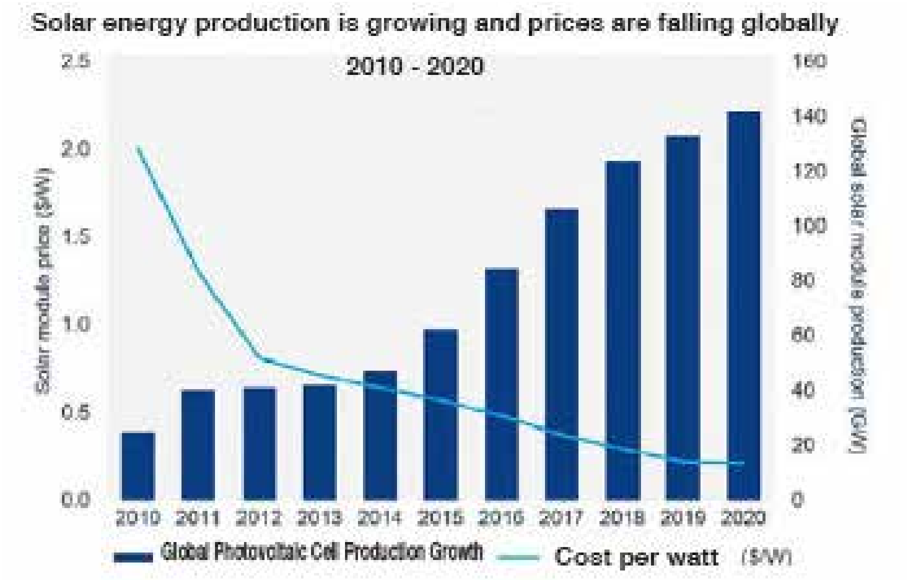

Figure (28)

Global Growth in Solar Energy Production and Decline in its Costs [4]

Figure 28 illustrates the global expansion of solar energy capacity, which surpassed 140 gigawatts in 2020, reflecting an annual growth rate of 8–10%. Additionally, solar electricity generation capacity in 2020 had more than doubled compared to production levels recorded in 2015.

The cost of electricity generated from photovoltaic (PV) cells has also experienced a significant decline, dropping from $2 per watt in 2010 to approximately $0.02 per watt in 2020. This substantial reduction in costs has made solar energy an increasingly attractive investment, to the extent that comparing it with conventional energy sources has become increasingly impractical. Moreover, the adoption of this clean energy source plays a crucial role in fostering environmental sustainability and promoting a healthier living environment.

In remote areas that lack access to electricity grids, energy storage solutions are utilized, including batteries and high-capacity thermal storage materials. Given the volatility of the global oil sector, it is essential to initiate pilot projects aimed at training a skilled workforce capable of managing future renewable energy initiatives. This is particularly relevant for the Arab world, where solar radiation intensity is estimated to be five times higher than that received in Europe, making solar energy an exceptionally viable alternative.

One method of integrating solar energy into national grids is two-way metering, which allows electricity generated during the day to be supplied to the grid and subsequently utilized at night. Additionally, alternative storage solutions include pumped-storage hydroelectric systems, which use excess daytime electricity to pump water to elevated reservoirs, enabling hydroelectric power generation during nighttime. The continuous advancement of lithium battery technology has further enhanced energy storage efficiency, with costs steadily declining.

Concentrated Solar Power Systems (CSP), while more expensive than photovoltaic cells, offer greater sustainability in electricity production. These systems utilize solar energy to heat a working fluid, such as water, to generate steam, which in turn drives electricity generation. An added advantage of concentrated solar power systems is their ability to store thermal energy, enabling electricity production even after sunset. It is important to differentiate between CSP systems, which convert sunlight into heat energy, and PV cells, which directly convert sunlight into electricity.

Although the cost of electricity generated by solar thermal systems remains higher than that of hydroelectric power, these technologies are not mutually exclusive. Instead, they can be integrated with other renewable energy sources, such as wind and photovoltaic systems, to ensure a continuous and stable electricity supply regardless of climatic variations. For instance, figure 27 page 202 has successfully combined wind energy and PV cells to achieve uninterrupted electricity generation. A similar approach was previously examined in the case of Germany, where hybrid renewable energy systems have demonstrated the ability to compensate for fluctuations in solar and wind availability, thereby ensuring a reliable and sustainable energy supply.

Image (26)

Combining wind energy and photovoltaic cells [5]

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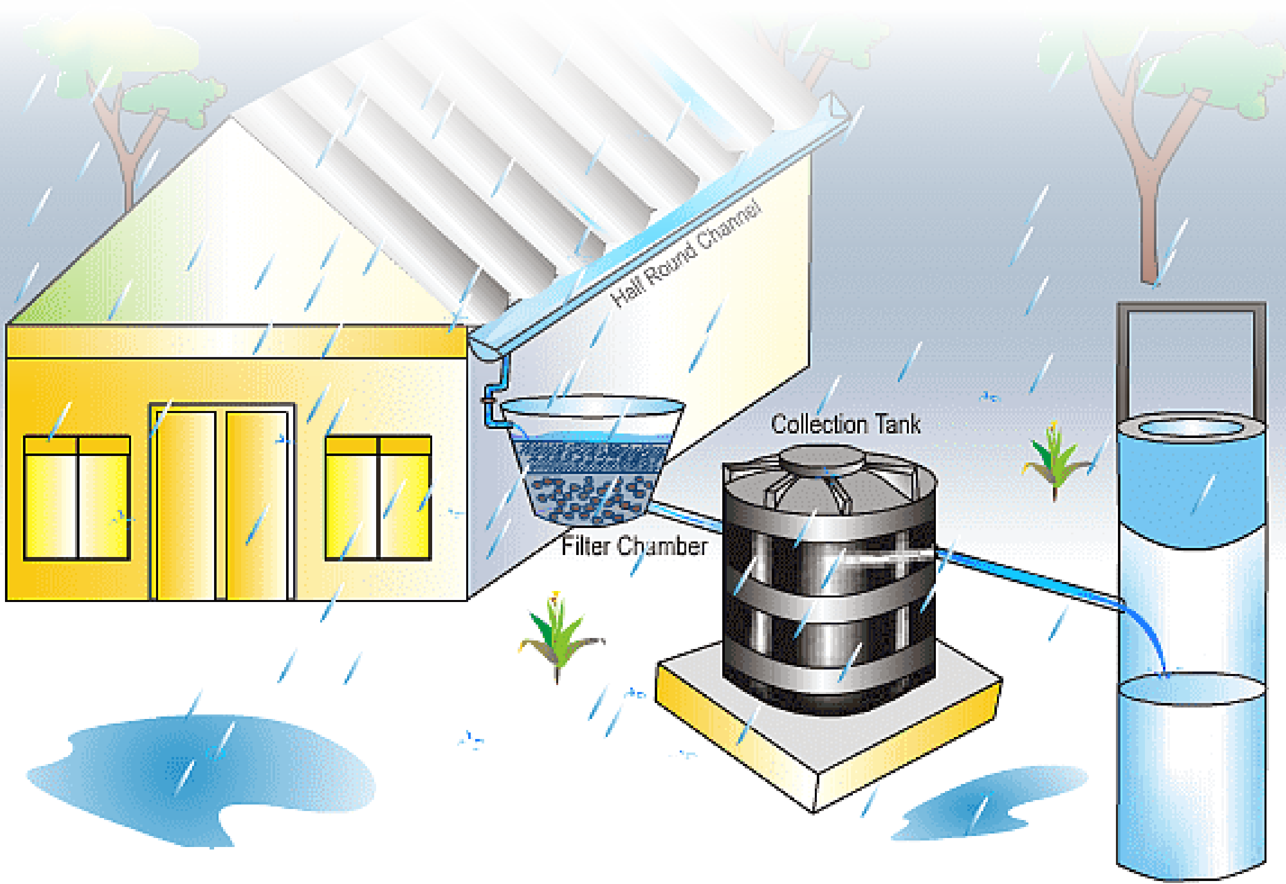
Chapter Eighteenth

Water Harvesting



Chapter (18)

Water Harvesting

It is well established that certain highland regions in the Levant, North Africa, Yemen, and other areas of the Arab world receive significant rainfall during the winter season. This precipitation presents an opportunity for effective water conservation through the collection and storage of rainwater in underground reservoirs or surface wells. Additionally, arid and desert regions frequently experience episodic flash floods, particularly in early spring, during which substantial volumes of rainwater can be captured in cisterns, reservoirs, or wells before being lost to surface runoff or evaporation in dry landscapes.

Engineering Considerations in Well Construction

The design and construction of rainwater collection wells necessitate specific engineering considerations to ensure both structural integrity and functionality. Proper ventilation systems must be incorporated, with at least two strategically placed openings—one at either end—to facilitate adequate air circulation. This ventilation is particularly crucial during maintenance and cleaning operations, as it prevents the accumulation of hazardous gases, such as carbon monoxide, which can lead to asphyxiation. Furthermore, ventilation mitigates water acidification, a process induced by the dissolution of carbon dioxide in stored water.

Ensuring secure well enclosures is essential to prevent accidental falls, particularly among children and vulnerable individuals. Additionally, overflow outlets should be integrated at slightly lower elevations than the well's roof to prevent excessive water accumulation, which could otherwise lead to structural degradation through the erosion of concrete surfaces and reinforcement materials.

The geometric design of wells also plays a critical role in long-term stability. It is advisable to deconstruct circular or square configurations to reduce thermal expansion and moisture absorption that may induce structural distortions over time. Moreover, the depth of a well should generally not exceed two meters, unless deemed necessary by a qualified engineer, to mitigate risks associated with high-pressure differentials, structural cracking, and water leakage into adjacent foundations or infrastructures. Exceptions to this guideline should be made based on rigorous engineering assessment and scientific supervision.

Integration of Greywater Management in Sustainable Buildings

Sustainable architecture and green building practices necessitate the incorporation of dedicated greywater collection systems. Greywater, which originates from bathing, washing, and other non-potable domestic activities, can be stored in specialized wells of limited capacity (a few cubic meters) and utilized for subsurface irrigation of non-edible crops. This controlled irrigation strategy ensures that human exposure to greywater contaminants is minimized, particularly in environments with children and at-risk populations.

Advantages of Rainwater Harvesting and Structural Protection

Rainwater harvesting yields numerous structural and environmental benefits, particularly in regions experiencing water scarcity. Significant advantages lie in the protection of buildings from moisture-induced deterioration. The accumulation of rainwater on structural surfaces can lead to water infiltration, which over time results in cracks, material degradation, and compromised foundation stability. By capturing and directing rainwater to designated storage systems, buildings can be safeguarded against hydrostatic pressure, moisture ingress, and structural weakening.

Additionally, rainwater harvesting reduces the burden on municipal sewage infrastructure. In urban environments, excess water storm runoff frequently enters public sewer systems, overwhelming treatment facilities and leading to the discharge of untreated wastewater into natural waterways. This phenomenon is particularly problematic during periods of heavy rainfall, when treatment facilities operate beyond their designed capacity, contributing to environmental pollution and public health risks.

The strategic distribution of multiple wells within a building complex optimizes water collection efficiency, particularly in structures with extensive roof drainage systems. Properly designed collection networks prevent excess moisture accumulation around the foundation, thereby mitigating risks associated with soil subsidence and expansion—an issue particularly relevant in regions with clay-rich soils prone to volumetric changes. This preventive measure ensures that buildings remain structurally sound during the winter season, reducing the likelihood of foundation cracks, floor displacement, plumbing failures, and electrical system malfunctions.

Risk Mitigation through Well Distribution

The allocation of multiple water storage wells also enhances resilience to potential leakage. If a single high-capacity well (e.g., 100 cubic meters) experiences structural failure, the entire water reserve is lost, potentially jeopardizing the integrity of nearby structures. Conversely, distributing storage across several smaller wells mitigates risk—should one well fail, only a fraction of the water supply is compromised, while the remaining wells continue to provide uninterrupted access to stored water. This approach is particularly beneficial during periods of prolonged drought, ensuring water availability throughout winter, spring, and early summer, when water demand peaks.

Hydrostatic Considerations and Structural Hazards

The accumulation of rainwater behind retaining walls and barriers presents significant engineering challenges. Retaining walls, unless specifically reinforced for hydrostatic loads, are susceptible to failure due to excessive water pressure. Inadequate drainage systems within retaining walls may result in structural collapse, which can occur through sliding, overturning, or fracture propagation. The risk is further exacerbated in aged or poorly maintained structures, where foundation erosion accelerates failure mechanisms. The potential consequences of such failures include severe damage to property and threats to human safety.

Excessive rainfall can also destabilize building foundations, leading to long-term structural vulnerabilities. Rainwater that accumulates on surface soil layers infiltrates soil pores and existing fractures, permeating foundation materials and weakening load-bearing capacities. This process poses significant structural risks, particularly in highly porous soils or foundations with pre-existing vulnerabilities. Moreover, prolonged moisture exposure contributes to the deterioration of construction materials, including the corrosion of reinforcement bars, weakening of substructures, and failure of essential utility installations such as electrical and plumbing networks.

Image (27)

Disintegration of concrete retaining walls due to water seepage through it [1]

image 27 illustrates the mechanism by which rainwater infiltrates the concrete of retaining walls, leading to the deterioration of concrete particles through the dissolution and transformation of calcium carbonate ($CaCO_3$) into calcium hydroxide [$Ca(OH)_2$]. This process, commonly referred to as concrete carbonation, results in the deposition of calcium carbonate on the exterior surface of the concrete, opposite to the water source.

Water infiltration is further exacerbated by capillary action, wherein moisture rises from the soil in contact with retaining walls or floor structures. This occurs due to the presence of surface water or residual moisture near the foundation, which subsequently migrates through capillary pores within the structural material. The effect of capillary porosity facilitates moisture movement within the concrete matrix, resulting in visible dampness at varying levels and in different patterns.

When rainwater ascends through walls and retaining screens under the influence of hydrostatic pressure or capillary attraction, it transports soluble salts from the surrounding environment. As the walls dry, these salts crystallize, leading to expansion and material degradation. The accumulation of these crystalline deposits contributes to concrete cracking, peeling of paint layers, and damage to other construction materials, as demonstrated in image 28.

Image (28)

Visible cracks in a building wall, a long with moisture rising from the soil [2]

Additionally, the moisture distribution in walls is characterized by a capillary rise pattern, wherein the uppermost water level forms a wave-like configuration, akin to ocean waves, as illustrated in image 28. This distinctive pattern is a direct consequence of capillary dynamics, influencing the structural integrity and aesthetic longevity of the affected surfaces.

Reference of Chapter 18

1. Author’s own photograph (2015) Photograph of a retaining wall in Quwaysma, Amman, Jordan.
2. Author’s own photograph (2015) Photograph of a fence in Madaba neighborhood, Jordan.

Chapter Nineteenth
Water Consumption

Chapter (19)

Water Consumption

The significance of water conservation arises primarily from the scarcity of water resources, particularly in arid regions, and more broadly, in various areas across the globe. Even some northern European countries have faced water usage restrictions since the 1970s. Consequently, the implementation of water conservation measures, including the reuse of water, has become imperative for those committed to environmental sustainability. This necessity is further reinforced by the relatively low cost of the additional infrastructure required for water reuse. Moreover, the reutilization of gray water offers significant environmental benefits, including the prevention of soil contamination and the mitigation of pollution in surface and groundwater systems. Additionally, it alleviates the burden on wastewater treatment facilities, thereby enhancing overall environmental management.

Several Arab nations rank among the most water-scarce countries globally, including Jordan, the United Arab Emirates, Saudi Arabia, Bahrain, Qatar, Kuwait, and Djibouti. The arid climate in these regions exacerbates the water crisis, particularly in the context of climate change and the intensification of droughts associated with global warming. Given these conditions, it has become essential for citizens in these countries to adopt exceptional water management practices to ensure environmentally sustainable living.

Despite the limited availability of freshwater resources, three Arab countries—Kuwait, Saudi Arabia, and Tunisia—are among the nations with the highest per capita water consumption. As illustrated in Figure 29, Kuwait's water consumption reached 111 gallons per person per day, surpassing that of the United Kingdom and China. Similarly, Saudi Arabia exceeded the water consumption levels of Spain and France, while Japan's consumption rate was equivalent to that of Germany.

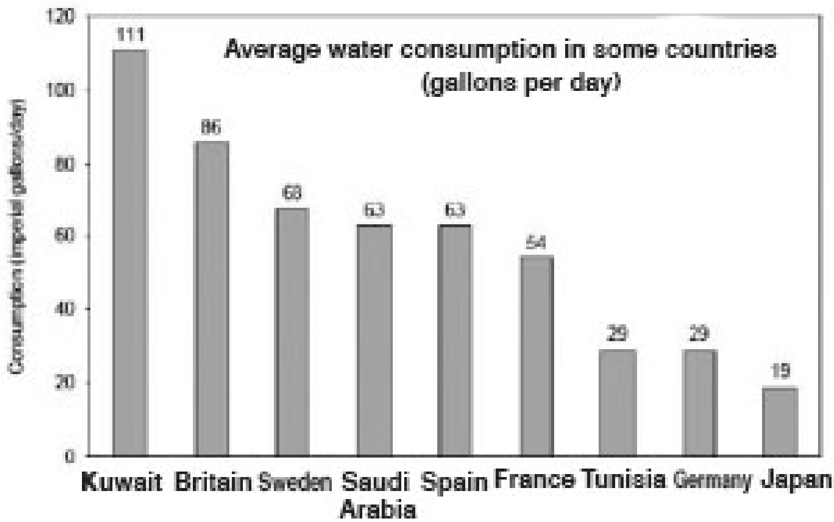


Figure (29)

Consumption of some countries from potable water (potable water consumption by some countries) [1]

Among the environmentally responsible practices that contribute to sustainable resource management is the reduction of water consumption through modifications in daily usage habits. These include activities such as bathing, washing, food preparation, dental hygiene, and general household cleaning. Individuals must develop an awareness of the volume of water consumed in each of these processes, particularly in the context of the water scarcity affecting their country, as well as on a global scale, especially in light of climate change and its impact on freshwater availability.

For instance, when utilizing sanitation facilities, individuals seeking to maintain an environmentally sustainable lifestyle should be cognizant of the water capacity of toilet tanks. Traditional toilet tanks often store approximately 12 liters (3 gallons) of water, whereas modern designs have significantly reduced this amount to nearly half, with some models utilizing high-pressure flushing mechanisms that further minimize water consumption. More importantly, attention should be given to the proper maintenance and functionality of toilet tanks to prevent continuous water leakage, which can contribute to excessive and unnecessary water depletion, thereby increasing the overall household demand for water resources.

Figure (30)

A typical distribution of water consumption in the United States for the year 1999 (2)

As illustrated in Figure 30, toilets account for the highest proportion of water consumption in buildings, representing 26.7% of total usage based on the general average for the United States in 1999. Given this substantial consumption, it is imperative to select toilet models that minimize water wastage.

Following toilet usage, the second-largest contributor to household water consumption is laundry, which accounts for 21.7% of total water use. This underscores the necessity of selecting washing machines that are designed for water and energy efficiency. Additionally, it is advisable to operate washing machines only when they are fully loaded to optimize resource usage. In the case of electric washing machines, even models with the highest energy efficiency ratings (such as those marked A+++) should be used with full loads, as both water and electricity consumption remain significant environmental concerns.

Showering constitutes the third-largest source of water consumption, accounting for 16.8%. This figure can be reduced through the adoption of water-efficient showerheads and the implementation of water-conserving behaviors. For example, individuals can minimize water wastage by turning off the shower while lathering shampoo or soap, rather than allowing water to run continuously. It is essential to use appropriate shower fixtures, including aerators that introduce air bubbles into the water flow to reduce consumption. Moreover, excessive use of shampoo or conditioner contributes to increased chemical contamination in wastewater, thereby complicating water treatment processes at wastewater treatment facilities.

Sink usage follows, accounting for 15.7% of household water consumption. Similar to showering, ethical and environmentally conscious practices should be observed to reduce unnecessary water use. Dental hygiene, for instance, is an area where water conservation can be implemented by avoiding prolonged running of the tap while waiting for warm water. Instead, individuals can begin brushing immediately and turn off the faucet while brushing to prevent unnecessary water loss. Continuous water flow from a sink faucet can result in a loss of at least one gallon of water per minute. Therefore, the installation of sensor-activated faucets, which dispense water only when a user's hand is detected, can contribute significantly to water conservation. This principle also applies to activities such as shaving and other grooming routines.

Finally, it is crucial to acknowledge that approximately 13.7% of household water consumption is lost due to leaks or failures in plumbing infrastructure. This underscores the necessity of regular maintenance and prompt repair of plumbing systems to prevent unnecessary water absorption and wastage. A comparative analysis of water consumption data from 1999 (Figure 30) and 2016 (Figure 31) reveals notable similarities. However, improvements have been observed in toilet water consumption (decreasing from 26.7% to 24%), as well as in water usage for laundry (declining from 21.7% to 17%). Additionally, losses due to leaks and plumbing failures decreased from 13.7% to 12%. Conversely, there was an increase in water consumption for sinks and showers, which suggests advancements in toilet tank efficiency, improvements in washing machine technology, and enhanced maintenance of sanitary infrastructure.

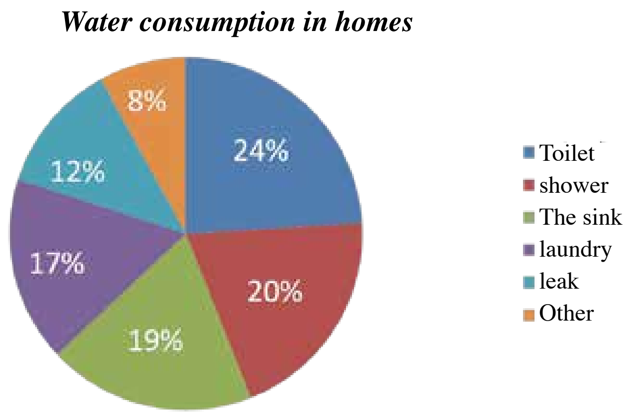


Figure (31)

Distribution of typical water consumption in the United States of America inside homes in 2016 [3]

It is undeniable that the distribution pattern of water consumption within households varies significantly between different residences and across different countries. Consequently, the figures presented in the referenced data should be considered as indicative rather than absolute, as variations in usage patterns are inevitable. Nevertheless, it is evident that toilets account for the highest proportion of water consumption, followed closely by showers, sinks, and laundry activities. Additionally, water loss due to leakage from toilets, rooftop water storage tanks, and other household activities, including kitchen-related consumption, further contributes to overall household water usage.

With regard to vehicle washing, the use of a water hose is often necessary; however, it is imperative to adopt efficient water management practices, such as filling a bucket instead of allowing continuous water flow, to minimize unnecessary wastage. Similarly, in garden irrigation, excessive water use can be avoided through the implementation of efficient watering techniques. For instance, covering the soil surface with small stones or mulch can significantly reduce evaporation rates. Furthermore, optimal watering times, such as early in the morning or in the evening after sunset, should be observed to minimize water loss due to evaporation.

Drip irrigation remains the most effective method for conserving water in agricultural and landscaping applications. Additionally, the utilization of gray water for irrigation presents a valuable approach to water recycling, thereby reducing reliance on freshwater sources. Rainwater harvesting is another critical strategy that enhances the availability of water for both domestic use and garden irrigation. This topic has been discussed in detail in previous chapter, emphasizing its importance in sustainable water management practices.

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Chapter Twenty

Electricity Consumption

Chapter 20

Electricity Consumption

To optimize electricity consumption in homes and workplaces, start by inspecting the electricity meter to detect potential leakage. Conduct regular maintenance on heating and cooling systems, ensuring their efficiency. Adjust the temperature settings of boilers, air conditioning units, and water heaters based on previous years, increasing or decreasing by a few degrees Celsius as needed. Since seasonal changes occur gradually, temperature modifications should be made accordingly.

Additionally, most electromechanical heating systems contain at least two water pumps. To enhance energy efficiency, these pumps should operate at the lowest speed. If currently set at levels 2 or 3, they should be reduced to the first speed setting (see image 29). This adjustment will not affect heat distribution but will contribute to significant energy savings. Implementing these measures ensures efficient electricity use, reduces energy waste, and promotes sustainability in residential and commercial environments.

Image (29)

Water pump with speed control switch indicated by a red arrow to the left [1]

To enhance energy efficiency, the temperature of electric water heaters should be reduced by a few degrees, with the option to increase it when necessary. Additionally, heating and cooling systems should be deactivated in unoccupied indoor spaces, such as unused bedrooms or fireplaces. The installation of automatic thermostats to regulate temperature at minimal levels can significantly contribute to energy conservation. It is also crucial to ensure that no heat is lost through cracks in exterior walls, windows, doors, or shutters. The application of flexible sealing materials around window frames and other building envelope openings can prevent warm air infiltration, which accounts for considerable energy loss in both summer and winter.

Lighting systems should also be evaluated for energy efficiency. Incandescent bulbs should be replaced with LED alternatives, which can reduce lighting energy consumption by up to 80% or more. Furthermore, outdated heating and cooling units should be replaced with energy-efficient A+ units equipped with inverters. Adjusting the thermostat to approximately 20°C and modifying it incrementally as needed can further enhance energy conservation.

Water coolers should not be left running during winter or overnight in summer. Instead, they should be activated only when required during the day and turned off once their use is no longer necessary.

Electronic devices such as televisions, computers, and chargers should not be left in standby mode overnight. The presence of a visible green light on the power pack indicates energy consumption even when the device is not in use. For instance, a television left in standby mode can consume between 2.25% and 5% of its total operational energy. This principle applies to other electrical appliances as well[(2)].

In winter, windows and curtains should be tightly closed at night to retain indoor heat. Conversely, during the day, shutters and blinds should be opened to allow sunlight to enter. In cold regions, if sunlight directly hits floor tiles, carpets should be temporarily removed to allow heat absorption and then replaced at sunset to retain warmth in the floor's thermal mass.

During hot summer conditions, windows and curtains should be opened at night to cool interior spaces, provided that outdoor temperatures are lower than indoor temperatures. However, if outdoor temperatures remain high, windows should remain closed to prevent additional heat gain.

To maintain thermal comfort, individuals should avoid increasing heating system temperatures excessively when feeling cold and instead opt for warmer clothing. If heating adjustments are necessary, lowering the heating source temperature while activating radiator systems during the day allows walls and ceilings to absorb and radiate heat at night, improving overall thermal comfort. The same principle applies to cooling during summer, where wearing lighter clothing enables comfort at higher temperatures.

Effective management of heating and cooling is essential. For instance, before leaving the living area to sleep, heating or cooling systems should be turned off at least 30 minutes in advance, as the gradual heat loss will be imperceptible, thus preventing unnecessary energy consumption.

Image (30)

two adjacent windows to reduce air leakage and increase sound and thermal insulation (3)

As illustrated in Image 30, the implementation of dual windows within an environmentally conscious architectural framework serves to mitigate the absorption of external heat into the interior spaces while simultaneously enhancing winter insulation and overall thermal efficiency. This approach can be effectively applied to existing buildings without the necessity of removing and replacing old windows. Instead, an additional window can be installed adjacent to the existing one, as demonstrated in Figure 30. This method offers advantages in terms of cost savings, reduced labor efforts, and minimized maintenance requirements.

Regarding ventilation concerns, it is observed that typical residential structures naturally experience air exchange approximately once per hour during winter through passive ventilation, facilitated by the opening of doors and the presence of apertures in the external building envelope. Consequently, additional ventilation is generally unnecessary during winter nights or on particularly hot summer days, except in cases where specific activities, such as cooking and bathing, necessitate increased airflow.[(4)] Proper ventilation in kitchens and bathrooms is essential to prevent the accumulation of humidity, the proliferation of fungal growth, and the emergence of unpleasant odors, as depicted in Image 31.

Image (31)

Mould growth on interior walls (5)

In general, maintaining kitchen and bathroom doors closed at all times proves ineffective in ensuring adequate ventilation. If natural ventilation through windows is insufficient, the installation of electric exhaust fans within glass windows is recommended to facilitate the removal of excessive humidity and improve indoor air quality.

Additionally, the use of dehumidifiers can be considered in cases where natural ventilation remains inadequate, particularly in areas with a high concentration of indoor plants, which contribute to increased humidity levels through transpiration. By implementing these measures, residential spaces can be optimized to provide a healthier and more environmentally sustainable living environment, minimizing adverse effects on both the ecosystem and public health.

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Chapter Twenty One

Green Behaviors

Chapter (21)

Green Behaviors

It is widely acknowledged that aspects of human behavior are both innate and acquired through education and practice. This ongoing debate between nature and nurture remains a focal point in social sciences, as researchers seek to understand their relative influences. Regardless of which factor exerts a greater impact, what is essential is their combined role in shaping environmentally sustainable habits within our homes and workplaces. This synergy contributes to the reduction of energy and water consumption, the achievement of thermal comfort, and the minimization of environmental pollution, ultimately fostering a more ecologically responsible lifestyle.

The discussion here may reiterate some previously mentioned activities; however, these considerations are crucial for raising awareness of individual responsibility in influencing human behavioral patterns. For instance, an individual can adopt environmentally conscious practices in public spaces, such as restaurants, by refraining from requesting unnecessary replacements of utensils like chargers, spoons, and forks. This practice helps reduce excessive consumption of water, energy, and chemical detergents used in dishwashing. A similar principle applies to drinking cups.

It is important to recognize that even a small cup of coffee requires substantial energy and water resources for production and subsequent cleaning. The cumulative environmental impact of such seemingly minor actions highlights the extent of human-induced strain on natural resources. However, the goal is not to discourage dining out or consuming beverages but rather to advocate for moderation and sensible consumption. Individuals should strive to meet their basic needs with minimal excess, as their sustainable choices influence friends and family over time, ultimately transitioning from individual responsibility to collective environmental impact.

In the context of household appliances, older washing machines historically consumed approximately 30 gallons of water per cycle. In contrast, modern, water-efficient models now require only 4 to 6 gallons per cycle. When compared to manual washing, the water used in just the first two minutes of hand washing can be equivalent to an entire cycle of a high-efficiency washing machine(1).

Given these considerations, responsible environmental management entails the adoption of water- and energy-efficient washing machines rather than relying on outdated models or manual washing methods that contribute to excessive resource consumption. By making such choices, individuals can significantly reduce their ecological footprint while promoting sustainable living practices.

Image (32)

A modern economic washing machine with an energy saving sticker (2)

The concept of sustainable design can be extended to the optimization of indoor lighting by ensuring that only the necessary lights are used and for the shortest duration possible. One effective approach is the installation of sensor-based systems that automatically switch off electrical lighting when a room becomes unoccupied. Advanced microwave monitoring systems (as illustrated in Image 33) can be employed to detect movement and control lighting accordingly. Additionally, occupancy-counting devices can be implemented, which track the number of individuals entering a room and deactivate lighting only after the last occupant has exited.

This environmentally conscious approach can result in significant energy savings, thereby reducing overall electricity consumption. Consequently, it contributes to minimizing emissions associated with electricity generation, particularly in cases where fossil fuels such as coal, oil, or natural gas are used as primary energy sources. By integrating such energy-efficient technologies, the environmental impact of power generation can be mitigated, supporting broader sustainability efforts.

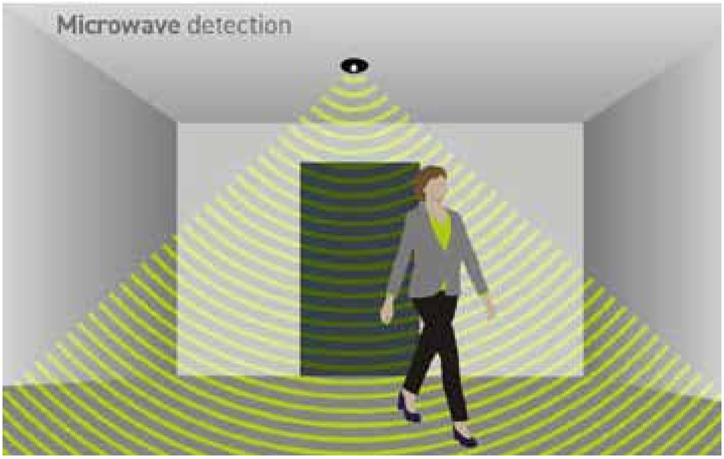

Image (33)

A microwave device to monitor movement and operate lighting (3)

The same principle applies to the use of cooling and heating systems, where it is essential to maintain an appropriate temperature without excessive adjustment or constant supervision. In winter, there is no need to excessively raise indoor temperatures and then compensate by opening windows for ventilation. Instead, a more energy-efficient approach is to slightly lower the temperature while keeping windows closed, thereby preserving indoor thermal balance.

An environmentally responsible approach also requires selecting appropriate clothing for different seasons. It is essential to wear warm clothing during winter to reduce reliance on heating systems, while lighter clothing should be worn in summer to minimize the need for cooling devices. Additionally, sustainable consumer behavior includes refraining from purchasing products derived from ivory, rare animal skins, or fur and avoiding actions that contribute to the endangerment of wildlife.

Further, automated insect control systems can be programmed to operate at specific times and shut off automatically, preventing unnecessary continuous operation. This principle is analogous to cooling and heating systems, which should not remain active throughout the night when not required.

Another effective strategy is integrating windows and external doors with the electrical system so that if a window or door is opened while a heating or cooling system is in operation, the device automatically shuts off. This mechanism prevents unnecessary energy loss and enhances overall efficiency.

Consequently, adopting environmentally conscious choices extends beyond energy consumption to other aspects of daily life, including food and beverage consumption, transportation methods, vacation destinations, clothing selection, and construction site planning. Environmentally sustainable practices also involve selecting construction materials with minimal ecological impact, promoting agriculture, recycling consumed materials, and rationalizing energy and water use. These principles should be incorporated into both residential and workplace settings, serving as models for real-world applications that influence broader society.

Additionally, the human need for nutrient-rich algae can be addressed through aquaculture, which involves cultivating and raising live food sources in water-based environments. Another sustainable agricultural system, permaculture, is a highly efficient approach to food production that integrates biological reproduction models. An example of this can be seen in Image 34, where an aquatic farming system was developed by converting a home swimming pool into a site for fish farming, with nutrient-rich water from fish waste being repurposed to cultivate vegetables. This method exemplifies an innovative and sustainable approach to food production, reinforcing ecological balance and resource efficiency.

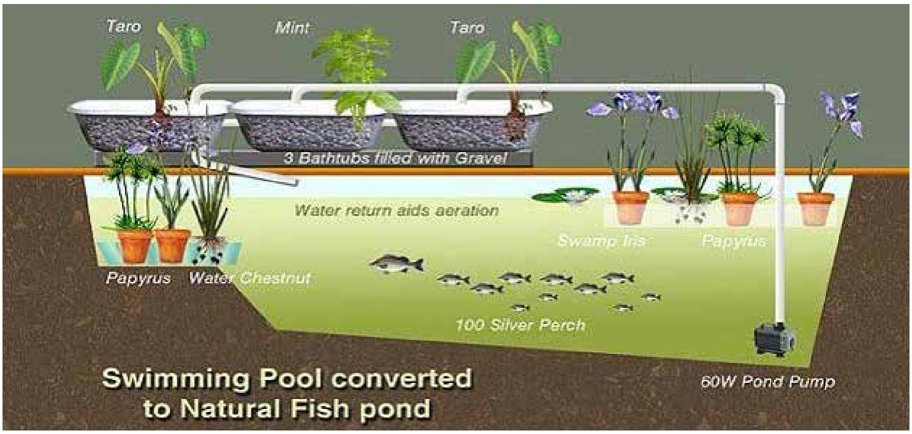

Image (34)

An integrated system for growing plants and raising fish [4]

These systems can be implemented on the rooftops of residential buildings or within basements equipped with artificial lighting to facilitate optimal growth conditions. Governments should take an active role in promoting such initiatives by offering comprehensive, ready-to-use packages that enable immediate production. Additionally, these systems should be made accessible to the public through affordable installment plans, thereby supporting individuals in cultivating essential food supplies and encouraging sustainable self-sufficiency, ultimately fostering a shift in societal lifestyles toward environmental sustainability.

To adopt a more environmentally responsible way of living, it is imperative to support organic farming products. Organic agriculture adheres to the European Union’s stringent regulations, which prohibit the use of genetically modified organisms (GMOs), synthetic fertilizers, herbicides, and chemical pesticides. Furthermore, organic farming requires additional measures to maintain soil fertility, such as crop rotation during the summer season and the exclusion of mineral nitrogen fertilizers.

Global awareness of the significance of organic farming has grown substantially, leading to notable transformations in agricultural practices. In 2018, global sales of organic food and beverages exceeded 100 billion USD, reaching approximately 120 billion USD by 2020. The largest markets for organic products included the United States (40.6 billion Euros), Germany (10.9 billion Euros), and France (9.1 billion Euros). France experienced the highest growth in organic product consumption, with organic food accounting for 15% of the country's total food consumption[5].

Additionally, 2018 saw a 3% increase in land dedicated to organic agriculture, totaling 71.5 million hectares. Approximately half of this land was located in Australia and its surrounding islands, with 22% in Europe and 11% in Latin America. The countries with the highest proportion of organic farmland relative to total cultivated land were Liechtenstein (38.5%), Samoa (34.5%), and Austria (24.7%)[6].

This expansion in organic agriculture underscores the growing global interest in organic products due to their scarcity, environmental benefits, and role in mitigating climate change. Furthermore, organic agriculture contributes to achieving the United Nations' Sustainable Development Goals (SDGs) for 2030. Therefore, it is essential to define and promote the concept of the green economy, identify the benefits of sustainable systems, and establish the obligations of green consumers. Raising awareness of these principles through social discourse can further reinforce environmentally responsible consumption patterns.

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Chapter Twenty Two

Climate Change

Chapter (22)

Climate Change

The primary drivers of climate change are the increasing emissions of greenhouse gases, which originate from human activities such as the combustion of fossil fuels, agricultural practices, transportation, and alterations in land use. These emissions contribute to a rise in the Earth's average atmospheric temperature and trigger significant disruptions in ecosystems, weather patterns, and the intensity and distribution of precipitation. Additionally, climate change affects wind patterns and the movement of ocean currents, leading to widespread environmental consequences.

The adverse impacts of climate change are extensive, including biodiversity loss, declining agricultural productivity, rising sea levels, and the accelerated melting of polar ice caps. As one of the most pressing global challenges of the modern era, climate change necessitates coordinated efforts at the international, institutional, and individual levels to mitigate its effects and implement sustainable solutions.

Figure 32 illustrates the global increase in coal consumption since the late 18th century, marking the advent of the First Industrial Revolution. The early 20th century witnessed a transition towards oil-based industries, signaling the onset of the Second Industrial Revolution, which was driven by oil, electricity, and the internal combustion engine. Since the 1970s, natural gas has gradually emerged as a replacement for coal and oil due to its significantly lower greenhouse gas emissions and widespread availability, highlighting a shift toward less carbon-intensive energy sources.

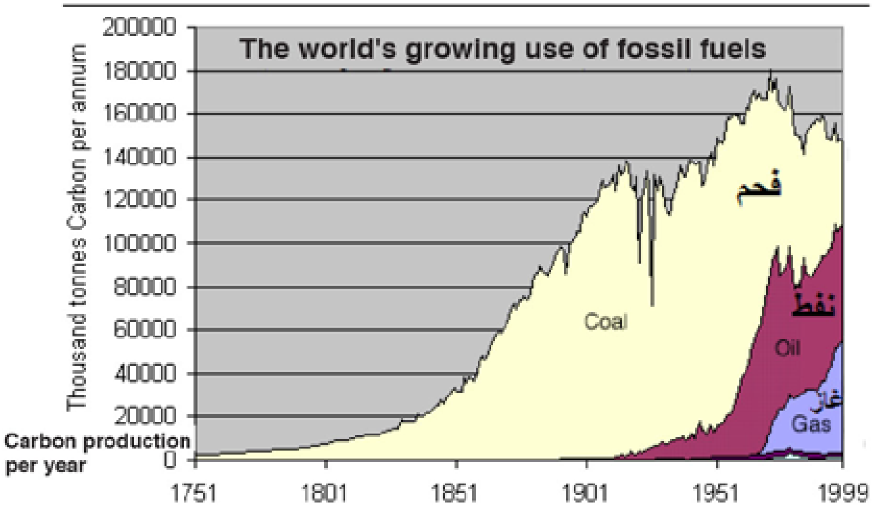

Figure (32)

The increasing use of fossil fuels in the world[1]

Despite the extensive environmental pollution caused by human activities, certain groups continue to deny the existence of global warming. These skeptics dispute the assertion that climate change is primarily driven by anthropogenic pollution, instead attributing it to natural factors such as the Earth's rotation, variations in the Sun's orbit, the intensity of solar flares, and other astronomical phenomena.

However, scientific evidence has conclusively demonstrated that greenhouse gas concentrations in the Earth's atmosphere began to rise significantly with the onset of the First Industrial Revolution in the late 18th century. This period marked the widespread use of coal as a primary energy source, particularly following the invention of the steam engine by Scottish mechanical engineer James Watt in 1776. Environmental pollution intensified further at the end of the 19th and throughout the 20th century with the discovery of oil and the rapid advancement of industrial machinery, particularly the internal combustion engine. The expansion of electricity production further exacerbated pollution levels, as early electricity generation relied heavily on highly polluting petroleum derivatives such as coal and furnace oil.

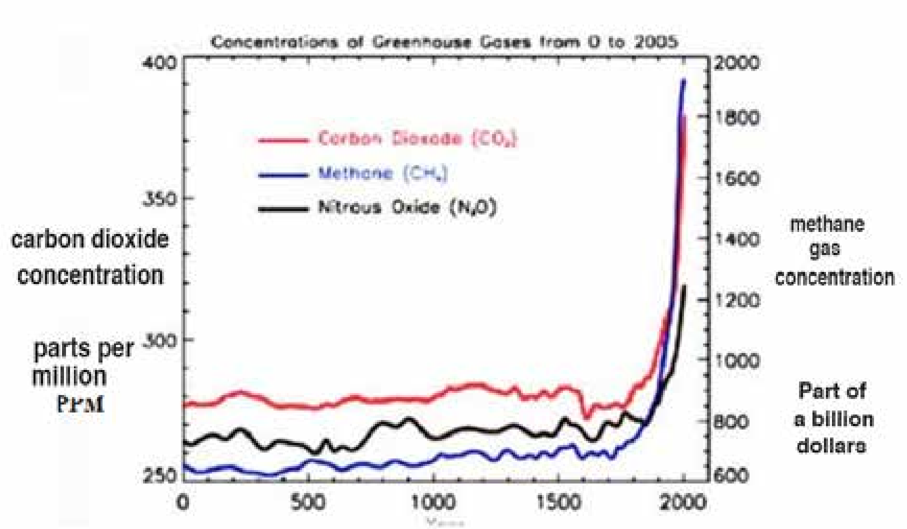

Figure (33)

Increase in the concentration of some greenhouse gases since two thousand years [2]

Figure 33 illustrates the increase in the concentration of greenhouse gases—including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)—over the past two thousand years. A significant shift is evident in the 19th century, marking the beginning of a sharp rise in atmospheric greenhouse gas concentrations, which intensified further throughout the 20th century and into the present. For instance, the current concentration of carbon dioxide exceeds 400 parts per million (ppm), whereas for the past two millennia, it remained below 280 ppm.

By 2013, global carbon dioxide emissions were 61% higher than in 1990, providing further evidence of the substantial increase in greenhouse gas concentrations in recent decades. This rise directly correlates with human activities detrimental to the environment, such as deforestation and the large-scale combustion of fossil fuels.

Climate change presents a critical challenge across all regions of the planet, manifesting in various forms, including the accelerated melting of polar ice caps and the consequent rise in sea levels, increases in average global temperatures, extreme cold events in certain regions, and irregular patterns of precipitation and storm intensity. While these changes may not be immediately apparent to individuals in some parts of the world, their consequences are severe[(3)].

Some nations are already experiencing submersion due to rising sea levels, while others, such as Belize, face acute water shortages as they rely on glacial melting water for drinking and agriculture. Additionally, several regions are at risk of losing their agricultural productivity due to climate change, with the most severe consequences affecting economically disadvantaged nations in the Global South. These challenges underscore the urgent need for comprehensive global efforts to mitigate climate change and adapt to its far-reaching consequences.

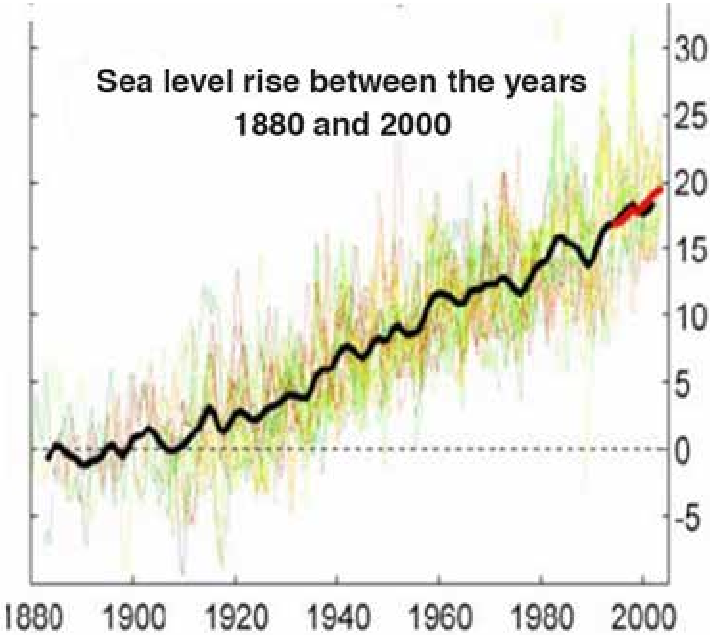

Figure (34)

Shows the rise in sea level during the years 1880 and 2000[4]

Figure 34 illustrates the rise in sea levels, measured in centimeters, between the years 1880 and 2000. This increase is primarily attributed to the melting of polar ice caps, a consequence of rising global atmospheric temperatures. Additionally, the figure highlights the correlation between this rise and the fluctuating tidal currents, represented by the oscillating green line, which surrounds the sharper line indicating sea level changes.

To achieve an environmentally sustainable lifestyle, it is essential to recognize global warming as a principal cause of climate-related adversities, particularly in impoverished and developing nations that bear minimal responsibility for greenhouse gas emissions. The consequences of climate change—such as rising temperatures, intensified droughts, desertification, food system disruptions, drinking water shortages, biodiversity loss, and ecosystem degradation—are disproportionately impacting these vulnerable regions. Moreover, phenomena such as soil erosion are exacerbating living conditions, driving mass displacements and fueling unregulated environmental migrations, a term referred to as "environmental migrations" in Yemen. These movements often lead to increased migration flows from affected regions to developed nations in the Global North and South.

It is important to acknowledge that a low-carbon lifestyle is attainable. During World War II (1939–1945), for example, global reliance on public transportation was significantly higher, with private vehicle usage being nearly nonexistent. Additionally, citizens contributed to food security by cultivating their own produce through initiatives such as the Victory Gardens, which, by 1943, accounted for approximately 42% of the United States' total fresh vegetable production(5).

Similar self-sufficiency efforts can be implemented today through sustainable agricultural practices such as aquaculture and permaculture. Aquaculture involves the cultivation of plants and aquatic organisms in water-based systems, while permaculture is an ecologically intelligent approach that fosters interdependent biological reproduction cycles. One example of permaculture is the design of an integrated aquatic farm, where fish are raised, and nutrient-rich wastewater from fish tanks is repurposed to irrigate and fertilize vegetable crops.

These sustainable agricultural systems can be implemented in urban environments, including rooftops and basements, thereby maximizing underutilized spaces for food production. Governments should actively promote such initiatives by offering comprehensive, ready-to-use agricultural packages that enable immediate implementation. Facilitating access to these systems through affordable installment plans would support individuals in cultivating essential and scarce food supplies while encouraging sustainable practices.

Additionally, another form of sustainable agriculture known as agroforestry involves integrating crop cultivation within forested landscapes. This method promotes land-use efficiency by utilizing spaces between trees to grow diverse crops. One of its key advantages is the exclusion of chemical fertilizers, which mitigates environmental degradation and enhances soil health. Agroforestry is widely practiced in numerous African and Asian countries as a means of addressing challenges such as deforestation and land encroachment, demonstrating its potential as a viable solution for sustainable food production and environmental conservation.

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Conclusion

Conclusion

Since the inception of this work, the objective of How to Live an Environmentally Friendly Life has been to guide readers toward adopting sustainable practices. This book has sought to equip individuals with the knowledge and tools needed to reduce their ecological footprint by reconsidering choices related to food consumption, transportation, vacation destinations, and clothing selection.

Additionally, it has provided insights into sustainable building practices, including selecting an environmentally suitable construction site, optimizing building orientation, and integrating Passive Design principles adapted to specific geographical locations. Other key aspects discussed include effective shading techniques, the selection of energy-efficient windows, and the use of environmentally friendly construction materials and finishes.

The book has also highlighted the importance of transitioning to clean energy sources and exploring alternative environmentally friendly solutions. Emphasis has been placed on thermal insulation techniques to enhance energy efficiency, recycling used materials, and incorporating sustainable agricultural practices into urban living. Water conservation strategies, including rainwater harvesting and the recycling of freshwater and gray water, have been explored in depth.

Another key focus has been reducing resource consumption by implementing strategies to minimize water and electricity use. This discussion naturally led to the broader issue of climate change, which remains one of the most pressing global challenges. As highlighted in this book, climate change is primarily driven by unsustainable human activities, including greenhouse gas emissions from industrial processes, transportation, deforestation, and agricultural expansion. The urgency of addressing this crisis underscores the importance of increasing environmental awareness and promoting sustainable alternatives.

One proposed solution discussed in this book is urban and evening agriculture, a method that reduces dependence on large-scale farming and minimizes soil degradation caused by harmful agricultural practices. Encouraging the cultivation of food in urban settings can significantly decrease the demand for chemical fertilizers and pesticides, which contribute to environmental pollution. Additionally, such practices offer an opportunity to produce essential crops without further encroaching on forests and green spaces, thus helping to preserve biodiversity and mitigate deforestation.

While it is unrealistic to expect every individual to fully adopt all the recommendations outlined in this book, any effort to embrace more sustainable habits is a step in the right direction. The transition to an environmentally friendly lifestyle is often accompanied by social, economic, and psychological challenges. However, even small changes—such as conserving water, reducing energy consumption, or opting for sustainable products—contribute to a collective effort toward environmental preservation.

The global response to climate change has been inconsistent, with many international agreements lacking enforceability. This was evident during the Conference of the

Parties on Climate Change (COP26) in Glasgow, Scotland (October 31 – November 12, 2021), and COP27 in Sharm El-Sheikh, Egypt (2022), where negotiations failed to produce binding commitments from all nations. As a result, individual responsibility has become increasingly crucial in the fight against climate change. While governments, international organizations, and civil society play fundamental roles, the contributions of schools, universities, and educational institutions are particularly significant. Education serves as the foundation for cultivating environmental awareness and fostering a new generation of citizens committed to sustainable living.

Finally, it is essential to recognize and support initiatives that honor individuals and institutions actively engaged in environmentally friendly practices. Programs such as the Environmental Books Initiative and the Zayed International Foundation for the Environment play a vital role in promoting sustainability. Encouraging such initiatives, particularly among young people, can inspire a greater commitment to environmental responsibility. By fostering awareness, innovation, and collective action, these efforts contribute to reducing harmful environmental behaviors and mitigating the existential risks posed by climate change.

In conclusion, while large-scale policy changes and technological advancements are critical, individual actions remain equally important. By integrating sustainable practices into daily life, people can collectively work toward a more environmentally responsible and ecologically balanced future. The principles explored in this book serve as a foundation for achieving this goal, empowering individuals to make informed choices that contribute to the well-being of the planet.

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9. If the book is accepted and a contract is signed, the author will receive 15,000 UAE dirhams (or equivalent) after completing all required revisions and submitting a final electronic Word version via email or flash drive.
10. If a translation is accepted and a contract is signed, the translator will receive 10,000 UAE dirhams (or equiv-

alent) after completing all required revisions and submitting a final electronic Word version via email or flash drive.

11. The translator is responsible for ensuring the intellectual property rights of the original author.
12. The Zayed International Foundation for the Environment is not responsible for the book's content, as the opinions expressed belong to the author.
13. The author or translator may not reprint the book without written permission from the foundation, which retains the publishing rights.
14. The foundation will provide 25 copies of the published book to the author.

Publishing Procedures:

1. An initial proposal outlining the book's general idea, topics, and significance should be submitted using the attached Book Proposal Form, along with the author's CV and signed agreement to the guidelines.
2. The book will be sent to specialized reviewers to assess its suitability for publication.
3. If approved by the reviewers and the editorial board, the manuscript will proceed to design and production.
4. The foundation will assign a professional production and printing company following the specifications set by the editorial board.

Subject Areas:

The series covers topics related to environmental conservation and natural resource management, in accordance with sustainable development principles that balance economic and social development with environmental protection.

Book Proposal Form for Publication

The Zayed International Foundation for the Environment extends its greetings to scientists, experts, and researchers in environmental and developmental fields and invites them to contribute to this series through authorship and translation. This initiative aims to guide development in Arab countries towards sustainability and ensure future generations' right to a healthy environment.

If you wish to participate, please review the publishing guidelines above, complete the form below, and send a signed copy via email to:

Editorial Board of the World of Environment Series

Zayed International Foundation for the Environment

P.O. Box 28399, Dubai, United Arab Emirates

Phone: +971 4 3326666

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Book Proposal Form

- Name:
- Academic Qualification:

- Occupation:
- Address:
- Phone:
- Email:
- Book Title:
- Brief Description of the Book's Importance and Content:

Declaration:

I, the undersigned, confirm that I have reviewed the publishing guidelines for the World of Environment Series and agree to grant the Zayed International Foundation for the Environment the publishing and reprinting rights according to the conditions outlined at the end of each book in the series.

- Signature:
- Date:

(Please attach the author's CV and a summary of the book's content outline.)

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