Choice, Adaptability and Circularity in Housing

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By

Avi Friedman

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PREFACE

Recent socio-economic and environmental challenges are forcing consideration of old practices and a search for innovative solutions in the built residential environment. From a demographic perspective, the make-up of society in many nations is much more diverse than in past decades. Designs proposed by architects and constructed by builders must be flexible and consider a wider range of household compositions, ages and living habits such as live-work and multi-generational arrangements.

Economic fluctuations have also taken their toll on society, affecting world markets and individuals' lives to make secure long-term employment less common. In addition, an "affordability gap" has emerged, where the rate of increase in house prices has surpassed the increase in household income. This has made it highly difficult for first-time homebuyers to purchase a dwelling in most urban centers.

In recent years, the homebuilding industry has taken centre stage in the need to rethink design and construction practices and align them with contemporary environmental constraints. Sustainable homes strive to meet present social and economic needs without the risk of exhausting the resources of future generations. They require reducing the impact of housing on natural resources, including materials and energy. Consideration of design concepts that minimize a home and a community's carbon footprint, by designing for passive solar gain and integrating Net-Zero concepts became common.

Designers are also exploring new means of housing production. It is becoming increasingly apparent that prefabrication is key to reconciling functional design needs with financial constraints. New technologies such as 3-D printing facilitate production of new components at a reduced cost and improve their appearance. Additionally, homebuyers are paying more attention to well-designed homes and will likely choose them over other units. The need to make homes affordable has initiated creativity in interior concepts that aim to make small spaces highly efficient.

This book addresses these contemporary social transformations and trends. It argues that homes must offer greater choice in the preoccupancy stage,

adaptability once the occupant has moved in, and when the structure or its subcomponents end its useful life, facilitating circularity. The book begins with an introductory chapter that sets the stage for the following chapters. These challenges are listed, investigated, and discussed in chapter one as an introduction to the main themes of this book: choice, adaptability and circularity, for which definitions are provided. Those emerging realities are also used to explain the need for sustainability, and their roots are also defined as the basis for understanding the emergence and growth of "green thinking" over the last decades. Finally, the author argues that the aforementioned challenges are leverage points for innovative ideas and practices in the contemporary housing market of various cities and nations.

Flexibility and adaptability in housing has been given a variety of definitions and interpretations by scholars and practitioners. It is, therefore, necessary to define basic terms, draw perimeters of those subjects, and investigate their roots and evolution. In addition, a historical overview of the development of choice, flexibility in housing and the author's objectives will be presented in chapter two. A promising approach to rethinking housing is the practice of the Circular Economy (CE), which envisions a sustainable future where waste is eliminated and materials and buildings are kept in use for as long as possible. Such an approach encourages a paradigm shift away from the current status quo, facilitating a culture of take-make-waste. CE practices are compatible with design for choice and flexibility.

The widening gap between household income and house prices has become a significant barrier to homeownership. In many nations, high cost of land, infrastructure, labour, and materials have put homes beyond the reach of first-time home buyers and renters. These factors have heightened the need for and importance of affordable dwellings. Affordable housing is commonly defined as dwellings where owners or renters do not spend more than 30 percent of their income on shelter expenses. Affordable design may require downsizing, but not necessarily lowering the quality and standards of the dwelling and community. Chapter three examines and outlines cost reduction. Offering choices where buyers can only pay for what they need and can afford is a strategy for affordability discussed in this chapter.

Western society underwent fundamental demographic changes in the past half-century, giving certain demographic segments an increasingly important profile in the housing market. One of the manifestations of these changing housing demands has been the diminishing size of the typical household. This shrinkage has meant that the number of households, or

equivalently, the number of occupied dwellings has risen faster than the population. The above changes necessitate a revaluation of the way in which one views the processes of household formation and behaviour and, consequently, the residential location decision process. A more comprehensive life cycle model has included groups which were formerly regarded as marginal and have increased their share. Chapter four investigates how dwellings can be made to be adaptable to the occupants' needs.

With the growth in the size of the elderly population in many nations and the expected "Gray Tsunami", cities are facing mounting challenges. Rationalizing investment in social and healthcare services forces cities to think innovatively. Aging also poses a challenge to seniors since trivial daily tasks become increasingly difficult as people get older. Adequate aging is also an important pillar of sustainability since poor management can drain a nation's finances and contribute to deteriorating personal well-being. Several residential design strategies, such as aging in place and multi-generational living, are known to alleviate those challenges. Therefore, the need to design inclusive environments and dwellings that are adaptable to people's needs will support aging in the community and at home. Chapter five investigates these approaches in the design of the home's interior with the accommodation for aging in place in mind.

A renewed interest in prefabricated housing has emerged along with recent developments in innovative manufacturing processes. The negative effects of conventional building practices on the environment and an urgent need for affordable housing have encouraged the home-building sector to prioritize resource efficiency and conservation. The rapid of digital production and mass customization that adapts the end product to a consumer's needs makes the long-term practice of off-site fabrication viable. Prefabrication's importance rests in its ability to provide flexible living models for various demographics while optimizing resource consumption. Chapter six introduces the fundamentals of prefabricated construction and its main types, including mass customization, and outlines dry interior construction methods and, designs for growth and adaptability.

Circular Economy (CE) is the suitable response to many architectural and urban issues related to demolition and waste, and as a result, it fulfills key sustainable development principles. While the term has been defined many ways, CE is a reconceptualization of the current economic system, with the goal of minimizing the disposal of construction materials and components

as much as possible. The current economic model that underpins contemporary urban design and housing is linear, relying on a “take-make-waste" model. The extracted raw material is used for a period of time and then disposed of as the material stock grows old or the use of the dwelling, for instance, ends. In a circular economy, however, the end-of-life idea that defines linear economy is replaced with revitalization through the use of renewable resources, impeccable design of products to maintain its quality for as long as possible, and the eventual re-use of material at the end of a product’s useful life. In this sense, circular economy aims to remove waste from the building process, which has significant implications for ecosystems, the economy, and society at large, which will be discussed in chapter seven.

Minimum-cost housing is common for housing lower-income people in many developing nations. The units are designed to offer safe yet quality living conditions to lower-income population segments. These lower-cost dwellings alternatives join self-help housing, where the occupants are active participants in building their own homes as a means of further cost reduction. In both cases, offering choices is a cost-reduction strategy. Chapter eight introduces and investigate strategies pertaining to self-help and progressive building as a means of housing the poor.

Each of the above-listed chapters pays special attention to the practices of choice, adaptability, and circularity in the conception and construction of homes. The author trusts that these ideas will make residential environments more adaptable to their occupants, affordable, and sustainable.

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Researching and writing on choice and adaptability in affordable and sustainable housing design was a subject of my work for years. It included collaboration with and contribution by numerous colleagues, assistants and students who directly and indirectly inspired my work. I apologize if I have mistakenly omitted the name of someone who contributed to this book. I will do my best to correct such omissions in future editions.

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—Avi Friedman

CHAPTER 1

A QUEST FOR A NEW PHILOSOPHY AND FORM IN HOUSING

Homes, community design, and construction are facing challenges, including climate change, scarcity of natural resources, shortage of affordable housing, and accommodating a growing aging population. These aspects are analyzed and discussed in this chapter, under the themes of environmental, economic, and demographic areas as an introduction. Since the contemporary housing challenge extends beyond mere shelter provision, an emphasis on addressing the diverse social demands by providing various innovative housing choices and enhancing housing adaptability and circularity is a necessity. In addition, the notion of sustainability has served as a catalyst for the rise of "eco-consciousness" over the past several decades. This has seen sustainable architectural design evolve into a significant aspect of modern architectural design and planning models. A project's sustainability potential is optimized by ensuring equal consideration of the four pillars during the decision-making and planning stages. In this context, the Kingsview Lands project is a case that provided a variety of housing options tailored to the client's needs. Finally, the author argues that these considerations could be used to innovate and introduce fresh approaches within existing housing markets across various cities and nations.

1.1 A Need for Choice, Adaptability, and Circularity

Social transformations are driven by demographic changes, economic shifts, and environmental concerns. These changes underscore a pressing need for choice, adaptability, and circularity. The recent COVID-19 pandemic led many to re-evaluate their housing choices. Numerous companies have embraced flexible work arrangements, allowing people to work either remotely or on-site. The pandemic demonstrated the significance of versatile living spaces that can simultaneously facilitate work, education, and social activities from home. This further highlighted the advantages of facilitating various functions over a building's lifetime, enhancing its spatial adaptability. The diverse housing options available to people emphasize the need for policies that empower rather than restrict.

Circularity refers to the transition from linear "take-make-dispose" economic models to circular ones emphasizing resource reduction, reuse, and recycling (Coste-Maniere et al., 2018) (Figure 1.1). A Circular Economy mitigates environmental damage and resource depletion, fostering sustainable growth. This approach is increasingly important as society grapples with the repercussions of unchecked consumption and waste generation. These three principles—choice, adaptability, and circularity, which are at the center of this book—are integral to navigating the complex social transformations and building a resilient, inclusive, and sustainable future.

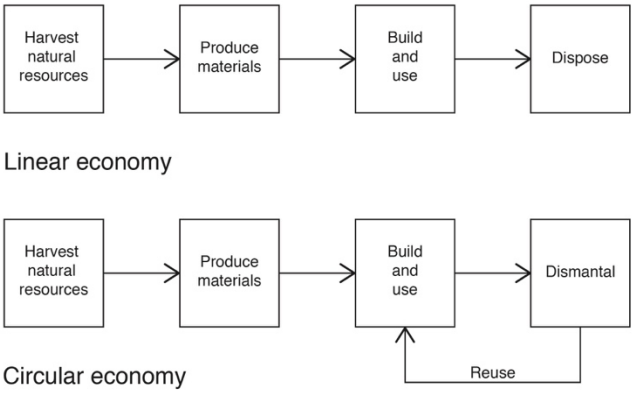

Figure 1.1: Unlike Linear Economy, Circular Economy refers to the transition from "take-make-dispose" economic models to circular ones emphasizing resource reduction, reuse, and recycling

1.1.1 Environmental Challenges

Unprecedented natural disasters have raised environmental worries and increased the need to develop housing designs that are particularly adept at responding to climate emergencies. Climate change, which has a long-term effect on temperatures and weather patterns and is an outcome of human activities, is the main cause of global warming (United Nations, 2015). Ever since the onset of the Industrial Revolution, humans have significantly increased their consumption of fossil fuels and transformed large tracts of forested land into agricultural fields and paved areas (United Nations, 2015). As a result of producing large amounts of carbon dioxide, human activities have exacerbated the greenhouse effect and disrupted the natural balance.

Climate change poses many risks to humans, flora and fauna. Compared to the beginning of the twentieth century, flooding is becoming a more significant hazard globally. Natural disasters such as the 2005 Category 5 hurricane Katrina slummed into the southeastern coast of Louisiana to take a direct hit on New Orleans (Figure 1.2). In 2021, floods in Henan, China, and the same year, German floods caused hundreds of people's deaths, millions of properties destroyed, and billions of dollars in damages (Lehmkuhl et al., 2022). In addition, drought is influenced by global warming and climate change, and areas already prone to drought are seeing increased severity and frequency. In 2022, 73 percent of the world's total land area was experiencing severe drought conditions, while an alarming 31 percent was categorized as being in extreme drought (White, 2023). The vast majority of the Western US was undergoing a moderate drought, with the remaining regions noted to be abnormally dry (White, 2023). Since food supply depends on weather conditions, the drought directly impacts food production and harvesting globally. To ensure food production, farmers need to irrigate more often to ensure food production since the high temperatures cause plants to dry up. When water resources are depleted, it impacts human consumption and agriculture and harms aquatic ecosystems, leading to further biodiversity loss.

Figure 1.2 Approximately 300,000 homes were either destroyed or made uninhabitable in the aftermath of Hurricane Katrina in 2005

Additionally, more wildfires occur when there are dry conditions. Studies have revealed that the length and frequency of wildfire season and the burned area have increased due to anthropogenic climate change (Smith, 2022). Due to variables including extreme weather and longer dry seasons,

the wildfire season has grown longer in many locations. The US experienced 20 wildfire incidents that cost more than US $1 billion in damage between 1980 and 2021, with 80 percent of those occurrences taking place after the year 2000, according to the National Oceanic and Atmospheric Administration (Smith, 2022).

Due to the negative impacts of climate change, current architectural practices and urban environments are becoming more adaptable and sustainable. Urban sustainability and innovation have recently been integrated into the UN's 2030 Agenda for Sustainable Development, a comprehensive action plan to address a wide range of global challenges (Figure 1.3). Its primary objective is to improve people's living conditions without compromising future generation's needs. The UN aims to stimulate sustainable activity over 15 years in areas of critical importance for humanity and the planet. The 17 Sustainable Development Goals (SDGs) and 169 related goals, which address sustainability's economic, social, and environmental facets, serve as the agenda's direction (UN, 2023).

Figure 1.3 A UN agenda introduced eleven Sustainable Development Goals (SDGs) and identified processes, policies, generation of finance frameworks and planning

These goals range from reducing hunger and poverty, ensuring sustainable water management, advancing gender equality in education, fostering climate change, using green energy, promoting well-being for all ages, and creating an inclusive and sustainable society (UN, 2023). The 2023 report on sustainable urbanization by UN-Habitat acknowledges that cities are pivotal to climate change solutions, sustainable management and strategies for natural resources and energy, architectural innovation, and urban

development. Fundamental tenets of the 2030 Agenda mean development benefits must reach all people regardless of their identity or circumstances, and the interconnected nature of the SDGs, recognizing that action in one area will affect outcomes in others (UN, 2023). For example, the Canadian government has built a 2022 to 2026 Federal Sustainable Development Strategy (FSDS) that supports Canada's efforts to advance the 17 Sustainable Development Goals of the United Nations 2030 Agenda for Sustainable Development (Government of Canada, 2022). The strategy emphasizes federal government initiatives over the following four years to promote the accomplishment of the 17 SDGs.

Governments worldwide are establishing innovative regulatory policies to address the increasing politicization of environmental issues. For example, in November 2018, the Canada-wide Strategy on Zero Plastic Waste was adopted by Canada's federal, provincial, and territorial governments via the Canadian Council of Ministers of the Environment (Government of Canada, 2023). Based on the Ocean Plastics Charter, this plan employs a Circular Economy and lifecycle approach to reduce plastic waste. It unfolds in two phases, focusing on augmenting the circularity of plastics, minimizing plastic waste, and heightening awareness. The strategy involves phasing out unnecessary single-use plastics and sourcing more sustainable substitutes with an aim to prolong product lifespans and reroute at least 75 percent of plastic waste from federal operations by 2030 (Government of Canada, 2023).

In response to social, environmental, and economic shifts, the Canadian government is incentivizing builders and consumers to promote energy-efficient housing. The Canada Greener Homes Grant is designed to improve home energy efficiency, generate energy advisor roles, bolster domestic green supply chains, and combat climate change (Canada Natural Resources, 2021). Backdated to December 1, 2020, the grant provides up to CAN $5,000 to around 700,000 Canadian homeowners and an additional CAN $600 to fund an EnerGuide home energy evaluation (Canada Natural Resources, 2021). The government is committed to extending the reach of the Greener Homes initiative nationwide, especially to those in remote and northern regions or those with limited internet connectivity.

1.1.2 Economic Challenges

The lack of affordable housing is a growing crisis in many countries. Uncertain economic conditions, rising real-estate prices, insufficient income, and unemployment are some of the causes. The demand and supply of

houses or apartments are unbalanced in many metropolitan areas (McAfee, 2015). For example, the city of Toronto has a population of nearly 6 million but fewer than 2.2 million dwellings to accommodate them (Statistics Canada, 2016). Between 2017 and 2022, the average home price in Toronto increased by 34 percent, according to Toronto Regional Real Estate Statistics, and the average Toronto dwelling cost in 2022 is approximately CAN $1.2 million (Toronto Regional Real Estate Statistics, 2022). However, the median salary after-tax income is around CAN $85,000 per year, which is higher than other cities but not sufficient to help those looking for homes (Robertson, 2022). Moreover, the shortage of rental housing also presents a significant challenge for individuals unable to afford a home, as over 90 percent of new housing is built for ownership (McAfee, 2015). Renters must spend well over the recommended 30 percent of their income on housing, leaving them with little disposable income (Figure 1.4).

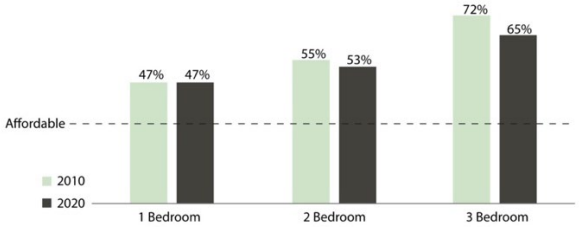

Figure 1.4 The shortage of rental accommodations presents a significant challenge for individuals who must spend well over the recommended 30 percent of their income on housing

The decline in supply has made affordable housing increasingly scarce for lower-income sectors, exacerbated by low vacancy rates, particularly in large cities (McAfee, 2015). Unable to afford ownership, households often live with family or share housing costs with roommates. Co-operatives and co-housing arrangements, which can be traced back to the 1930s in Canada and encompass 100,000 units, offer secure and cost-shared accommodation options (McAfee, 2015). Meanwhile, market rental housing, developed and managed by private entrepreneurs, includes purpose-built rentals, temporary owner-rented units, and secondary suites in single-family homes. However, most people who live in rental housing receive little to no government support to cover their expenses. Aid is often limited to social housing and rent supplement programmes (McAfee, 2015). For people who can afford a property, mortgage rates constitute an important portion of the household income. In some Canadian cities, mortgage payments for single-family

homes accounted for a staggering 85.4 percent of family income in 2021 (Statistica, 2021).

While strategic planning and policy implementation are crucial elements in creating affordable housing, architects play a critical role in building affordable housing by employing their expertise in design and construction strategies. Their responsibilities include developing innovative and cost-effective designs, optimizing resource utilization, and implementing sustainable practices. In addition, architects are instrumental in repurposing existing structures, contributing to community planning and policy changes, and advocating for affordable housing alongside community leaders and policymakers. Their multidimensional approach involves creating designs that meet community needs while remaining economically sustainable, positioning architects as critical players in the affordable housing landscape.

1.1.3 Demographic Challenges

Demographic diversity and the aging population are known to shape social, economic, and political landscapes worldwide. They can profoundly impact society, from changing the workforce composition to influencing policy decisions. Demographic diversity, defined by various groups based on criteria such as age, gender, race, religion, and country, presents challenges and opportunities (Edwards and Nakintu, 2022). While such diversity might cause social tension and demand infrastructure and legislative changes to ensure inclusivity, it can also accelerate innovation by offering diverse perspectives.

On the other hand, the growth of the aging population has risen rapidly as birth rates have declined in recent decades. By 2030, it's forecasted that globally, one out of every six people will be 60 years old or more (World Health Organization, 2022) (Figure 1.5). At that time, the global population of those above 60 years of age will have swelled to 1.4 billion, a significant increase from 1 billion in 2020 (World Health Organization, 2022). For example, Japan already has 30 percent of the population over 60 (World Health Organization, 2022). The worldwide population of those 60 and above is set to double, reaching 2.1 billion by 2050 (World Health Organization, 2022). Over the same period, the number of people aged 80 or more is expected to triple, reaching 426 million (World Health Organization, 2022). Although the demographic shift towards older ages, the most drastic changes are currently being experienced in lower to middle-income nations because the shift may strain healthcare systems and public

budgets while potentially shrinking the labour force. However, many elders continue contributing to society after retirement by volunteering, imparting wisdom and knowledge, and participating in community activities. Also, the demand for products and services catering to older adults could stimulate economic growth and innovation in the healthcare, technology, and leisure sectors.

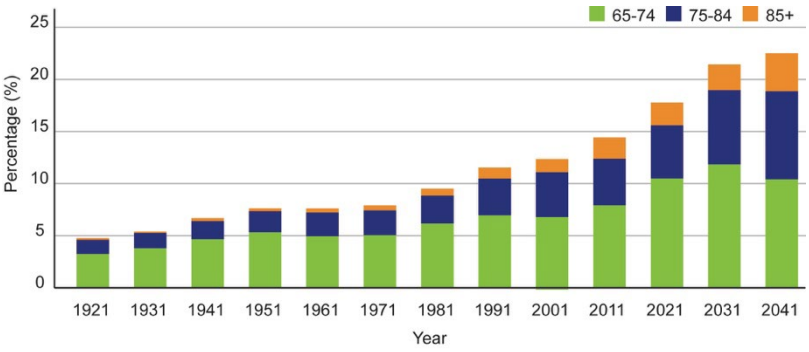

Figure 1.5 In Canada, it is forecasted that one out of every six people will be 60 years old or older by 2030

Aging population growth and demographic diversity have accelerated a call for new housing designs that can suit the needs of all generations. As lives undergo changes - be it family expansion, aging, or lifestyle adjustments - homes should be adaptable over time. Architects and planners could pay greater attention seniors' socio-economic inclusivity and active engagement. In addition, the homebuilding industry must come to realize that due to greater demographic diversity, the existing housing stock is not adequately designed to accommodate specific demographic cohorts.

1.2 Defining Choice, Adaptability, and Circularity

Contemporary housing is a multidimensional social issue that demands innovative, inclusive, and sustainable solutions. It requires a systemic transformation of contemporary housing systems, where choice, adaptability, and circularity are embedded at the core. These changes in the built environment ultimately affect the four sustainable dimensions that one must consider from design to construction and thereafter. Definitions of the concepts that make up the key tenants of this book are introduced below.

1.2.1 Choice

Society constitutes a complex system, amalgamating aspects of multigeneration, diverse cultures, environments, and economic systems. The heterogeneous needs of various societal strata and generations necessitate a shift toward innovative housing alternatives and options. The term choice in residential design is defined as the range of options available to households or individuals to choose from based on their needs, preferences, and budget (Brown and King, 2006). In addition, choice in housing design provides the flexibility for customization and personalization, considering components like layout, building materials, finishing touches, colour schemes, and overarching style. Governments often support a more comprehensive range of housing typologies to the public (Brown and King, 2006). Various kinds of housing typologies promote societal inclusivity by addressing the needs of a broader range of socio-economic groups. However, most individuals choose from a restricted, minimal, confined range of options (Figure 1.6). Such a home may be the greatest option for a family, given the limited offerings accessible to them at a certain point in their life.

Figure 6 Most homebuyers choose their dwelling from a restricted, minimal, confined range of options, which is commonly displayed in model homes like the one shown here

The phrase real housing choice has been developed to refute the term housing choice. Selecting a preferred option from a group of standout alternatives means real choice (Brown and King, 2005; Elster, 1999). Indeed, very few people who are actively exploring the housing market have access to diverse choices. The absolute lack of options, where available choices do

not even meet the most basic housing needs of a shelter for homelessness. True and varied choices are often lacking in the social housing market. Although choice-based rentals have introduced some variety for those living in social housing, standout options remain limited for most. The choice set is significantly larger for individuals who own their homes or rent privately. Nonetheless, even for most of these sectors, actual choice is still restricted (Van Ham and Manely, 2012). Measuring genuine preferences and aspirations is challenging as households frequently adjust their choices to align with the practical options available to them (Van Ham and Manely, 2012).

1.2.2 Adaptability

Adaptability in residential design often refers to the ability of a structure or space to respond and adjust to changing circumstances, functions, or user demands over time (Friedman, 2002). In other words, houses should be flexible throughout time to accommodate changes during the residents' different life stages, such as the growth of families and aging in place (Figure 1.7).

In addition, the need for adaptive living conditions to facilitate working, studying, and socializing from home has been highlighted by the COVID-19 pandemic. This reaffirmed the advantage of allowing a variety of applications during the building's lifecycle to increase. When thinking about designing spaces that can be easily modified, reconfigured, or expanded without major structural alterations, professionals and the public tend to associate its application with technical advances (Friedman, 2002). Adaptive design strategies may involve using modular, movable, or dismantlable partitions, or incorporating resilient materials and systems that can withstand environmental stressors. Providing residents with forms and means that facilitate a fit of their potential future needs, allowing for flexibility and accommodating different uses or occupants throughout their lifespan (Friedman, 2002). Adaptability is not just about physical modifications but extends to the adaptability of housing finance, regulations, and community infrastructure to support diverse life scenarios. The trend results from society's accelerating demographic, economic, lifestyle, environmental, and technological transition, creating a desire for flexible dwelling forms among architects, builders, and customers.

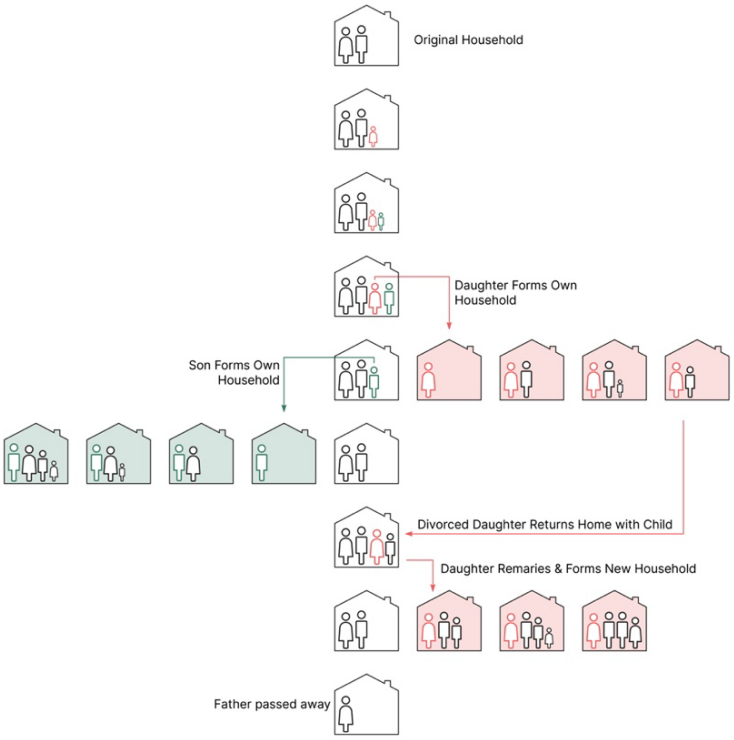

Figure 1.7 Houses should be flexible to accommodate changes during the residents' life stages, such as the growth of families, unexpected life circumstances and aging

1.2.3 Circularity

The concept of circularity in housing is a response to the escalating environmental crisis and resource scarcity. It refers to an approach that promotes sustainable and environmentally friendly practices in a circular economy (Coste-Maniere et al., 2018). The evolution of the built environment requires a radical rethinking of how homes are designed, constructed, and deconstructed. As society adopts climate-focused strategies for the built environment, the main principles of circularity in housing are reducing energy consumption, minimizing waste, and lowering carbon emissions throughout the design process.

By considering the entire lifecycle of the building from construction to deconstruction, designers involved strategies such as using renewable or recycled materials, designing for deconstruction, optimizing energy efficiency, and implementing effective systems for waste and waste recycling systems. The goal is to create environmentally adaptive homes and contribute to a more circular economy. Forecasts suggest that by 2020, human demand on Earth's ecosystem will outpace nature's ability to regenerate by approximately 75 percent, and by 2030, this demand will be double the Earth's regenerative capacity - effectively requiring the resources of two Earth planets to fulfill human needs (European Union, 2018) (Figure 1.8). Currently, humanity consumes resources at a speed 50 percent faster than what nature can replenish (European Union, 2018). The strain on finite, non-renewable resources like fossil fuels and minerals is escalating due to factors such as population growth, climate change, and environmental deterioration.

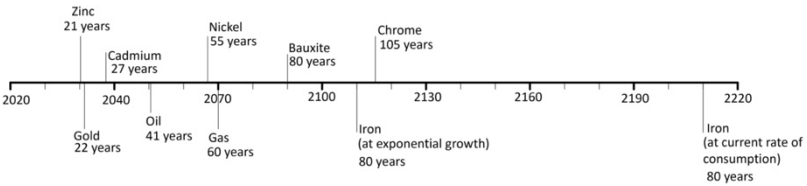

Figure 1.8 The strain on finite, non-renewable resources like these minerals is escalating due to factors such as overconsumption, waste, and climate change

Since certain regions of the world currently have a severe shortage of resources, further depletion would have devastating social and economic effects on progress. Designing houses and other infrastructures that support renewable and sustainable resources can help partly solve this issue by preventing shortages. Designing for climate change adaptation as a future strategy is the unifying element of all these figures and forecasts. Widespread integration of renewable energy and resources will be a part of the process to support development.

1.3 Sustainability as a Design and Planning Framework

In design and planning, the essence of sustainability lies in its emphasis on long-lasting impacts, resource utilization efficiency, and the promotion of social equality (Figure 1.9). This perspective champions the judicious use of resources, prioritizing renewable, reclaimed, or recycled materials and advocating for techniques that conserve energy and water. In addition, durability and adaptability to future requirements or shifts are integral aspects of sustainable design, considering the local environment, culture, and materials, ensuring the design harmonizes with and respects its immediate context. A sustainable approach is committed to minimizing environmental impact and curtailing pollution, waste, and destruction of habitats. At its core is social equality, promoting inclusivity and accessibility in design and planning, thereby ensuring society-wide benefits. Sustainable design also touches on health and well-being, fostering environments that positively affect mental and physical health. In the face of global challenges like climate change, sustainable design and planning consider resilience, preparing for extreme eventualities and incorporating redundancy into critical systems. Various techniques come to the forefront in this context, such as green building design, sustainable urbanism, permaculture, and participatory design processes. In essence, sustainability in design and planning is a multidisciplinary effort to create economically viable, ecologically sound, and socially equitable systems that appeal aesthetically. This calls for innovation and cross-sectoral collaboration.

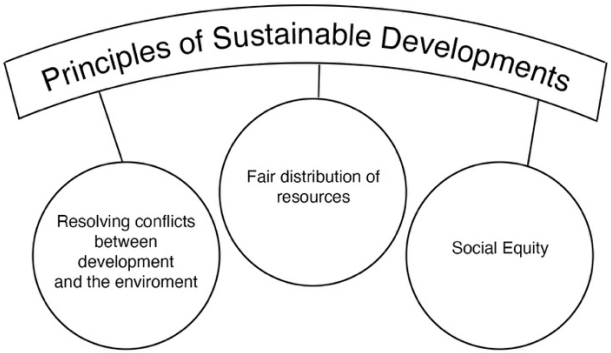

Figure 1.9 Key principles of sustainable developments

1.3.1 Brief History of Sustainability

The concept of sustainability has been rooted in various cultural, scientific, and political contexts, though it has gained significant prominence over the last few decades. Historically, indigenous peoples have had sustainable and biocentric ways of existence, living, and learning for thousands of years (Moore and Nesterova, 2020). Their sustainable living has supported communities in growing toward positive, happy, and inclusive futures and harmonizing their existence with nature. There are over 5,000 different aboriginal groups that speak over 7,000 languages (Moore and Nesterova, 2020). Despite such diversity, all the Indigenous cultures have commonalities. Indigenous knowledge is built on peaceful relationships with people, an understanding of the Earth's boundaries, and lengthy histories of adaptive practices that are crisis-resilient (Harvey, 2009). Based on their traditional belief, aboriginal peoples believe themselves to be part of creation and think that they were created from the land by the Creator Spirit, who provided for their gifts of nature from the Earth or the mother, and each person has a responsibility to care for the Earth (Moore and Nesterova, 2020). Aboriginal spiritual links with land ensure everyone respects and preserves the Earth’s resources for future generations. Indigenous ways of knowing, being, and seeing the future focus on land management, interconnections, and recognizing interactions between people and the natural environment as crucial entities that need support, mentoring, and recognition in everyday life.

The concept of sustainability in its contemporary form began to take shape after the Industrial Revolution, and with the onset of technological advancements, people started recognizing the environmental impacts of human activities (Du Pisani, 2006). The availability of urban occupations led to a fast expansion in the city population, frequently leading to congested areas. Cities were filthy because of the mechanization of production chains and relied on coal as an energy source. Additionally, unsanitary living conditions and inadequate housing contributed to the rise of several diseases (Du Pisani, 2006). Buildings and neighbourhoods have replaced extensive agricultural and forested land, and a sizable quantity of natural resources have been seized to develop and maintain the infrastructure necessary for these car-dependent lifestyles. Environmental deterioration of soil, groundwater, and natural habitats has rapidly wiped-out complex ecosystems and endangered species. Because of the detrimental environmental effects, there is an urgent need for "green thinking," which entails thoughtfully integrating ecology into the environment and society.

A formal statement signed in 1969 by 33 African nations and sponsored by the International Union for Conservation of Nature (IUCN) was the first to use the phrase sustainable development. The United States Environmental Protection Agency was founded in the same year, and its rules have greatly influenced the development of theories and practices in global environmental policy. Sustainable development is defined as “economic development that may have benefits for current and future generations without harming the planet's resources or biological organisms" by the statute that formed the NEPA (the National Environmental Policy Act, 1969).

Sustainability gained prominence in the 1970s and 1980s. One critical moment was the publication of the Limits to Growth report in 1972, commissioned by the Club of Rome. This report warned of potential future resource shortages if unchecked growth continued. Another critical turning point was the Brundtland Report, published in 1987 by the World Commission on Environment and Development. The Brundtland Report was crucial in raising awareness of the concerns surrounding development for the earth and our future through sustainable development.

Sustainability has been integrated into almost every sector, from agriculture and economics to energy production. The United Nations' Sustainable Development Goals are a prime example of the worldwide dedication to sustainability, tackling environmental, economic, and social factors to guarantee everyone a more sustainable and prosperous future. Furthermore, sustainability principles extend beyond just economic, social, and ecological considerations; they profoundly impact architectural design and construction, dictating our understanding of environmental integration within these designs. The growing prevalence of green building certifications is a testament to the increasing commitment to enhance sustainability efforts.

The US Green Building Council developed the widely recognized green building certification programme, Leadership in Energy and Environmental Design (LEED) (USGBC, n.d.). It provides a framework for environmentally friendly practices pertaining to the design, construction, operation, and maintenance of buildings and neighbourhoods. LEED promotes sustainability by assessing performance in essential areas such as water efficiency, energy usage, material selection, indoor environmental quality, and innovative design. Although green construction may entail higher upfront costs, LEED buildings often yield long-term cost savings through reduced energy and water expenses. They may also qualify for tax breaks, zoning allowances,

and other incentives in some areas. Additionally, with sustainability gaining importance among consumers and businesses, LEED certification can boost a building's market appeal. Research indicates that certified green residential properties, including those with LEED certification, register around four percent lower vacancy rates than non-green properties. Furthermore, their lease-up rates often exceed the average by approximately 20 percent (USGBC n.d.). Therefore, LEED is a crucial tool in steering the industry towards sustainable practices, significantly mitigating climate change, enhancing health and well-being, and fostering sustainable economic growth.

From the past to the present, sustainability has evolved as a crucial idea in international discourse, influencing practices and policies to strike a balance between human advancement and Earth’s health. For the first time, a theory linking human advancement to the necessity of resource management best practices had been developed. This implied a dramatic shift in sustainability, particularly ecological sustainability. Additionally, it represented an essential aspect by situating it within human development's social and economic framework.

1.3.2 Definitions of Sustainability

Sustainability, with its multiple dimensions encompassing both human and natural aspects, is a multifaceted concept that requires a deep comprehension of its fundamental principles to guide subsequent architectural designs. With the urgent need to tackle issues such as urban sprawl and insufficient services in underprivileged neighbourhoods, there is a demand for a shift in current urban development. This transformation necessitates creative and sustainable architecture and urban planning resolutions to mitigate these problems. One of the most widely recognized definitions comes from the United Nations Brundtland Commission Report in 1987. This report introduced the concept of sustainable development, defining it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"(World Commission on Environment and Development, 1987). This definition implies a balance between environmental protection, social equity, cultural diversity, and economic growth, often referred to as the four pillars of sustainability. By integrating the four pillars into the built environment, an enhanced quality of life can be achieved for everyone, regardless of their financial situation or geographical location. The following details on each

dimension will aid in understanding their significance in creating sustainable homes (Figure 1.10).

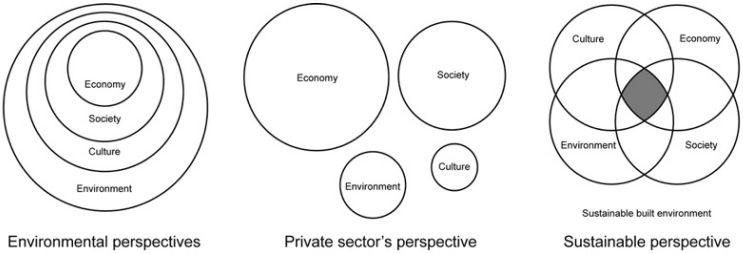

Figure 1.10 Societal, economic and environmental issues must be equally considered by all stakeholders in a decision-making process

Environmental sustainability refers to the mindful engagement with our surroundings to prevent the exhaustion or deterioration of natural resources, thereby maintaining enduring environmental quality (University of Alberta Office of Sustainability, 2021). As a vital facet of the broader sustainability concept, it includes aspects like resource conservation, ecosystem health, reduction of pollution, climate change mitigation, and sustainable development. The goal is to limit the use of exhaustible resources, promote recycling, and advocate for renewable alternatives. It also highlights the necessity of preserving varied ecosystems, habitats, and species. Moreover, environmental sustainability implies curbing emissions and waste to protect air and water quality and formulating strategies to diminish and adapt to climate change effects. Sustainable development, which aims to cater to today's needs without jeopardizing the future generations' ability to fulfill their own, is integral to this perspective (University of Alberta Office of Sustainability, 2021). Hence, environmental sustainability encompasses individual, corporate, and governmental choices to safeguard the environment and assure the planet's health and vigour for the generations to come.

The social aspect of sustainability underscores improving the quality of life for individuals and communities and ensuring an equitable distribution of the benefits of sustainable development across all societal levels. This includes fairness and equality, striving to provide a balanced distribution of resources and opportunities across diverse social segments, and tackling disparities in income, health, education, and beyond. Focusing on community advancement helps establish resilient, inclusive societies,

offering avenues for social engagement and civic participation. For example, the design of densely populated housing units featuring outdoor social spaces and gardens for residents to interact and cultivate food can enhance their overall well-being and physical activity, serving as a conduit towards achieving social sustainability. Social sustainability further highlights the necessity for everyone to access fundamental services like healthcare, education, housing, and utilities, regardless of their financial status or background. By integrating these elements, social sustainability underlines the interconnectedness of individual and community wellness, economic stability, and environmental conditions, advocating a comprehensive approach to sustainable development.

The essence of economic sustainability lies in a country or municipality's ability to uphold stable and accessible financial systems (Davidson, 2010). This is fundamental for communities and individuals to acquire the necessary resources to fulfill their needs and sustain their financial autonomy within the economic framework. As growing income disparities bear heavily on families, the development of building solutions that counter market inflation is essential for sustainable architectural growth. Effective resource management forms a pivotal part of this strategy, intending to reduce waste and optimally utilize all resources; natural, human, and financial. The long-term cost of home ownership can be reduced by designing homes with superior energy efficiency and minimal water consumption. This can be achieved through by installing energy-efficient windows, solar panels, passive ventilation systems, and water-conserving faucets. These measures can lower monthly expenses while positively contributing to environmental preservation. Ultimately, economic sustainability is about establishing and upholding a robust, resilient economy that benefits everyone, present and future, within the confines of environmental limits.

Cultural sustainability involves the conscientious preservation, evolution, and dissemination of cultural heritage, identities, traditions, and values in a way that honours diversity, fosters social unity, and aids sustainable development. It encompasses the protection of tangible cultural elements like monuments, artifacts, and landscapes, as well as intangible facets such as languages, traditions, arts, and practices. Cultural diversity is at the heart of cultural sustainability, ensuring that every cultural group can express and cultivate their distinct cultures. Encouraging intercultural dialogue and understanding is vital, as well as advocating for social cohesion, peace, and mutual respect through education, cultural exchange programs, and