

URBAN RECREATION AREAS IN TERMS OF RESILIENCE TO CLIMATE
CHANGE: THE CASE OF HUNTER’S POINT SOUTH PARK, NEW YORK CITY



by
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URBAN RECREATION AREAS IN TERMS OF RESILIENCE TO CLIMATE
CHANGE: THE CASE OF HUNTER’S POINT SOUTH PARK, NEW YORK CITY

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ABSTRACT

URBAN RECREATION AREAS IN TERMS OF RESILIENCE TO CLIMATE CHANGE: THE CASE OF HUNTER'S POINT SOUTH PARK, NEW YORK CITY

Climate change-induced natural disasters have severely affected cities and their residents. Rapid urbanization has led to crowded and vegetation-deprived urban areas, compounded by the greenhouse effect and inadequate infrastructure. The Intergovernmental Panel on Climate Change (IPCC) has highlighted the negative impacts of climate change on the environment and human health for over 40 years. Regrettably, the outcomes fall significantly short of what was anticipated, even to the extent of needing to be improved. Each year, millions of individuals are impacted, either directly or indirectly, by the occurrences resulting from climate change.

On the other hand, as impacted by the detrimental side effects of climate change, a concept arises: *resilience*. *Resilience* is the ability to withstand and rebound from disruptions, which is crucial in urban design to address climate-related disasters. Climate-resilient urban development emphasizes local governance, community involvement, and the integration of physical, social, and economic considerations.

This thesis study focuses on cities' resilience, explicitly looking at Hunter's Point South Park design case in Long Island City, New York. The study aims to examine the resilient design of the park created during Hurricane Sandy. Design assessments and research studies are conducted to comprehend better and improve resilience. This thesis explores potential actions within each category. The assessment section, therefore, focuses on creating a resilience evaluation for urban studies and aiding researchers. Several tools from organizations such as the Resilience Alliance, Rockefeller Foundation, Arup, and UN-Habitat are used in evaluation processes. In order to gain insights into resilience strategies, one can use assessment questions covering essential aspects such as resource use, funding, environmental impacts, spatial changes, organization, and stakeholder involvement. The study is aiming to develop an updated resilience toolkit for the designated area and beyond by integrating assessment tools. This process includes the creation of a comprehensive questionnaire that incorporates key elements from the Resilience Assessment Workbook and the Guide to the City Resilience Profiling Tool. The ultimate aim is to develop an updated

assessment toolkit tailored to the specific area of focus, which can be expanded in scope and applied to diverse areas within the field of resilience studies. As highlighted by the assessment studies, creating a sustainable project necessitates incorporating multiple systems from beginning to end. It is critical to engage community members, local authorities, and the natural environment and view their input as essential development components.

In conclusion, the involvement of stakeholders is crucial to achieving project resilience, as each stakeholder has a significant role to play. A systems thinking approach, which involves considering various factors and connections, is encouraged. Choosing durable, low-maintenance, and adaptable materials is essential to ensure sustainability. Selecting plant species and greenery that require minimal upkeep is also vital for enhancing the project. By implementing these strategies, the project's objective should be to achieve long-term sustainability, efficiency, and resilience. More field studies and research are needed to address climate change resilience further and guide development decisions.

ÖZET

İKLİM DEĞİŞİKLİĞİNE KARŞI DAYANIKLILIK AÇISINDAN KENTSEL REKREASYON ALANLARI: HUNTER'S POINT SOUTH PARK ÖRNEĞİ, NEW YORK

İklim değişikliğinin neden olduğu doğal afetler şehirleri ve kent sakinlerini ciddi şekilde etkilemektedir. Hızlı kentleşme, sera gazı etkisi ve yetersiz altyapıyla birlikte kalabalık ve bitki örtüsünden yoksun kentsel alanlara yol açmıştır. Hükümetlerarası İklim Değişikliği Paneli (IPCC), 40 yılı aşkın süredir iklim değişikliğinin çevre ve insan sağlığı üzerindeki olumsuz etkilerine dikkat çekmektedir. Ne yazık ki, sonuçlar, beklenenin çok gereisinde kalmakla beraber iyileştirme çalışmalarına da ihtiyaç duymaktadır. Her yıl milyonlarca kişi iklim değişikliğinden kaynaklanan olaylardan doğrudan veya dolaylı olarak etkileniyor.

Öte yandan iklim değişikliğinin zararlı yan etkilerinin yanında bir de yeni bir kavram ortaya çıkmaktadır: *dayanıklılık*. Dayanıklılık, iklimle ilgili felaketlere yönelik kentsel tasarımda çok önemli olan aksaklıklara dayanma ve toparlanma yeteneğidir. İklimle dirençli kentsel gelişim, yerel yönetimi, topluluk katılımını ve fiziksel, sosyal ve ekonomik hususların entegrasyonunu vurgular.

Bu tez çalışması, New York Long Island City'deki Hunter's Point South Park tasarım örneğini açıkça inceleyerek şehirlerin dayanıklılığına odaklanmaktadır. Çalışma, Sandy Kasırgası sırasında oluşturulan parkın dayanıklı tasarımını incelemeyi amaçlamaktadır. Dayanıklılığın daha iyi anlaşılması ve geliştirilmesi için tasarım değerlendirmeleri ve araştırma çalışmaları yapılmaktadır. Bu çalışma, her kategorideki potansiyel eylemleri araştırmaktadır. Bu nedenle değerlendirme bölümü, kentsel çalışmalar için bir dayanıklılık değerlendirmesi oluşturmaya ve araştırmacılara yardımcı olmaya odaklanmaktadır. Değerlendirme süreci kapsamında, Resilience Alliance, Rockefeller Vakfı, Arup ve UN-Habitat gibi kuruluşların kaynakçaları kullanılmıştır. Dayanıklılık stratejileri hakkında fikir sahibi olmak için kaynak kullanımı, finansman, çevresel etkiler, mekansal değişiklikler, organizasyon ve paydaş katılımı gibi temel hususları kapsayan değerlendirme soruları kullanılabilir. Amaç, değerlendirme araçlarını entegre ederek belirlenen alan ve ilerisi için güncellenmiş bir dayanıklılık araç seti geliştirmektir. Bu süreç, Dayanıklılık Değerlendirme Çalışma Kitabı ve Şehir Dayanıklılık Profil Oluşturma Aracı Kılavuzundaki temel öğeleri

de içeren kapsamlı bir anketin oluşturulmasını hedeflemektedir. Çalışmanın nihai amacı ise, kapsamı genişletilebilecek ve dayanıklılık çalışmaları alanındaki çeşitli alanlara uygulanabilecek, belirli bir odak alanına göre uyarlanmış ve güncellenmiş bir değerlendirme araç seti geliştirmektir. Değerlendirme çalışmalarının da vurguladığı gibi sürdürülebilir bir proje oluşturmak, baştan sona birden fazla sistemin bir araya getirilmesini gerektirmektedir. Topluluk üyelerinin, yerel otoritelerin ve doğal çevrenin katılımını sağlamak ve onların girdilerini temel kalkınma bileşenleri olarak görmek kritik öneme sahiptir.

Sonuç olarak, her bir paydaşın oynayacağı önemli bir rol olduğundan, paydaşların katılımı projenin dayanıklılığını sağlamak için çok önemlidir. Çeşitli faktörlerin ve bağlantıların dikkate alınmasını içeren bir sistem düşüncesi yaklaşımı teşvik edilmektedir. Sürdürülebilirliği sağlamak için dayanıklı, az bakım gerektiren ve uyarlanabilir malzemelerin seçilmesi önemlidir. Minimum bakım gerektiren bitki türlerinin ve yeşilliklerin seçilmesi de projenin geliştirilmesi açısından hayati öneme sahiptir. Bu stratejileri uygulayarak projenin amacı uzun vadeli sürdürülebilirlik, verimlilik ve dayanıklılığa ulaşmak olmalıdır. İklim değişikliğine karşı dayanıklılığı daha fazla ele almak ve kalkınma kararlarına rehberlik etmek için daha fazla saha çalışması ve araştırmaya ihtiyaç bulunmaktadır.

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LIST OF SYMBOLS/ABBREVIATIONS

AIA	American institute of architects
CRD	Climate resilient development
EDA	Economic development agency
EPA	Environment protection agency
ESG	Environment, social and governance
GHG	Greenhouse gases
GST	Global stocktake
IPCC	Intergovernmental panel for climate change
IWGCCH	Interagency working group on climate change and health
MDG	Millenium development goals
NDC	Nationally determined contributions
NOAA	National oceanic and atmospheric administration
OECD	Organization for economic co-operation and development
SDG	Sustainable development goals
SDSN	Sustainable development solutions network
UHI	Urban heat island
ULI	Urban land institute
UN	United nations
UNDESA	United nations department of social and economic affairs
UNFCCC	United nations framework convention on climate change
WHO	World health organization

1. INTRODUCTION

Climate change is the lengthy shifts in temperature and weather patterns. These shifts could be created by natural processes such as solar cycle fluctuations. Human activities, however, have been the primary contributor to climate change since the 19th century, notably the combustion of fossil fuels such as coal, oil, and gas. While climate change is becoming more hazardous to the planet, it has some negative consequences for the environment and humanity. While discussing these side effects and their adaptation processes, I also wanted to discuss the design process expected to occur in urban areas resulting in climate change. By researching urban resilience and what measures are being taken to define the most important characteristics of resilience and resilient elements, the study aims to contribute to this issue while designing the public places many city dwellers would frequent. Using some of the resources created by experts in their field and along with the literature reviews, the study can inform researchers about the history of climate change and how it's related to urban resilience.

1.1. AIM OF THE STUDY

This study aims to provide a guideline for resilience to climate change by addressing the system's priorities according to the key elements of the selected area, Hunter's Point South Park, located in the east riverside of NY. The case study area is chosen since it's one of the largest metropolises in the world from both an economic, social, and cultural standpoint. New York's vitality and resilience are critical to the United States and the rest of the world. The research focuses on design aspects, resilient urban design concepts, and the purposeful and meticulous design elements used to create durable urban spaces that can stand out after major disasters.

The literature reviews, as well as the current UN agendas and IPCC Reports, will be analyzed to observe the interconnections between resilience and climate mitigation. As a result, the purpose of this research is to investigate the design objectives that define the primary features of resilience strategies in terms of adaptation and mitigation measures to the detrimental effects of climate change.

1.2. SCOPE OF THE STUDY

The primary goal of this thesis study is to define the lead effects of climate change internationally, then locally and to observe the interlinkage with urban resilience in a way in which elements of urban environments and cities are the most harmed by this abrupt harm, and what can we do to prevent further damage. The study consists of 5 chapters.

Firstly, the current UN and IPCC Reports and literature reviews are thoroughly examined, and made sure the guidances are followed. Observing and defining climate change, its effects, and its causes both locally and internationally are key. Secondly, the historical background of the concept of climate and climate change is examined through diverse literature reviews. How these shifts are changed over time and how they affect humans and the environment and what projections are on the way. Next, assessing key elements of resilience and the concept in diverse disciplines will be a central focus. “Climate Resilient Development” techniques will be examined globally and then the example of New York will be forthcoming. The 4th chapter of the study consists of the assessment criteria of resilience and resilient development interactions with sociological and ecological environments. Lastly, the case study of New York will enable the thesis study to exemplify the design and materials used in a resilient composition. This study aims to provide a comprehensive understanding of the risks and negative impacts of climate change as it pertains to built environments also in New York. As part of a comprehensive approach to resilience thinking in New York, design elements must be utilized to create more resilient compositions, opportunities that contribute to resilience, opportunities, and necessities in a resilient design approach, and design elements must be included in a comprehensive approach.

1.3. METHODOLOGY OF THE STUDY

Firstly, the literature reviews, books, journals, and conference proceedings regarding climate change and resilience subjects have been thoroughly reviewed while conducting the fundamental research for the thesis. The study conducted throughout the literature evaluation demonstrated that climate change poses a threat to many areas of the environment and health. It has been revealed that climate change has a direct impact not only on the environment and health but also on urban resilience. Resulting the first phase of the research study, in chapter 4, the assessment of resilience is made throughout the Resilience Alliance’s workbook for practitioners. The 5th chapter allows me to introduce the research site, Hunter’s Point South

Park in depth, with it's hstorical background as well as the sustainable and resilient design elements implemented to the park and how it values the neighborhood and the city that it's part of.



2. THE CLIMATE CHANGE: INTRODUCTION AND DEFINITION

Climate change is defined by the United Nations Climate Change Action Plan as lengthy shifts in temperature and weather patterns [1]. These shifts could be generated by natural processes such as solar cycle fluctuations. Human activities, however, have been the primary contributor to climate change since the 19th century, notably the combustion of fossil fuels such as coal, oil, and gas.

Nearly thirty years ago, the first mention of climate change appeared in the medical literature. Professor Alexander Leaf of Harvard Medical School and Chair of Medicine at Massachusetts General Hospital authored an article titled “*Potential Health Effects of Global Climatic and Environmental Changes*” for the New England Journal of Medicine. In a seminal article, Professor Leaf discussed the topic of climatic and environmental changes caused by human activity. This topic has been widely covered in the news lately [2]. The article raises important questions such as whether we should be alarmed by the projected rise in mean temperature by 2° to 5°C over the next 100 years, or the potential rise in oceans by 1m in the next 50 to 100 years. The article also asks how these changes will impact human health and whether we can accurately predict their consequences to take appropriate action. Given the uncertainty surrounding these changes, the article questions whether it would be wise to delay action or put it on the back burner while we wait and see. Nine years later, in 1997, the famous Canadian ecologist, C.S. Holling, published an article on “Regional Responses to Global Change”, where he mentions a Special Focus that captures the experiments conducted in the field of climate change [3]. He states as the current and developing class of global concerns that pose fresh threats to the integrity of ecosystems and local economies are the main focus of these experiments. Examples include the effects of declining biodiversity, the creation of new illnesses, and the hemispheric disruption of animal movement. In this Special Focus, the most evident contemporary concern is highlighted. Even while more evidence of the harmful consequences of climate change is being gathered every day, it has only been in the last 30 years that these effects have been recognized as a harmful (alarming) threat.

The very beginning of **the IPCC 2022 6th Report** [4] states that climate change has caused adverse effects on both nature and people, as natural, social, and climate systems are interdependent. Vulnerable people and systems are more severely impacted by climate extremes, with some irreversible impacts. To create a just, fair, and sustainable world, limiting global warming to 1.5°C across all sectors and regions is crucial. There is a strong interdependency between nature and urban environments. Carbon emissions will inevitably continue to increase as cities continue to build unplanned infrastructure resources to accommodate growing populations. A renowned academician as well as the first White House National Climate Advisor, Regina McCarthy states during the interview of EdX Harvard University course, **The Health Effects on Climate Change**, that *"It looks at many years of trends to understand what's happening with the climate and what is causing the increase in the temperature that is getting so dramatic these days. And I feel very confident that the science is very clear, given the IPCC work, and the consensus among the vast majority of scientists. But the challenge then becomes, how do you take this science and make it personal for people?"* [5]. This line makes us all ponder how significant and relatable the issue was and continues to be.

Worldwide, over 50% of the population now lives in cities, meaning that addressing climate change in the 21st century will largely involve mitigating its effects in developing city centers. [6]

The Organization for Economic Co-Operation and Development (OECD) recently proposed a Strategic Orientation Plan the 30th point of the proceedings emphasizes the importance of taking globally ambitious climate action in a fair and effective manner [7]. This means that efforts to reduce carbon emissions should not simply shift the problem from one part of the world to another. Fossil fuels and excessive energy consumption are major contributors to carbon emissions and should be reduced.

When discussing climate change, we must consider greenhouse gases as a major source of climate change. *Environmental Protection Agency* in United States (EPA) made a collaborative research with United Nations that states GHG emissions are caused mainly by human activities in large cities [8]. These activities are (and are not limited by) using fossil fuels for energy, heat, and transportation. While greenhouse gases vary from fuel combustions, energy industries, and manufacturing industries to transportation, aviation, and other related or independent sectors as can be observed in the United Nations Climate

Change Greenhouse Inventory Data , the sources of GHG are many and efforts need to be shown to minimize it's adverse effects to below 5% in the upcoming 8 years to reach the goal of 2030 [9].

IPCC 2022 Climate Change 2022 Report states in its introduction part the interconnectivity of climate, biodiversity, ecosystems, and human societies and incorporates knowledge across the environmental, biological, social, and economic disciplines more strongly than preceding IPCC reports [4]. It is imperative to evaluate climate change impacts and risks, as well as adaptation, within the context of concurrently unfolding non-climatic patterns, including habitat loss, inappropriate resource consumption, degradation of land and ecosystems, rapid urbanization, demographic changes, inequalities, and pandemics. Working groups have cited some key notions that attribute deeply to this matter such as *risk, climate-related hazards, exposure, and vulnerability*. Then comes adaptation, which refers to the process of adjusting to the actual or expected climate and its effects. In human systems, it aims to minimize harm and take advantage of beneficial opportunities. In natural systems, adaptation is the adjustment process to the actual climate and its effects, which can be facilitated by human intervention. When a sudden change occurs, adaptability to the current state is essential and to take further precautions are necessary. Another important term is mentioned in this report: "Resilience". According to the common terminology of the IPCC Report, **resilience**, the ability of social, economic, and ecosystem systems to adapt to a hazardous event, pattern, or perturbation by reacting or reconfiguring in ways that protect their essential components, identity, and structure, as well as biodiversity in the case of ecosystems, is characterized by resilience [10]. In another sense, a person is considered to be resilient if he or she can adapt, learn, and/or change.

Research by Leichenko indicates that the concept of resilience is gaining traction in a variety of works related to cities and climate change [11]. In spite of some conflict among these various works of literature about how to define and measure resilience, there is widespread agreement that urban areas must become adaptable to a broader range of stressors and disruptions in order to be prepared for climate change; and attempts to facilitate climate change resilience must be integrated with initiatives to promote urban development and sustainability.

The relevance of resilience in the context of mitigating the harmful side effects of climate change has become increasingly critical over time. From the Kyoto Agreement of 1997 [12]

to the latest IPCC 2022 Report [4], it's clear to observe the seriousness of the matter. The latest report's chapter 18th, *Climate Resilient Development Pathways*, is specifically allocated to finding pathways, understanding the existing developments, making connections between development and climate action, and understanding the various elements involved in achieving a more successful structure to enable a more strong and livable future [13]. The detailed IPCC 2022 Report includes the core concepts of *Climate Resilient Development* (p.28-33), and they presented the various concepts to us under headings that we can examine in the outline [4].

Climate change and environmental preservation have long been a source of worry on the world stage. Adding *resilience topics* and *climate resilience development* to the current agenda, we come across the UN's *Sustainable Development Goals*, or briefly *SDGs*. The Sustainable Development Goals were established in 2012 at the United Nations Conference on Sustainable Development in Rio de Janeiro (SDGs) [14]. The purpose of standardizing these goals was to create a series of global objectives that address the world's severe ecological, political, and economic concerns.

The SDGs supersede the Millennium Development Goals (MDGs) [15]. They have initiated a global effort to combat poverty in 2000. MDGs have established quantitative, globally agreed-upon targets for combating extreme poverty and hunger, avoiding lethal diseases, and expanding primary education. The final MDG Report states that strategic planning may bring millions out of poverty, strengthen women and girls, improve overall health and well-being, and open up huge new avenues for better living [15].

The SDGs constitute a brave pledge to complete what predecessors commenced and tackle some of the world's largest immediate problems. As each of the 17 Goals is interconnected, success in one goal has an effect on the success of the others [14]. Climate change mitigation affects the way we take care of our natural environment, attaining gender equality or improving healthcare contributes to fighting poverty, and fostering peace and inclusive society reduces inequities and helps economies grow. In essence, this is our strongest chance to improve lives for coming generations.

The SDGs were approved at the same time that another historic deal, the Paris Climate Agreement, was signed in 2015. These treaties, together with the *Sendai Framework for Disaster Risk Reduction* agreed upon in Japan in March 2015, offer a set of shared criteria

and attainable objectives for reducing carbon emissions, managing the risks of climate change and natural disasters, and rebuilding better after a disaster [16]. In the current SDG Agenda, 17 goals represent important initiatives and they each identify up-to-date and crucial topics in establishing a more livable earth for mankind. Goal 11, Make cities and human settlements inclusive, safe, resilient, and sustainable, entails ensuring that everyone has availability to adequate, safe, and cheap housing, basic necessities, and services by 2030, as well as slum improvement [17]. Providing access to safe, affordable, convenient, and sustainable transportation systems to everyone; enhancing road safety, especially by increasing public transportation; and enhancing participation in urban planning and participation. Much importantly, by 2020, it offers to dramatically increase the number of cities and urban expansions incorporating highly established policies and plans for inclusion, resource efficiency, climate change mitigation and adaptation, disaster resilience, and develop and apply multifaceted disaster risk management at all levels following the Sendai Framework for Disaster Risk Reduction 2015-2030.

2.1. THE HISTORY OF CLIMATE & CLIMATE CHANGE

While defining climate change, we need to mention its history and historical findings. There are various literature reviews and books written on this subject. Researchers throughout the world have conducted numerous studies on this topic, yet the climate dilemma is still a crucial topic of interest as humans evolve and grow inharmoniously with nature.

In 1922, 2 scientists from Yale University, Ellsworth Huntington and S.Sargeant Visser wrote a book on “*Climatic Changes: Their Nature and Causes*” [18]. The book gives great examples of the diverse eras of humanity, starting from cosmic time and moving forward, it shows us the basics of how the evolution of humans impacted the climate and the environment. The authors make a strong case for the importance of climate in our lives, both now and in the past. Our food, clothing, shelter, recreation, occupation, health, and energy are all deeply influenced by the climate we live in. Even animals are impacted, as they have not developed artificial means of protection from the elements. For example, the thick-haired "husky" of the Eskimos is very different from the small and nearly hairless dogs found in Mexico. Plants are even more sensitive, with only a limited range of temperatures in which they can thrive. Any departure from these optimal conditions can lead to reduced efficiency, lower reproduction rates, and changes in characteristics. In extreme cases, it can even lead to suffering or death for individuals and species. Overall, climate plays a crucial role in shaping the world around us. Although this book was written almost a century ago, the current situation seems still challenging and needs a meticulous plan to apply. Almost 60 years later, in 1992, an English scientist, John T. Houghton presents, in this report, he refers to as supplement “*Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment*”, the author concludes that the main focal points of today are accentuated by scientific research findings since 1990 [19]. The evidence shows that human activities are increasing atmospheric concentrations of greenhouse gases, including carbon dioxide, methane, chlorofluorocarbons, and nitrous oxide. The sensitivity analyses indicate that the global mean surface temperature is unlikely to lie outside the range of 1.5 to 4.5°C for doubling CO₂. Over the last 100 years, the global mean surface air temperature has increased by 0.3 to 0.6°C, which is consistent with predictions of climate models and natural climate variability. However, this observed increase could be due to natural variability or offset by

other human factors, making the detection of the enhanced greenhouse effect from observations unlikely for a decade or more.

To appreciate the breadth of the research undertaken in this discipline, consider some of the scientists who contributed to them over the period of a century. For starters, John Theodore Houghton was a pioneer in the subject of climatic changes, and the principal contributor to the IPCC. Being a well-renowned physicist at the University of Oxford he has been a long-time researcher in climate change [20]. He made a significant impact on the field through his leadership at the Appleton Laboratory, the Meteorological Office, and the IPCC Science Board.

In 1990, John Houghton has decided to come up with a more determined vision to address climate change and prediction. He founded “The Hadley Center.” The Hadley Centre has become a key part of the Intergovernmental Panel on Climate Change's activities (IPCC). Despite its modest name, it has been involved in authoring periodical studies under the aegis of the United Nations that examine and warn global governments about the likelihood and potential consequences of climate shifts. The IPCC was founded in 1988, and John Houghton was a driving force behind it; he headed the scientific assessment body and was the principal author of numerous important papers. The assignment though was challenging. Getting approval from more than 100 varied national groupings had to be obtained while there was opposition from lobbying groups as well. Years later, he would obtain the fruition of his hard work along with his team. He and his group of scientists obtained the 2007 Nobel Peace Prize on behalf of the IPCC [21].

2.2. CLIMATE CHANGE AND IT’S CAUSES

As human activities increased and technology evolved throughout the time after the Industrial Revolution nature was affected by these changes [22]. The increase in urban infrastructure and replacements of low-rise buildings with 10-20 story buildings can be a few examples of these changes. In addition, car parks, shopping malls, and concrete constructions started to invade the urban settlements. This irregular and unproportionate urbanization, and the decrease in green and planted areas not allowing people to breathe have also had a negative impact. It’s possible to state that people started to disrupt the climate of the world they live with their own hands.

The physicist W.R. Frisken, in his research “*Extended industrial revolution and climate change*” states that to design an effective usage of human resources, everyone needs to think about the whole ecosystem; and the earth's climate is perhaps the most crucial aspect in this environment [23]. They should comprehend how the climate will shift and whether man's actions will have an impact on the climate. It seems obvious that if human actions are sufficiently massive to cause the climate to worsen, they may also be big enough to ameliorate it, at least for a small portion of the world's population. Understanding is also crucial for individuals whose interests may be stifling such studies. It brings out another question, the inclusivity of all the sectors, all the scholars and scientists to act together to achieve a more sustainably livable world.

Throughout the research, it's possible to observe that living a more sustainable and equitable lifestyle can support the achievement of low-carbon emission growth. Although two centuries passed, technological advances resulting from the industrial revolution have not benefited every individual equally simply because not every person has the same resources and financial abilities.

A government climatologist, J Murray Mithcell Jr. shares his research and opinions, in the article “*A preliminary evaluation of atmospheric pollution as a cause of the global temperature fluctuation of the past century*” [24]. He states that climatic change is a basic attribute of climate, which implies that climate is difficult to describe in the first place and that the changes caused by man's actions may first be difficult to remove from climate's 'auto-variation.' If humans wish to isolate negative impacts early on, they will need to supplement the observations of the real climate with data from numerical tests using the best available models. He explains the dilemma of climate and climate change as circumstantial reasoning is one path of thought. It starts with the conclusion that, according to numerous meteorological facts, the earth's large-scale climate has shifted in the past century. This shift happened at a period when a modern industrial human was only starting to establish himself as a formidable controller of his physical surroundings. So because the basic reason or causes of this climate variation have yet to be determined, it is maintained that one or more accidental outcomes of man's (historically unprecedented) actions cannot be ruled out as probable contributory factors. According to Mitchell, the alternative method of thinking is more straightforward and, sometimes in ways, more appealing. This one is based on the reality that high concentrations of air pollution, such as those found in cities and heavy-

industry regions, have demonstrable impacts on local weather and climate. Reduced sun radiation and visibility, increased fog and low cloudiness, and perhaps unusual temperature conditions are among these impacts.

It comes down to the fact that, along with the natural ways of climate shifts happening, climate change was accelerated by human activities and innovations. So, would there be a more feasible, more genuine way to implement the innovations? Well, lifestyle changes also are one of the main contributors to climate change. J.Roy and S.Pal explain in their research paper “*Lifestyles and climate change: link awaiting activation*” that since the Rio Summit in 1992, the goal has been on sustainable living and consumer habits [25]. Ecological footprint calculations suggest that it currently takes the Earth more than a year and two months to restore the resources utilized in a single year. Simple eco-logical reasoning and the effects of global warming compel the renunciation of high-consumption lifestyles to minimize the throughput of energy and materials in economic systems. 'Environmental modernization,' which follows high wealth and enhances our ability to behave in a more ecologically responsible manner, cannot be linked to GHG reduction behavior. Carbon emissions are not reducing in countries with growing incomes such as the United States. Also, with the increase in wealth, the consumption of energy, land, and resources, also known as the ecological footprint, has not decreased. Briefly, the overall energy consumption in most industrialized nations continues to rise. This research shows that developed countries also can not comply with sustainable ways. Using scooters instead of cars, electric bikes instead of motorbikes, subway and public transportation instead of cars, and driving by shared cars instead of taking flights are some of the eco-friendly and feasible examples.

Sir John T. Houghton, in his article “*Climate Change and Sustainable Energy*” stated that those in developed countries have enjoyed the benefits of fossil fuel energy for many generations [26]. However, everyone must be mindful of the responsibility to address climate change, especially as it will have a greater impact on poorer nations and further widen the gap between the rich and poor. An article from over 30 years ago still has a huge actuality and the world needs to adjust its needs more than ever on this matter. Fossil fuel consumption didn't stop completely or even reduce since it was one of the GHG contributors mentioned in IPCC 2022 [4].

When discussing the causes of climate change, John T. Hardy states several aspects of the topic and adds visuals in his book “*Climate Change: Causes, Effects, and Solutions*” [27].

He states that "*climate change*" is a change in climate that is ascribed either directly or indirectly to human activity, modifies the composition of the global atmosphere, and is seen across similar periods in addition to natural climatic fluctuation. Human activities produce a variety of greenhouse gases that contribute to climate change. To assess the solo and cumulative impacts of these substances on the Earth's climate, we must look at their total amount, natural and human sources to the atmosphere, rates of loss to natural sinks, past and predicted rates of growth, and individual and cumulative heating capabilities. In these visuals, he shares "*the United Nations Environment Programme: Introduction to Climate Change*" where the contributing materials (the chemicals) of greenhouse gases are explained in detail. The details of these harmful materials are presented in another scientific research "*Climate change and greenhouse gases*" where authors discuss in detail GHG and the earth-atmosphere energy balance [28]. While talking about the persistence of greenhouse gases, they state that mathematical models that mimic future additions and removals are used to forecast the future persistence of anthropogenic greenhouse gases in the atmosphere. These models' predictions of greenhouse gas concentrations are vulnerable to considerable uncertainties in the impacts of both natural processes and human actions. Also, while explaining predicted climate change from increased greenhouse gases in their research, the authors state that some of the statistical approaches to rises in greenhouse gas levels involve rises in mean surface air temperature, rises in global mean rates of precipitation and evaporation, rising sea level, and shifts in the biosphere. Many of these forecasts are heavily reliant on computer models that replicate fundamental geophysical processes.

Tim Herzog, in "*World greenhouse gas emissions in 2005*" states the facts that transportation and energy use produce carbon dioxide which is one of the main contributors of GHG and there's a detailed visual extant in the research as well [29]. In the meantime, he and the group of scientists analyze in the 2005 publication "*Navigating the Numbers: Greenhouse Gas Data and International Climate Policy*" [30] that carbon dioxide (CO₂), the main heat-trapping greenhouse gas, has increased by 35% in the atmosphere since the start of the industrial revolution. This rise is mostly due to the use of fossil fuels and deforestation. So we observe that in addition to chemicals contributing to climate change in a negative way, humans also contribute by harming the environment.

While mentioning the greenhouse gases, we can state that the greenhouse effect was first introduced in the science by Joseph Fournier in 1824 as stated in the book "*Greenhouse*

gases: Worldwide Impacts”, as a natural process of the earth’s atmosphere. The research specifies that alone without the natural greenhouse effect on Earth, life, as we know it today, would not be conceivable, according to the greenhouse effect and global warming [31]. To comprehend the causes and consequences of global warming, one must first comprehend the Earth's natural greenhouse effect and the functions of various greenhouse gases, such as carbon dioxide (CO₂).

2.3. CLIMATE CHANGE ON GLOBAL SCALE

Nowadays, globally, people tend to live in large cities rather than remote areas or suburbs because of increasing job opportunities and low transportation costs. Under these circumstances, we can observe that the green areas were replaced with more concrete. Statistical data is shown in Nate Berg's article from Bloomberg of 2012; the US Census Bureau's 2012 research states that over %80 of the population lives in cities and large urban areas. So, inevitably, this shift towards cities will have its effects on the climate globally [32].

2.3.1. The Numerous Side Effects of Climate Change

Nature nurtures and balances the climate as well. A scientific fact, living distant from nature and green negatively affects humans and human lives. Not only air pollution and exposure to hazardous chemicals, but cities might encounter much more significant threats. A recent article by researchers from McGill and Wageningen University, "*Climate change adaptation planning in large cities: A systematic global assessment* ," shows that a large number of the biggest cities in the world are situated in coastal regions, making them vulnerable to expected rises in sea level, storm activity, and related floods and that regarding the probable threats and other dangers related, cities are playing an increasingly active part in climate policy action, with well-documented mitigating experiences [33]. OneNYC 2050 is an outstanding example of well-documented strategic planning. Its purpose is to protect New York City's future by addressing current and future challenges. Through initiatives to address our climate crisis, promote equity, and reinforce our democracy, OneNYC 2050 is working towards building a robust and just city. This long-term strategic plan was created in compliance with Local Law 84 of 2013. The reports and summary [34] are shared with the public, giving details of all the changes over time with visuals that depict all the necessary steps to be taken.

The aim of OneNyc 2050 is to inform citizens better, show them accurate statistics, and guide them on what to do.

While dealing with the climate change challenge, another critical topic arises Urban Heat Island Effects (UHI). Urban Heat Island Effect, formed mainly due to the weather, the location, and the urban features, has varying sizes throughout time and space [35]. These are signs that urban environments will be affected by climate change. The constructed infrastructure and humans are affected by these effects—a recent study of C. Wang et al. states that the combined impact of the environmental challenges endangers human health, quality of life, and long-term development goals [36]. Annual heat-related fatalities are expected to increase from 32.1 per million in 1986-2005 to 59.2-81.3 per million with the 2.0 C warming. Continuing urbanization will increase the frequency of high-temperature severe events, leading to a three-to-sixfold increase in urban population exposure by 2090 and worsening population mortality. Thus need for more green and viable living areas is not a luxury but a must for humanity. The continuance of the studies illustrates the visual utility of green areas and contributes significantly to mitigating the harmful consequences of climate change. Urban Heat Island (UHI) effect, in this case, is not a local but a global problem nowadays.

The study of Nuruzzaman shows that The UHI arises when a large area of natural land is displaced by a manufactured constructed surface that absorbs incoming solar radiation or heat and re-radiates it at night [37]. In reality, this phenomenon may be found in practically any major metropolis. This impact is attributed to various causes, including human heat emission, surface cover, meteorological conditions, and air pollution. So it is clear to observe the disadvantages of this phenomenon which affects not one city in particular. However, the world in general, since skyscrapers and mega-structures have mostly supplanted short-story buildings. While observing the main aspects of the UHI, the ecological footprint mentioned in the research study of M. Santamouris et al., "*Estimating the ecological footprint of the heat island effect over Athens, Greece*" can be of guidance [38]. They state that the UHI contributes to an additional environmental strain. The researchers obtained results by calculating the increased ecological footprint caused by the heat island effect. The researchers explain the ecological footprint as the land and water area necessary to sustain the material quality of life of a particular human population continuously using current technologies. It is clear that as much as the green spaces disappear within the cities'

perimeters, the heat island effect will increase, and the ecological footprint will constantly change with new constructions built. Thus, the quality of life in the cities and built environments depend on the ratio of green areas where people can spend quality time and enjoy practicing their hobbies and sports. The leading causes of the UHI, as cited in the Nuruzzaman study, can be observed as low albedo materials, gatherings of people, the increase of using artificial air cooling systems, massive destruction of trees, urban canopy, wind blocking, and air pollutants [37].

2.4. POSSIBLE SCENARIOS OF CLIMATE CHANGE EFFECTS

Going through the many side effects of the ongoing climate shift as a challenge for our world for over a century, it is vital to state that it influences both humans and the environment. As stated in *World Health Organization's 2017 Update Booklet*, climate change and instability are triggering more violent heat waves, fires, and floods, as well as a rise in the predominance of food-, water-, and vector-borne illnesses [39]. Climate change will strain environmental and health indicators such as food security, poor air quality, and water quality. A climate-resilient future is dependent on lowering greenhouse gas emissions.

As explained through a visual out of the studies of Smith K.R et al., the climate change challenge is about social and environmental issues and health effects that directly interact with sustainable living (Page 2). Therefore, this issue is sensitive to a multifaceted dynamic and emerges as an issue that should be addressed by more than one sector working together.

The 2022 IPCC Report states that, given the visuals as well, climate change has already had a wide range of negative impacts on human activities, including water security and food production, wellness and well-being, and urban areas, settlements, and infrastructure. Environmental and health effects are interrelated. Researchers also observed that when one of the systems is disrupted or affected, there are deteriorations and changes in the functioning of the other (Figure 2.1. IPCC 2022 Report) [4].

In Figure 2.1. below, extracted from IPCC 2022 Report, it is possible to observe that climate change has impacted the ecosystem, health, and well-being in section b. Impacts include infectious diseases, heat, malnutrition, mental health, and displacement. In order to address the current state of climate change consequences, action must be taken before they become

worse than expected. We observe that climate change impacts the ecosystem, health, and well-being in section b. The impacts break down into infectious diseases, heat, malnutrition, mental health, and displacement. The study will break into three subcategories such as *health-related*, *environmental-related*, and *society-related*.

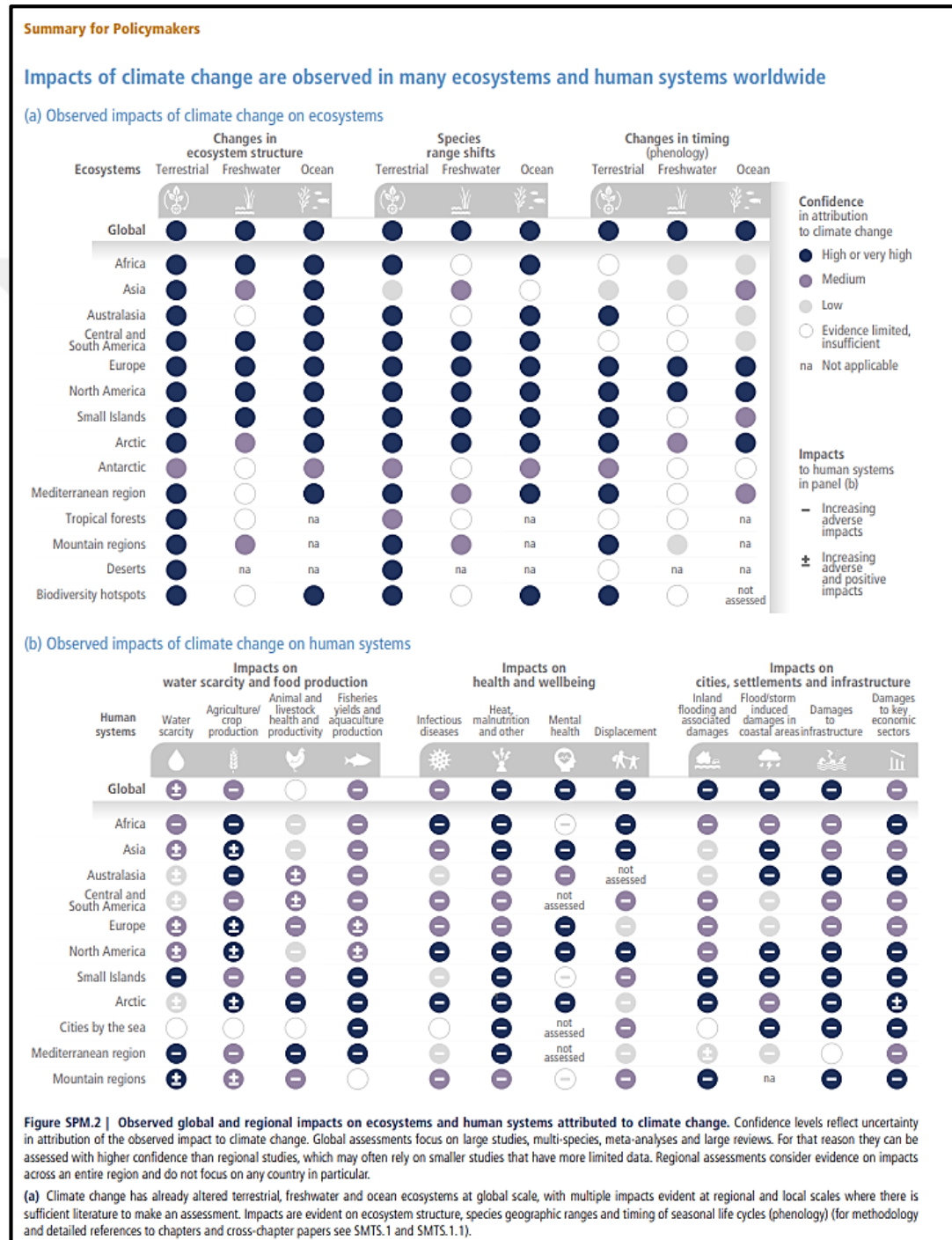


Figure 2.1 Impacts of Climate Change on both ecosystems and human systems [4].

2.4.1. Health Related Issues

Climate change has multiple adverse health effects, as seen in the chart above published by IPCC4. Also, the Harvard University research and course on "*The Health Effects Of Climate Change*" indicates that health should be the human face of climate change. In the diagram below, named "*Climate/Health Framework*" prepared by Harvard University, we can observe all the correlating aspects of climate shifts [40]. Figure 2.2. represents the systems, mechanisms, and conditions interlinked with the climate issue. The health-related challenges are not limited, but the ones that will be most affected are shown in the visual. The most mentioned 10 cases/ conditions, as stated in Table 2.1, are:

Table 2.1. Conditions and diseases [5]

Conditions / Diseases	
Heat Related Diseases	Trauma
Environmental Allergies	Vectorborne Diseases
Maternal & Newborn Outcomes	Cardiovascular Diseases
Waterborne Diseases	Mental Health Disorders
Respiratory Diseases	Nutritional Diseases

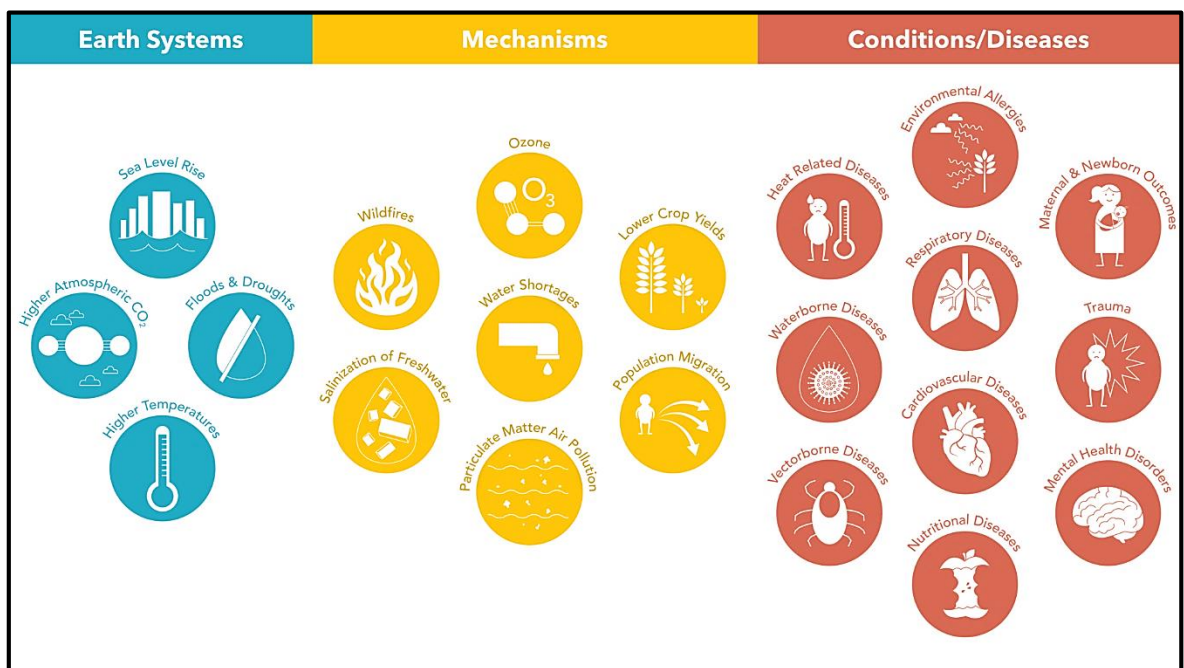


Figure 2.2. Climate/Health Framework [5].

So, in the next 7 years to reach the Paris Agreement 2030 vision, it's vital to accord high-level importance to adaptation and mitigation of climate change. Taking a good record of every necessary step, keeping in mind the consequences of not being proactive, and knowing that future generations and millions of species depend on our responsive actions is key to this matter.

Looking back to recent studies and published books, a lot of establishments and universities have contributed to this crucial topic. I'd like to initiate by referring to one of them as an example of the studies conducted to point out the effects of climate change on health and move along by showcasing diverse examples that complement each other.

In his 1989 essay, Doctor Alexander Leaf from Harvard University and Mass General aimed to explore the issue of climate change and its potential impact on human health and society. He emphasized the importance of keeping this issue in mind as scientists consider whether taking action or remaining inactive is the best approach. His article delved into environmental and climatic changes' effects on human health. The author shows the readers that these two concepts complement each other and are interlinked by adding the health-related parts of climate change to his essay, which he starts by describing its *ecological aspects*. He begins the article "*Health Consequences of Climate Change*" by informing readers that increased air pollution caused by climate warming can predict respiratory irritants and worsen lung conditions such as bronchitis, bronchiectasis, asthma, and chronic obstructive pulmonary disease, increasing morbidity and death [41]. Industrial activities, which will expand as the world population grows and more countries seek a higher standard of living, are also expected to worsen air pollution. He points out that thinning the ozone layer will affect the skin and increase carcinoma, commonly known as "*skin cancer*." Another fact, since it will affect all populations, an increasing prevalence of *cataracts* may be a more pervasive health effect of ultraviolet-B radiation than cancer. According to the Environmental Protection Agency (EPA), between 550,000 and 2.8 million more Americans born before 2075 would develop cataracts. The *loss of vision* caused by cataracts may already be partially restored by surgery and the insertion of prosthetic lenses.

Nevertheless, issues would still arise if the prevalence of cataracts among younger individuals rose significantly. A third outcome could be that recent years have seen much research on how *UV-B radiation affects the skin*. Ultraviolet-B radiation causes DNA breaks, changes in how keratinocytes and macrophages release cytokines, the redistribution of

lymphocytes and antigen-presenting cells, less effective antigen presentation by epidermal cells, the formation of suppressor cells in the epidermis that are resistant to UV radiation, and immunologic tolerance to UV-induced cutaneous tumors. Additionally, waterborne illnesses will occur more often as another outcome of increasing climate. Due to rising population density and air pollution from respiratory irritants, the prevalence of airborne illnesses is observed to rise significantly. People who are infected and unimmunized are likely to appear in nations with developed healthcare systems if rising sea levels and regional droughts cause significant population shifts. As a result, the incidence of diseases like *measles*, *pertussis*, and *poliomyelitis*, as well as that of *tuberculosis*, *leprosy*, and other *chronic illnesses*, will likely rise. Additionally, known to weaken the immune system, malnutrition increases the illness's likelihood and severity.

The research published in "Clinician's Corner" in 2004 by Andy Haines and Jonathan A. Patz walks us through the historical background of climate and gives us England and the United States as examples [42].

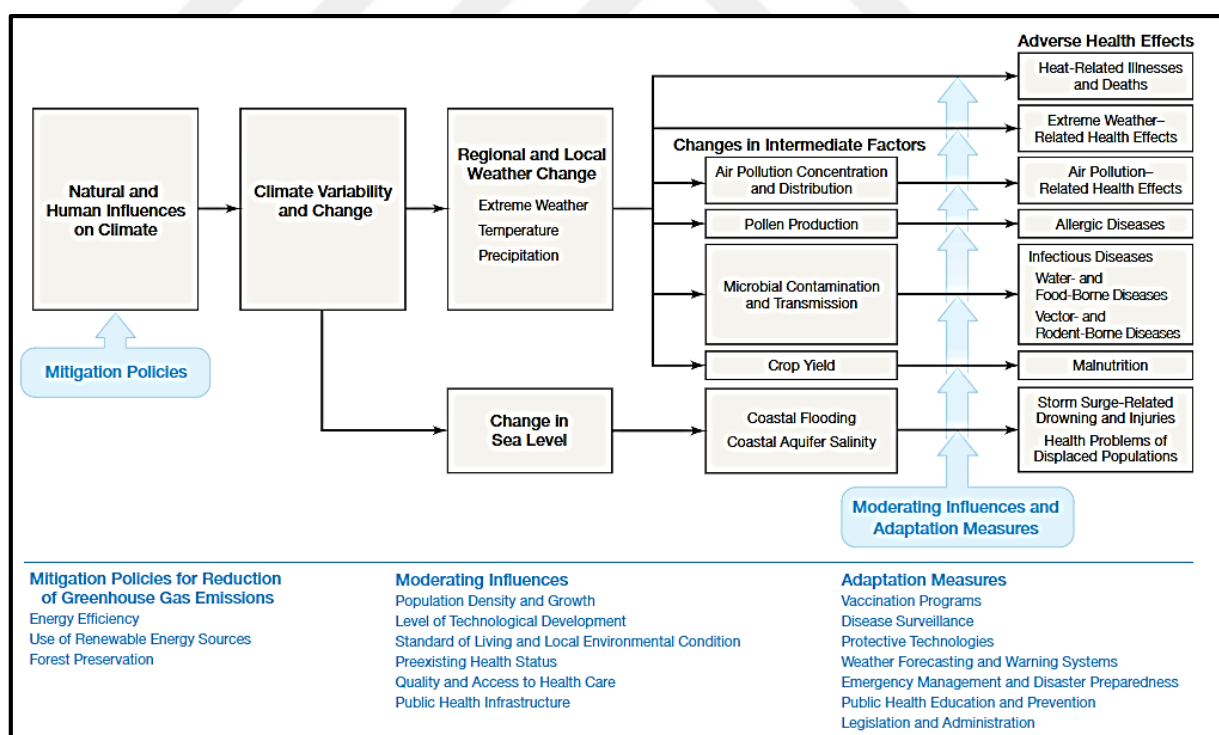


Figure 2.3. Diagram illustrating the various ways in which climate change can impact different aspects of human health [42].

In Figure 2.3, it is possible to observe some trends that appear. "*Natural and Human Influences on Climate*" create "*Climate Variability and Change*," which also creates "*Regional and Local Change*" and "*Change in Sea Levels*," which contribute to both "*Changes in Intermediate Factors*" and "*Adverse Health Effects*." Here, one more time, readers get to witness the interlinkage between climate change challenges and health-related issues. "*Adverse Health Effects*" are shown in the box on the right, which includes almost the same outcomes as the Harvard University research ones. This research study offers mitigation and moderation processes, as shown in the diagram in Figure 2.3. So, for every challenge, the audience is offered a solution, such as "*Mitigation Policies for Reduction of Greenhouse Gas Emissions*" and "*Moderating Influences and Adaptation Measures*," pointed out in blue. According to the authors of this research article, one of the most crucial tasks in dealing with climate change falls on physicians, and changes in the healthcare system are vital for adaptation to climate change.

In 2006, another study conducted in Australia by Woodruff R et al., "*Action on climate change: the health risks of procrastinating*," [43] remarks similar concerns. They state that in light of the growing worry about the pathway of climate warming and the acknowledgment that today's acts impact tomorrow's well-being, the *Australian Medical Association* and the *Australian Conservation Foundation* ordered a research study in 2005 to investigate the impact of a range of cutbacks in global greenhouse gas emissions on the rates of identified health effects in Australia. The authors discuss the implications of these two scenarios (a decisive policy action and no policy action) for two health outcomes: *heat-related mortality* and *dengue fever spread*. They also mention the consequences for mental health and neighboring nations. Concluding their study, they emphasize the importance of adaptation to climate change.

In 2010, a study collaboration of 20 researchers, "*A Human Health Perspective on Climate Change: A Report Outlining Research Needs on the Human Health Effects of Climate Change*" [44] was published [44]. The researchers are part of the ad hoc Interagency Working Group on Climate Change and Health (IWGCCCH) [45]. Their study includes 11 critical human health areas anticipated to be influenced by global warming. There is no occurrence order, and they are only alphabetically listed. The 11 areas are *asthma, allergies, and airway diseases; cancer; cardiovascular disease and stroke; alterations in normal development; heat-related morbidity and mortality; mental health and stress*

disorders; neurological diseases and disorders; nutrition and food-borne illness; vector-borne and zoonotic disease; waterborne disease; weather-related morbidity and mortality. They also imply clearly that until today, most climate change research has concentrated on environmental rather than health implications when climate change jeopardizes population well-being. So it is necessary to increase the scientific and awareness foundation of how it unfolds. The objective of this publication is to highlight gaps in the literature to comprehend climate shifts and health truly. Additionally, they offer a conceptual framework for this matter, shown in Figure 2.4.

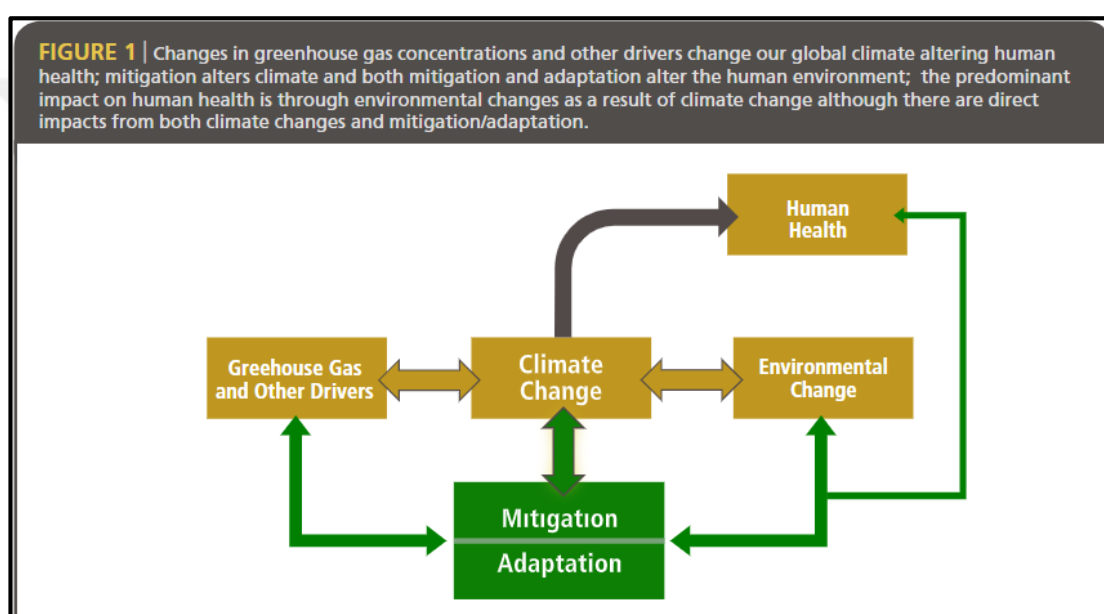


Figure.2.4. Conceptual framework [4].

According to the authors, in addition to the direct impact of heat on individuals, climate change has the most significant impact on human well-being because of changes in human habitat, such as rising oceans, shifting weather patterns, and decreasing fresh water supplies. Climate change mitigation entails measures taken to minimize greenhouse gas emissions and improve sinks that capture or extract carbon from the atmosphere to reduce the severity of climate change. Adaptation leads to the implementation of necessary steps to minimize the effects on health and the environment due to changes that are unable to avert through mitigation. As can be seen from the chart, with efficient steps and timely decisions, the side effects of global warming will be reduced, as well as the health problems that may occur.

As explained in, which stands as Figure 2.5 below, global warming has a direct influence on *five characteristics* of the human environment (*red lines, purple circles*), which in turn have an impact on other environmental parameters. These environmental changes then impact twelve different areas of human health (tan boxes). Mitigation and adaptation affect the human environment to address climate change and, as a result, human health. Finally, all climate-targeted health locations have vulnerable populations, and health systems play an essential role in addressing the health problems caused by climate change.

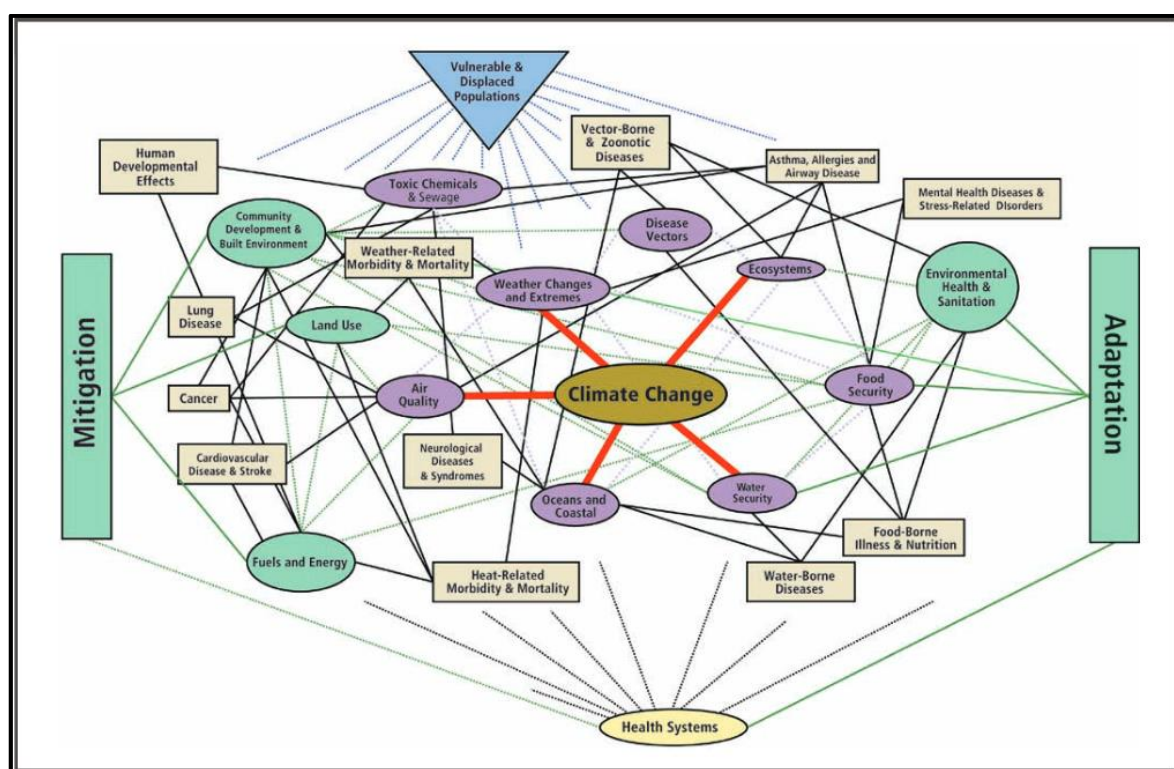


Figure.2.5. climate change impacts relationships with environment and health issues [4].

The climate-related health issues, according to the same research study, can be cited as follows:

Conditions such as asthma, respiratory allergies, and diseases affecting the airways.

- The disease characterized by uncontrolled cell growth, known as cancer.
- Health issues related to cardiovascular diseases and strokes.
- Illnesses caused by consuming contaminated food and the impact of nutrition.
- Health problems and deaths associated with excessive heat.

- The effects on human development caused by various factors.
- Disorders related to mental health and stress.
- Diseases and disorders affecting the nervous system.
- Diseases transmitted through vectors and those originating from animals.
- Illnesses caused by ingesting contaminated water.
- Health issues and deaths resulting from extreme weather conditions.

A decade later, a submission on health issues in the face of global warming comes in the scientific area, *The Lancet Countdown*, which is a collaborative study of a team of trained professionals and 35 top academic institutions and UN organizations from around the world [46]. The team takes Paris Agreement as a milestone of the studies. It states that while taking ownership of "progress toward achieving the mission and long-term objectives of the Paris Agreement, as well as opportunities for more effective action and support to achieve its purpose and goals," the global stocktake (GST) must grasp advancement forward into lowering health effects and effects of global warming, along with improvement toward climate policy that really can achieve health benefits to current and future populations. The updating and enhancement of actions and support by Parties under the overarching goals of the Paris Agreement will be of utmost importance. The GST (global stocktake), agreed upon during Paris Agreement, is the procedure for taking ownership of the Agreement's execution to assess the globe's joint success toward attaining the Agreement's purpose and long-term goals .

The team further on, observed various health-related problems caused by the use of fossil fuels and other contributors to global warming. In the "*Loss and damage*" chapter, they brief their study by highlighting the essential topics to consider. They once again emphasize the importance of controlling climate change and minimizing its impact, adding that both the consequences and health risks of climate change must be continuously monitored to guide the adoption of efficient and effective strategies to avoid, minimize, and rectify the human components of loss and damage. According to the statement, the study was carried out using various indicators developed through a tiered approach. The first echelon of indicators monitors the trends in health hazards related to climate change.

In contrast, the second level combines environmental and climatological data with demographic and epidemiological data to estimate the exposure and vulnerabilities to those hazards. The third level captures the health burden by modeling the expected impacts or attributing observed health outcomes. The Lancet Countdown has adopted this three-level methodology to optimize the available data and generate a comprehensive evaluation of the multidimensional health risks and impacts of climate change.

2.4.2. Environmental Issues

This chapter observes another side effect of climate change: environmental *impacts*. A current study by NASA on "*The Effects of Climate Change*" under the section "**Global Climate Change**" states that human-caused global warming is already occurring, is irrevocable for individuals living now and will intensify as long as humans continue to contribute greenhouse gases to the atmosphere [48]. Additionally, they list the effects in the US one by one:

- Sea level rise of 30.48 cm- 243.84 cm ,
- Increasing hurricanes,
- More droughts, heat waves,
- Prolonged wildfire seasons,
- Shifts in precipitation patterns,
- An extension of the frost-free season (and growing season),
- A rise of global temperatures and melting of the ice in the arctic poles.

These key events have an impact not just on the environment but also on the ecosystem that makes it up. Living animals and creatures strengthen and vitalize the ecosystem, restoring equilibrium.

According to the Harvard University course, **The Health Effects on Climate Change** [5], the effects are cited as follows:

- *The sea level rises* are caused by the melting of the ice, *Floods, and droughts* mainly occurring due to massive and sudden heavy rains.
- *Ocean acidification* is one of the many direct side effects of CO₂ and occurs when carbon dioxide reaches the waters; it degrades and increases acidity. Due to increasing atmospheric carbon dioxide concentrations, the seas have gotten more acidic since the Industrial Revolution. The aftershocks of the acidification have negative impacts on sectors relying on the ocean as well. Coral reef bleaching and local animals migrating are a few of the harms done by this change.
- *Wildfires and particulate matter issues* are happening due to heavy droughts and higher temperature levels.
- *Algal and cyanobacterial blooms* occur from an operation similar to plants in that they consume carbon dioxide and release the oxygen we require to thrive on Earth. However, they can create poisons that harm wildlife and swimmers. Warmer ocean temperatures and heavier precipitation can enhance the growth of algae and cyanobacteria by increasing the transport of nutrients such as nitrogen and phosphorus to coastal waterways and lakes. Algal blooms, such as those shown to the right, occur when the conditions are favorable. These formations are also dangerous for many industries depending on water-related sectors like fishing.
- Also another mentioned side effect is *the salinization of freshwater*, which is studied in the article "*Freshwater Salinization Syndrome: From Emerging Global Problem To Managing Risks*" [49]. It is stated that the topic is a growing global water quality issue. The authors inform readers that while freshwater salinization from highway salt usage had been discovered as early as the 1960s, the local concern of freshwater salinization only achieved general notice in the mid-2000s. Also, as explained in *The Health Effects on Climate Change*, salinization of coastal groundwater is becoming more likely as sea levels rise [5]. The pressure of salt water intruding through rock and soil into aquifers increases as the sea level rises, driving salty water into pure water. As sea levels rise, groundwater withdrawals are increasing globally, particularly along the world's coasts, where population development is highest. Higher groundwater extraction causes water to move quicker through reservoirs, perhaps adding salt since soils above aquifers may contain salt.

- *Lower crop yields* are another environmental setback. As described in the study "*Climate change impacts on crop yield, crop water productivity, and food security – A review*" , climate shift harms global food security, making it one of the most urgent concerns of the twenty-first century to provide enough food for an expanding population while supporting an already strained ecosystem [50]. They continue to add that variations in agricultural production-related climate factors may significantly impact regional and worldwide food production. Another study [51] by Tom Osborne et al. states that the production of crops is one of the industries most subject to climate unpredictability and change.
- *Degradation of Soil and Water* is another issue that arises. The surge in severe precipitation events in our agricultural landscape seriously threatens the degradation of essential soil and water resources. This could lead to excessive runoff, leaching, and flooding, putting crop productivity at risk due to soil erosion, decreased water quality in lakes and streams, and damage to rural community infrastructure. As explained in detail in Chapter 10, Agriculture and Rural Communities' part of "Fourth National Climate Assessment" [52],

The "Fourth National Climate Assessment" [52] of the US Global Change Research Program points to important issues that need to be addressed when conducting a comprehensive study of the impacts of climate change in various fields. Chapter 7 , entitled "*Ecosystems, ecosystem services, and biodiversity*," encompasses diverse subjects ranging from energy to water and starts the chapter by stating what they call "*key messages*", a list of the significant areas scientists wanted to emphasize [53]. **Key message 1**, "*Impacts on Species and Populations*" observes the scientific facts that climate change remains to have a profound and measurable influence on species and people and adds that it's modifying the properties of terrestrial, freshwater, and marine creatures, as well as the timing of biological processes and their geographic ranges. Local and global extinctions may occur when climate change outpaces species' coping ability. **Key message 2**, "*Impacts on Ecosystem*" address the topic stating that climate change is influencing ecosystem efficiency, hastening the development of foreign species, and modifying how organisms interact with one another and with their surroundings. These shifts are reshaping ecosystems in unexpected ways. This section elaborates that productivity will be affected, and there will be changes in the ecosystem's biology.

Additionally, some species would extinct due to the potential invasion of others. **Key message 3**, "*Ecosystem services at risk*," explains that the implications of climate change on ecosystems imperil the resources and services people rely on for their occupations, survival, safety, and well-being. Significant changes are taking place in agriculture and fishery productivity, clean water supply, extreme event protection, and culturally valued resources. The **4th key message** pertains to the challenges faced in natural resource management. It highlights the impact of climate change on traditional methods and the adoption of adaptive methods in recent cases.

In the study dated 2005 by The Millenium Assessment Organization, the board of scientists revealed eye-catching data [54]. Amongst the various findings, the first one states that humans have altered environments faster and more widely in the last 50 years than at any other time in human history, primarily to fulfill constantly increasing demands for food, fresh water, lumber, fiber, and fuel. It has led to a significant and permanent loss of biological variety on Earth.

Scientists, as a result of their research, conclude that the form and operation of the planet's ecosystems altered faster in the second half of the twentieth century compared to any other period in human history. They are adding a note that so much land was turned to farmland in the 30 years after 1950 than in the 150 years preceding it. Fostered areas (zones where croplands, shifting cultivation, restricted livestock production, or freshwater aquaculture comprise at least 30% of the terrain) presently cover one-quarter of the Earth's land surface. In order to meet the demands of a growing global population, forests were cleared, and trees were used as raw materials in industries like wood and paper. In their ongoing research, scientists explain that the increased demand for these ecosystem services was met by consuming a more significant portion of the available supply, such as using more water for irrigation or harvesting more fish from the sea, as well as increasing the production of certain services like agriculture and cattle. This research study demonstrates that the increasing global resource demand has exacerbated climate change.

A 2013 study published in The Ecological Society of America justifies the critical aspect of climate shift effects once again [55]. The researchers state in its introductory part that the burgeoning discipline of climate adjustment has seen a tremendous surge in interest as the effects of climate change on biodiversity and ecosystems have become more apparent. Preparation for and response to these changes have become crucial topics in conservation

and natural resource policy and management. Instead of simply maintaining current conditions, adaptation is now being considered as a way of managing change. It is highly emphasized in the study to lean towards adaptation of all systems, planning and designing all future goals into considering the new formations, and adaptive strategies, in mind. In the study, researchers have touched upon many topics, and they created an "*Illustrative adaptation effort*," as shown in Figure 2.5. as the "*Illustrative adaptation efforts*" are composed of the following:

- * Adaptation action,
- * Description of the situation,
- * Key climate concerns,
- * Adaptation mechanisms,
- * Intended outcome.

This summarization also demonstrates the significance of constructing a diagram by defining the priorities to maximize the efficiency of the studies being conducted.

To summarize the environmental impacts, "climate change is directly linked with all environmental elements. Whether the shortage of crops, the poor quality of the harvest, or the deaths of coral reefs leading to the decrease of living sea animals, all of these are harms of climate shifts.

2.4.3. Societal Issues

The impact of climate change is felt globally and has resulted in various societal issues. The constant climate changes and the direct and indirect factors affecting it have created new challenges for millions of poor people worldwide. These challenges include severe weather events, health issues, food and water security, livelihood security, migration, forced relocation, loss of cultural identity, and other threats. This chapter focuses on the social impacts of climate change, as more attention needs to be given to the social effects and income disparity outcomes of climate change mitigation policies.

As stated in the 2019 study of Markkanen S and Annela Anger-Kraavi study, more attention needs to be paid to the social effects and income disparity outcomes of climate change mitigation policies [56]. The terms "*inequality*" and "*equity*" are often mentioned in studies and policies concerning this topic. *Inequality* and *equity* are often emphasized in climate change debates concerning the unequal sharing of the expenses (both economic and social) and rewards of climate change and climate change policy, often throughout the globe. The most impoverished and oppressed communities (such as indigenous people groups) have contributed the least to historical greenhouse gas emissions (advantages), are the most vulnerable to climate change (costs), and have the fewest resources to adapt to extreme weather events and increasing temperatures. Nevertheless, more attention should be paid to climate change mitigation initiatives' potentially negative inequality impacts. One point that draws the most attention is that specific communities, such as *migrants*, *ethnic minorities*, and *low-income individuals*, are nearly uniformly underrepresented in decision-making processes while bearing the brunt of the negative consequences of poorly planned and executed policies. Also, The Paris Agreement and European regulatory policies emphasize the need to evaluate the consequences of climate change and reduction methods for disadvantaged groups. Still, a long road is ahead. Additionally, the inability to adequately reimburse unwillingly resettled populations—for example, by providing them with reasonably priced clean energy, irrigation, and improved health services—can result in mental and physiological health problems as a result of community breakdown, environmental degradation, ecological changes, in-migration, social problems, and land loss and livelihoods.

When researching the social impacts of climate change, it is important to highlight certain key concepts. According to the report "*Adapting to the Impacts of Climate Change*," which is widely referenced in this field, climate change vulnerabilities and adaptation strategies are so diverse and location-specific that a wide range of stakeholders at all levels of government, business, and society will need to make and implement adaptation decisions [57]. Adapting to the impacts of climate change involves identifying, evaluating, and assessing activities and strategies to minimize vulnerabilities, build adaptive capacity, improve resilience, and promote effective adaptation across various areas, sectors, systems, and populations. This comprehensive study also emphasizes that adaptation to climate change is a collective effort rather than the work of a single individual.

The social challenges caused by climate change are many, yet it is vital to emphasize the ones most mentioned in studies, which can be stated as :

- Human Migration,
- Hunger,
- Poverty.

2.4.3.1. *Human Migration*

Migration, which can be classified as a demographic factor, can occur for various causes [5]. Some individuals will relocate to avoid sea-level rise, while others will endure acute water shortages that will force them to leave their houses. It is particularly problematic for maternal and infant health, causing cardiac pressure and mental and emotional difficulties for people who must relocate. The various studies on this topic suggest that the different consequences of greenhouse gas emissions, such as water scarcity, food insecurity, rising sea levels, and extreme weather events, can be seen as part of a more extensive, interconnected pathway that ultimately leads to forced migration. Greenhouse gas emissions are causing people to move involuntarily, as they are left with no choice but to seek out new areas to live in due to the negative impacts of climate. Carleton T. and Hsiang S. explain in their study that human mobility is most certainly a crucial method for dealing with climate change [58]. However, it is difficult to define because climate appears to have two conflicting influences: Migration is motivated by deteriorating economic conditions and safety. At the same time, household resources required for relocation are being depleted. The net consequences are varied; for instance, if temperatures reach crop-damaging levels and moisture levels fall, urbanization and outmigration from agriculturally reliant areas may grow. They do suggest that this area of climate-related social effects be researched further, stating that climatological natural disasters that affect incomes, such as hurricanes and flooding, appear to have a limited impact on total migration in low-income contexts and cause simultaneous inflow and outflow of migrants in the United States. Generally, the broad climate impacts on migration need to be better studied and are still being examined.

On the other hand, Nielsen P. et al. state in their article that they tried to identify the factors causing mass populations to migrate [59]. Afterward, some factors impacted by climate change are discovered, resulting in four plausible mechanisms: tropical cyclones, floods, droughts, and sea level rise. After researching various factors, floods were selected due to

their occurrence at the intersection of climate change and migration on multiple levels. Floods can be triggered by factors such as increased rainfall intensity, tropical cyclones resulting in storm surges or heavy rainfall, and rising sea levels. When more information on the direct and indirect consequences became available, floods were prioritized over tropical cyclones as an example of a hazard with a quick onset. Then secondly, researchers included sea level rise because it is thought to be the most direct process and is supposed to trigger the most migration. Another study raises a new question: "What causes migration ?" [60]. The majority of reviewed studies rely on the New Economics of Labor Migration (NELM) theory, which considers households as the primary decision-making unit and identifies risk aversion as a crucial factor in migration decisions. They also go beyond this theory by suggesting that weather shocks can influence migration by affecting both the vulnerability and the capacity of households. "*Capacity*" refers to what households or individuals can do, such as pursue their goals and live fulfilling lives. The resolution of the subject suggests that climate change has a more significant impact on poorer households, making them more susceptible. It could be expected that poorer families to be more inclined to move in response to weather shocks since migration is frequently regarded as a last alternative for adaptation when households face financial restrictions. Migration is viewed as a "forced" decision for these households in this circumstance. These same households, however, may need more financial resources to afford the upfront expenditures of migrating. Migration is viewed as a hazardous investment in risk reduction available primarily to better-off families (i.e., a type of "adaptation"). At the same time, poorer households are "forced to remain" owing to financial constraints. The study of Klepp S. states that The United Nations Environment Program (UNEP) uses the terms "environmentally induced migration" or "environmentally induced population movement" as the most general and vague way to connect migration with environmental change [61]. Another term commonly used is "environmentally displaced person." Although the term "environmental migrants" is used more generally, it typically refers to the movement of people caused by human-made climate change. The study of Black et al. also states that many research studies have attempted to create more complex models than the basic idea that individuals living in regions facing environmental problems like land deterioration, reduced agricultural yields, greater risk of flooding or storms, or rising sea levels might be compelled to relocate [62]. Additionally, a growing number of publications have featured specific examples of how environmental factors and migration are interconnected in local contexts, which can be intricate and multi-faceted. On a new basis,

the study offers readers a new perspective. Typically, analyses of how environmental factors impact migration begin by examining how the environment serves as a driver and how that leads to migration. However, the framework proposed in their study takes a different approach that centers on the general drivers of migration, exploring how environmental changes can influence these drivers. These drivers are explained as political, economic, demographic, social, and environmental. The study provides valuable insights for policymakers and researchers seeking to understand the implications of environmental change for human migration. The spectrum of additional migratory determinants listed in their framework may be examined for direct and indirect effects to comprehend the influence of future political, economic, social, or demographic change. So it is a subject open to debate as time passes and mitigation and adaptation processes improve.

It is possible to comprehend from the various research that migration has multi-faceted and challenging consequences that impact human lives to various extents. (Figure 2.6.)



Figure 2.6. Relationship of climate change and migration [5].

2.4.3.2. *Hunger*

UN WFP research indicates that climate-related pressures, such as high temperatures, sea level rise, crop pests, and other factors, make it increasingly challenging for individuals to produce sufficient nutritious food [63]. Additionally, climate-induced shocks, including floods, droughts, and storms, are causing extensive damage to food systems, resulting in

millions of people losing their homes, crops, and livelihoods across Africa and the Americas. Failure to take immediate action will lead to continued food price hikes and instability as people compete for scarce natural resources, resulting in an unprecedented level of hunger. Consequently, addressing climate change is essential to ending hunger.

The World Food Programme article also states that in case of emissions are not decreased, there is a high likelihood of experiencing food-supply shocks where multiple countries that produce a significant amount of food experience failed harvests at the same time [64]. The consequences of harmful emissions will result in shortages and increased prices. Global heating has already caused a 21 percent decline in food productivity growth. Climate change does not work alone; it exacerbates current vulnerabilities and makes risks more intricate and challenging. So, again scientific researches lead to worrying consequences of climate warming, which, in this case, would lead to the famishment of millions of people worldwide.

The study conducted by Rosenzweig et al. reports that the first models analyzing the influence of climate change on global food supply were published in the early 1990s, which indicates that researchers have recognized the possible impact of climate change on food production for many years [65]. Subsequently, numerous studies have explored this subject, highlighting the susceptibility of food systems to climate change and the potential for significant disturbances in the food supply. The overall findings from those studies remain relevant today, indicating that climate change will most likely result in a decrease in global food production and that there will be a higher likelihood of hunger in the most vulnerable economies. After considering multiple scenarios, they conclude that, in general, climate change may result in higher crop yields at latitudes closer to the middle and high regions. In comparison, lower yields may occur in tropical and subtropical zones. However, there are exceptions where increased monsoon intensity or northward movement of monsoons leads to more available moisture. Climate change will likely increase the risk of hunger, particularly in southern Asia and Africa. Nevertheless, in some regions, this increase in risk is more due to an anticipated rise in the number of impoverished people in those areas (i.e., the population at risk) than the regional climate change pattern. According to the publication by World Food Programme, dating back from 2009, there has been a significant advancement in our knowledge of the effects of climate change on hunger in the past 15 years [66]. Initial studies indicated that developing nations would encounter the most significant decline in yields of essential crops like wheat, rice, and maize due to heightened

heat and water stress, leading to projected reductions of 9% to 11%. The side effects of climate change would have resulted in a surge in global prices by 25% to 150%, consequently leading to a 10% to 60% increase in hunger worldwide. Consideration of potential adaptations in farming practices and institutions is crucial when projecting the impact of climate change on hunger. Small-scale changes, such as adjusting planting times, can reduce the estimated increase in hunger by up to 50%. Meanwhile, more significant measures, like increasing irrigation, can bring it down to just 5%. A global response to climate change, such as liberalizing world food trade, can also lower the number of people at risk of hunger by 20% compared to a world without climate change. Researchers have concluded that the impact of climate change on hunger will be more significant in areas with social inequality and underdevelopment. This assertion is based on an analysis of factors such as population growth and regional income.

They also confirm that Africa is particularly vulnerable to climate change, with approximately 65% of the projected global increase in climate-related hunger expected to occur on the continent. Taking steps to mitigate climate change and lower greenhouse gas emissions would significantly reduce the risk of famine. If greenhouse gas concentrations are stabilized at 500 parts per million (ppm), the expected rise in hunger could be decreased by 50%. This underscores the critical significance of worldwide initiatives to curtail our greenhouse gas emissions.

On the other hand, The United Nations SDG's Goal 2 is "Zero Hunger" [67]. The goal briefly informs the readers of current numerical values that depict the level of urgency in mitigating climate change. It states that over the past 20 years, rapid economic growth and increased agricultural productivity have significantly reduced the number of undernourished people worldwide, with many developing countries making great strides in eradicating extreme hunger. Central and East Asia, Latin America, and the Caribbean have significantly progressed. However, hunger and malnutrition remain considerable obstacles to development in many countries. As of 2017, an estimated 821 million people suffer from chronic undernourishment, often due to environmental degradation, drought, and biodiversity loss. Over 90 million children under five are dangerously underweight, and undernourishment and severe food insecurity continue to rise in almost all regions of Africa and South America.

Additionally, it is vital to point out that the Sustainable Development Goals (SDGs) aim to end all forms of hunger and malnutrition by 2030 by ensuring sufficient and nutritious food for all, especially children, throughout the year. Achieving this goal requires promoting sustainable agriculture, supporting small-scale farmers, ensuring equal access to land, technology, and markets, and international cooperation to invest in infrastructure and technology to improve agricultural productivity. Based on the progress made, the issue of hunger could be resolved in less than a decade, possibly even by 2030. It is clear once again that collaboration with economists and experts from other related fields is necessary to re-establish the disrupted order and generate a comprehensive solution to the hunger problem.

2.4.3.3. *Impoverishment*

In the research article by United Nations on "Ending Poverty", researchers define poverty as a factor that's not limited to the absence of income and resources needed for a sustainable livelihood [68]. It also results in malnutrition and hunger, restricted access to essential services such as education, social exclusion and discrimination, and a lack of participation in decision-making. As of 2015, over 736 million individuals were living below the international poverty line. Before the pandemic, approximately 10% of the global population was in extreme poverty and struggling to meet necessities like healthcare, education, and access to clean water and sanitation. There were 122 women between the ages of 25 to 34 living in poverty for every 100 men in the same age group, and over 160 million children were at risk of continuing to live in extreme poverty by 2030.

As a study on Climate Change and Poverty explains, the term poverty should be observed broadly regarding its relationship with climate change [69]. Climate change vulnerability is commonly exacerbated by poverty, regardless of how poverty is measured. In this context, economically disadvantaged individuals are more susceptible to the negative impacts of climate change due to various factors. They possess fewer resources to recover from climate-related shocks and stressors such as droughts, hurricanes, and floods. Their livelihoods rely more on climate-sensitive sectors, such as agriculture, forestry, fishing, and pastoralism, or low-wage informal or hourly jobs with inadequate protection against climate-induced employment disruptions. They are more likely to reside in regions with a greater likelihood of exposure to climate extremes, and they are less likely to be insured against such events.

Additionally, they need more access to knowledge and information about adaptation and have fewer alternative livelihood opportunities. An important point emphasized in the study is that financially disadvantaged individuals often face more health issues, mental stress, social stigma, shame, humiliation, and other challenges that exacerbate their financial struggles and impede their ability to overcome poverty, cope with unexpected events, or plan for the future. Recent studies suggest that poverty also harms the cognitive abilities of those who experience it, leading to poorer financial decision-making skills in developed and developing countries. Having to deal with severe financial constraints constantly reduces one's capacity to deal with other challenges. Although the impact of poverty on cognitive abilities is thought to erode the resilience of poor populations, more research is necessary to confirm this hypothesis. Researchers also highlight that poverty alone is not the sole determinant of susceptibility to climatic shocks. Instead, it is often a combination of various aspects of poverty, such as low income, social exclusion, lack of assets and capabilities, as well as various contextual factors and external stresses, and sometimes failed development policies, that increase the vulnerability of poor communities. Although there is limited case evidence, recent studies suggest that poor individuals and communities can demonstrate high levels of resilience and possess a significant capacity to learn from extreme events and take action to reduce future vulnerability. As poverty is directly in contact with economics, the book "*The State of Economics, the State of the World*" offers readers a broad perspective on correlations of various issues with economics [70]. A group of prominent economists discusses the current difficulties economics faces in theory and practice during a period of political and economic turmoil. The past ten years have seen financial crises, national debt issues, political tensions, and increased prejudice and protectionism, resulting in global economic instability and uncertainty about the capacity of economics as a field to explain unpredictable events. This publication examines the status of the discipline in a world where economic and political crises continue to occur.

In the book, Chapter 7 is solely allocated to *Climate Change, Development, Poverty, and Economics*. As stated in the chapter, one of the primary concerns in the current situation is the impact of climate change. Although several environmental challenges confront us daily, climate change is distinct because of its magnitude and the significant hazards it presents. This threat can significantly exacerbate other pressing issues, including habitat destruction, disease, and global security, as highlighted by the IPCC in 2014.

Moreover, climate change endangers the developmental progress made in recent decades. If not addressed, it could dramatically alter the geography of the Earth and force us to reconsider where and how we, as well as other species, can reside. Adding an economic background to the topic, the characteristics of the climate issue have consequences for a financial examination. Economics can contribute considerably and still provides significant perspectives, but a perilous inclination exists to limit climate change within traditional, narrow ways of thinking. This challenge requires modification. We must create theories and models that reflect the structure and magnitude of the issue and the situations in which it arises. Helpful to add that the awareness that individuals living in poverty are at a higher risk of being impacted by climate-related disasters and strains has sparked an interest in gathering data and estimating the number of impoverished individuals who may be adversely affected by climate change. These investigations have focused on identifying the physical exposure of susceptible populations. They have revealed that globally and regionally, impoverished communities are more prone to being exposed to climate-related dangers, including rising sea levels.

3. RESILIENCE

The term "resilience" was first described by C.S. Holling in his journal "*Resilience and Stability of Ecological Systems*"; the article is considered a *pioneer* in its field with the most citation percentage in scientific research [71].

C.S. Holling's definition of **resilience**, as presented in his 1973 seminal paper "*Resilience and Stability of Ecological Systems*," is "*the amount of disturbance that a system can withstand without changing state*". Holling's study emphasizes that ecological systems are susceptible to disruptions like fires, floods, and insect infestations, which can be either absorbed by the system or cause substantial changes to its organization and performance. For instance, a forest ecosystem may tolerate small fires, but large-scale disturbances, such as clear-cutting or intense fires, can transform it completely. He also argues that ecological systems can display various forms of resilience, depending on their structure and the type of disturbances they face. Just like a system with a high level of redundancy, i.e., multiple species that perform similar functions may be more resilient to losing one or more species. Conversely, a system with a limited range of ecological niches may need to be more resilient to changes in environmental conditions. As a whole, Holling's notion of resilience highlights the capacity of ecological systems to endure and adjust to disruptions while preserving their entire organization and operations.

The concept of *resilience* can be extended beyond the environment and applied to other domains, such as social, economic, and political systems. In these contexts, resilience refers to the ability of a system to withstand and recover from disturbances or disruptions. Therefore, the *idea of resilience* emphasizes the significance of *being able to tolerate and recover from disturbances to survive in the face of change*. It may be applied to many systems beyond the environment.

As stated in Folke et al. study, when it comes to the resilience of social-ecological systems, it is determined by three factors [72]:

(a) the system's ability to withstand and recover from a significant disturbance while maintaining its current state,

(b) the system's capacity for self-organization, and

(c) the system's ability to develop skills for learning and adaptation. Management's actions can enhance or diminish resilience depending on how the social-ecological system responds to them. Also, they add to their statement that social-ecological systems that are more resilient can absorb larger shocks without undergoing fundamental changes. When a significant transformation is unavoidable, resilient systems have the necessary components for renewal and reorganization, allowing them to cope, adapt, or reorganize without compromising their ability to provide ecosystem services. Resilience is often linked to diversity, whether the variety of species, human opportunities, or economic options, which promotes adaptation and learning. Generally, resilience arises from factors that can only be replenished slowly, such as soil nutrients, ecosystem diversity, or genetic variety. Social-ecological systems are constantly evolving, and while ecosystems usually respond to gradual changes smoothly, regime shifts (abrupt changes) can occur that are difficult, costly, or even impossible to reverse. Although we can identify regime shifts in ecosystems after the fact, predicting them in advance is challenging. Thresholds that trigger regime shifts are hard to measure or predict accurately, and these thresholds can shift over time. Designing assessment programs that keep up with changing thresholds takes time and effort.

The **Resilience Alliance Workbook** defines it as *a property of a system that pertains to its ability to withstand changes or disturbances without transitioning to a different state with distinct structural, functional, and ecosystem service properties* [73]. This definition implies that a resilient system can endure substantial disturbances without undergoing changes that would disrupt the ecosystem services that benefit people. Instances of transitions between different states can be observed, such as the transformation from coral reefs to rocks covered in algae, grasslands to landscapes dominated by shrubs, and clear water to cloudy water in freshwater lakes. Alterations in the availability of ecosystem services, such as fish production, grazing capacity, and opportunities for tourism and recreation, accompany each of these transitions.

One can perceive resilience as a comprehensive concept comprising several interconnected components that work together to create a more significant whole than the sum of its individual parts. Physical, economic, cognitive, and social perspectives can all be used to examine the idea of resilience. These fields are related and may have an impact on one another. For instance, social resilience may affect physical resilience, while emotional resilience can influence cognitive resilience. Additionally, resilience is impacted by social and environmental elements in addition to being a personal quality. Resilience must be understood holistically, considering the intricate interactions between social, environmental, and human elements.

The following paragraphs in this section will discuss the relationship between resilience and climate change and its multidisciplinary linkages. Afterward, an analysis of resilient urban development will be presented.

3.1. THE RESILIENCE AS A CONCEPT

The 6th IPCC Assessment Report states that the impact of climate change is leading to more frequent humanitarian emergencies, particularly in areas where more susceptible communities are exposed to climate hazards (particular) [4]. Across the globe, extreme weather and climate events are increasingly responsible for displacing people, with the Small Island States being disproportionately affected.

The term climate resilience refers to the ability of a system or a community to withstand and adapt to climate-related hazards and disruptions while maintaining their fundamental functions, structures, and identity. The peculiarities of resilience include the ability to anticipate, plan for, and recover from climate change-induced disturbances and enhance their adaptive capacity over time. It also involves reducing vulnerability to climate risks and creating more resilient and equitable systems that thrive despite changing climatic conditions.

So, how are resilience and climate change related ?

To fully understand the relationship between resilience and climate change, readers need to recognize that sustainability is the overarching concept that includes resilience as a subset. The United Nations Brundtland Commission in 1987 defined *sustainability* as "*the ability of future generations to fulfill their own needs without compromising the ability of the current generation to do so*" [74]. Therefore, it is fundamental to guide inclusive and hands-on collaboration to mitigate the negative impacts of the climate challenge to live in a healthy and feasible environment where each individual has equal rights. As stated in SDG Good Practices Booklet⁸⁷, the urgent nature of the current requirements necessitates the mobilization of increased involvement and direction from all segments of society, along with more funding and innovative solutions that can significantly impact tackling the growing issues of inequality and the worsening climate crisis. As stated in the IPCC Chapter 1, where all critical concepts are explained in detail, it states that diverse actors take part in bettering the system change [4]. According to Pelling et al. research, various actors can promote or hinder significant system change [75]. The power dynamics within and between different activity spheres can impact the distribution of risks and the process of transformational adaptation. Within sustainability transitions literature, every group of participants - encompassing academia, politics, industry, civil society, and households - contributes a distinct set of resources, skills, beliefs, strategies, and interests. These factors shape their goals, capacity to influence the transition process, and effects on other actors involved.

In addition, the researchers realized they must also consider the climate change continuum in their study. In so, they stated in their research that since climate change is an ongoing phenomenon, it is more helpful to focus on enduring continuous disruptions rather than recuperating from individual incidents [76]. This concept also encompasses the ability to bounce back from severe climate-related incidents, which are predicted to become more common as a result of climate change. To be practical, they recommended adopting a practical attitude: acknowledge that resilience is a wide-ranging term encompassing a variety of related ideas, and ensure that its intended meaning is explicitly stated when applied to particular situations.

The term "**adaptation**" has become an integral part of the discourse surrounding climate change. In their study, Morecroft et al. examine the concept of resilience from various perspectives and assess its implications for specific sectors. They argue that when employed in a broad sense, resilience can be a valuable tool for conservation managers, provided they possess a clear understanding of their system and defined adaptation goals. It is crucial for them to consider the potential range of changes that may occur or be required at different levels of ecosystem organization and spatial scales, ranging from maintaining "resilience" to undergoing "transformation." The primary advantage of resilience as a concept lies in its focus on preserving similar communities or ecosystem services, rather than passively accepting or actively promoting change in response to climate change. While it pertains more to the mindset of conservationists than the inherent properties of the natural environment, it remains a critical aspect of conservation due to its implications for human activity. In terms of risk management, building resilience is often preferable to taking no action or advocating for drastic changes. However, there is a caveat to this approach. As the impacts of climate change become increasingly pronounced and organisms exhibit diverse responses, we may encounter the limitations of resilience more frequently. International agreements have sought to limit the global temperature increase to 2°C, but current emission patterns indicate a potential rise of approximately 4°C over the course of this century. It is possible to reach a point where transformational approaches are necessary to maintain overall biodiversity and protect ecosystem services, which poses a profound challenge to scientists and conservationists. Preparing for this possibility is critical.

However, regardless of sectors and people, the fundamental duty of every human being should be to do their best to lower the adverse impacts of climate shifts.

3.2. **RESILIENCE CONCEPT IN DIVERSE DISCIPLINES**

Following the study of literature reviews and publications, it is possible to state that the topic of resilience has expanded to encompass a broad range of scientific disciplines.

As Meerow S et al. stated in their study, the notion of resilience has acquired great appeal in academic and policy debate in recent years, and there are various causes for this trend [77]. *Resilience theory* can help manage complex socio-ecological systems, especially in climate change. Because this approach sees systems as continually developing nonlinearly, it is

essential for dealing with future climate uncertainties. Furthermore, because resilience has an excellent cultural connotation, it is preferable to charge ideas like vulnerability more negatively. As a result, socio-ecological resilience theory has become a hotly debated issue in various scientific domains.

This chapter describes resilience in several subcategories and discusses diverse approaches to resilience. Resilience approaches are classified alphabetically as ecological, economic, socio-ecological, and urban.

3.2.1. Ecological Resilience

Ecological resilience, as an updated definition, is the capability of an ecosystem to maintain its normal processes of nutrient circulation and living creature development in the face of environmental upheaval [78]. When an ecosystem is unable to recover after a disturbance, whether caused by natural events like storms or human activities like overfishing and pollution, it endangers the benefits that humans receive from that ecosystem, like food, clean water, and beauty. Ecological resilience has also grown more relevant in conservation techniques and ecosystem management, especially since the latter has begun to highlight the value of ecosystem services. Food, fuel, and natural goods (e.g., compounds for pharmaceutical research) are examples of such services, as are climate mediation, removing hazardous elements from environmental reservoirs, and the aesthetic satisfaction people gain from the natural world.

Although many species remain essential within the context of ecosystem services, most of the conservation attention has shifted from individual species to the overall ecosystem preservation; mainly, it is the capacity to keep structure and production rate. Another scientific idea states that the idea of ecological resilience assumes the existence of several stability domains and the system's tolerance to shocks that ease shifts between stable states. The capacity of a system to withstand disturbance and remain in a stable state is referred to as its ecological resilience. It depends on how much disruption the system can endure without transitioning to a different state. Also, ecological systems undergo transitions between multiple stable states, as observed in Africa and Australia where grazing pressure has caused shifts from grass-dominated to woody-dominated semi-arid rangelands, resulting in different dominant plant forms. Clear to turbid lakes are also subject to transitions, with disturbances such as light and temperature changing the primary producer assemblages and

physical variables. However, various fields have also shown the presence of ecological resilience.

According to Seidl et al. study, forests with a large diversity of tree species are more tolerant to disturbances like fires, droughts, and insect outbreaks than monoculture forests [79]. Also, disruptive factors and the benefits provided by ecosystems may change in the future, so the questions about what makes a system resilient and what it is resilient may also change. There is a possibility of new invasive species causing disturbances and societal needs changing rapidly. Since forest management decisions can have long-term effects, it is essential to study potential scenarios involving new ecosystems and societies and to consider uncertainties and unexpected events in management planning. Also, when considering the resilience factor to sustain more efficiency in the long run, planting durable trees for an extended period is essential.

A study conducted on the resilience of mangrove trees shows readers that mangrove ecosystems are very robust and can endure natural disturbances such as variations in sea level, temperature, freshwater and salt exposure, and anoxia caused by continuous exposure to such elements [80]. Chronic exposure aids in selecting species that are resistant and tolerant to these perturbations. As a result, mangroves can recover swiftly following significant, isolated disturbances such as storms, hurricanes, tsunamis, droughts, and strong winds.

3.2.1.1. *Coral Reef Resilience*

According to NOAA's "**Coral Reef Ecosystems**" article, **coral reefs** have a remarkable diversity since they are one of the most diverse ecosystems in the world [81]. Coral polyps, the primary builders of reefs, exist in various forms and sizes, including vast colonies that form the reef structure, flowing fans that move with the water, and even small, lonely individuals. Scientists have identified many coral species, some of which thrive in warm and shallow tropical seas, while others reside in the chilly and dark depths of the ocean. They fulfill several critical tasks, including protecting coasts from storms and erosion, offering economic possibilities for neighboring populations, and functioning as a recreational sites. They are also an essential source of food and have the potential to produce novel treatments. Coral reefs provide nourishment, income, and protection to almost 500 million people globally. The website emphasizes that numerous reefs are under threat due to a multitude of

issues, including excessive fishing of herbivorous fishes, introduction of nutrients from land-based activities, coral mortality, and recruitment failure. These factors have caused a transition from coral dominance to an overabundance of fleshy seaweed or other weedy assemblages. This change has a detrimental impact on other species that rely on coral habitat. The study by Hughes et al. indicates that local preservation of fish species and better water quality, from a management standpoint, may, given enough time, improve the possibilities for recovery and boost resilience [82].

3.2.1.2. *Grassland Resilience*

The research by David L. Hoover et al. investigates how well grassland ecosystems can withstand and recover from extreme climate conditions [83]. The study suggests that grasslands with more plant species can resist severe weather events like droughts and heat waves. Additionally, grasslands with a more significant proportion of deep-rooted plants have greater resilience to drought since they can obtain water from deeper soil layers. The researchers also found that frequent disturbances, such as fire, can boost the resilience of grasslands to climate extremes by stimulating the growth of new plant species better suited to changing environmental conditions. Overall, the study underscores the significance of maintaining grassland biodiversity and implementing management strategies that encourage ecological resilience in response to climate change. It is better to define grassland and what they signify to the ecosystem. Grasslands are regions where the predominant vegetation consists of grasses growing in a near-continuous carpet [84]. These areas occur in environments favorable for grass growth but not for taller plants such as trees and shrubs. The reasons for the absence of these taller, woody species are diverse and multi-faceted. The vast natural grasslands are the middle ground between two ends of an environmental continuum. At one end are the forests, which thrive in the most hospitable environments with sufficient moisture to support tall and dense vegetation dominated by trees. At the other end are deserts, which arise in areas where the lack of moisture makes it impossible for continuous and permanent vegetation cover to exist. In between these two extremes are grasslands. Grasslands, like savannas, deserts, and scrublands, emerged during the cooling and drying of the global climate in the Cenozoic Era, spanning from 65.5 million years ago until the present day. Another study by Robert J. Griffin-Nolan et al. looks at how protracted drought alters the functional content of plant communities in grasslands [85]. According to the study, prolonged drought causes significant changes in plant functional features, such as

a decrease in the abundance of tall and fast-growing grasses and an increase in the number of short and slow-growing grasses. The study also discovered that changes in functional composition were associated with changes in soil attributes, such as a decrease in soil moisture and an increase in soil nutrient concentration. The study emphasizes the necessity of knowing plant communities' functional responses to drought conditions and the potential for variations in plant composition to have significant implications on grassland ecosystems.

To sum up, **grasslands** are vital ecosystems that provide numerous benefits, including the support of various plant and animal species, habitat for grazing and predator animals, carbon sequestration to mitigate climate change, water filtering and purification, soil erosion prevention, and cultural and economic significance. These intricate ecosystems have played an essential role in human history and provide various ecological, cultural, and economic benefits.

3.2.1.3. ***Wetland Resilience***

Wetland resilience refers to an ecosystem's capacity to endure and recover from disturbances such as changes in water supply, land use changes, and natural catastrophes. The resilience of an ecosystem is a measure of how well it can retain its structure, function, and general health in the face of severe changes. Wetlands, by definition, are intricate ecological systems that arise from flooding or soil saturation, leading to low-oxygen conditions that encourage specific plants, animals, and microbes that have evolved to withstand periods of still or slow-moving water [86]. Based on their soil and plant life, these environments are commonly classified into different types, such as bogs, marshes, swamps, and similar areas. In terms of the environment, the formation of wetlands is affected by both climate patterns and the constraints presented by the physical features of the land. The overall amount and timing of water accessible for the development or preservation of wetland conditions are determined by the balance between precipitation and evaporation. Also, wetland soils, also known as *hydric soils*, are created when the soil experiences prolonged saturation or flooding during the growing season, leading to oxygen-deprived areas in the upper layer of the soil where roots grow. These soils can either be composed of organic material or minerals. Wetland soils made of organic matter, such as peatland soils, usually contain a minimum of 12 percent organic matter and have an acidic pH level. They also possess a high capacity to retain water but have limited nutrient availability. So, climate change has a significant impact on wetlands and their resilience. The research paper "*Wetlands in a Changing Climate: Science, Policy,*

and Management” by William R. Moomaw et al. discusses the importance of wetlands as a critical component of the global carbon cycle and ecosystem services, as well as the challenges posed by climate change to wetland ecosystem conservation and management [87]. The essay emphasizes the ability of wetlands to buffer climate change by sequestering and storing carbon. However, it also warns of the hazards of wetlands loss and degradation due to temperature changes, precipitation patterns, sea level rise, and human activities. The authors make policy and management recommendations to promote wetland resilience in the face of these challenges, such as wetland protection and restoration, incorporating wetland conservation into climate change mitigation and adaptation plans, and involving local communities and stakeholders in wetland management. To sum up, wetlands are essential ecosystems that provide several environmental and societal advantages. They offer habitat for a wide variety of plant and animal species, filter water, reduce floods, help to regulate the climate by storing carbon, and give economic advantages like as recreation and resources. Wetlands must be protected and restored in order to preserve biodiversity, water quality, and the general health of the planet.

3.2.2. Socio-ecological Resilience

In light of previous definitions and analyzed research studies, socio-ecological resilience means *the ability of social and ecological systems to adapt and survive in the face of environmental and social stresses and disruptions*. It is a concept that acknowledges the interconnection of social and ecological systems and the importance of understanding and managing these systems as integrated entities.

The research study, *"Synthesis: building resilience and adaptive capacity in social-ecological systems"* by Carl Folke, Johan Colding, and Fikret Berkes, also elaborates on socio-ecological resilience and its importance for the sustainability and management of complex social-ecological systems [88]. The authors underline that socio-ecological resilience is founded on *recognizing that social and ecological systems are interrelated and mutually reliant*. They suggest that developing resilience and adaptive capacity in these systems necessitates a comprehensive approach that acknowledges social and ecological processes' interaction and feedback loops between them. The study emphasizes the significance of variety, connectedness, and adaptive governance in improving socio-

ecological resilience. The authors emphasize the importance of diversity in social and ecological systems in increasing resilience by giving adaptive alternatives and lowering vulnerability to perturbations. Connectivity is also crucial for preserving resilience and facilitating the transmission of information and resources, both within and across social and natural systems. The analysis also emphasizes the importance of adaptive governance in fostering resilience in social-ecological systems. Adaptive governance entails the creation of flexible, responsive, and participatory management techniques capable of adapting to changing situations and incorporating local knowledge and input. Adaptive governance can improve the resilience of social-ecological systems by encouraging learning, innovation, and cooperation. Overall, the study emphasizes the necessity of a holistic, integrated approach to promoting resilience and adaptive capacity in socio-ecological systems, which acknowledges the interdependence of social and ecological systems and encourages variety, connectivity, and adaptive governance.

Another study by Carl Folke, shows the significance of resilience in comprehending and handling social-ecological systems is highlighted in the study overview [89]. Also, recognizing the presence of numerous stable states and the necessity of adaptive ability, variety, and learning is part of resilience thinking. Adaptive governance, collaborative management, and using indicators to monitor and analyze system health are all essential management practices that foster resilience.

Panarchy, in addition to these elements, is critical in resilience thinking. *Panarchy* is a conceptual framework (as shared in the study of Folke) that describes the interactions of ecological and social systems at various time and space scales. It highlights the necessity of understanding the dynamics of change and transformation and the interconnection of systems. The panarchy framework assesses the resilience of social-ecological systems by considering their ability to adapt and alter in response to disturbances and changes. Incorporating panarchy into resilience thinking enhances our understanding of the complex and interconnected nature of social-ecological systems and the need for adaptive management approaches to promote resilience. As a result, it is necessary to examine social-ecological systems from several perspectives and to recognize that multiple factors impact the resilience of these systems. Considering that humans play a significant role in the ecosystem's operations, the factors that promote socio-ecological resilience consist of diversity, redundancy, connectivity, and feedback between social and ecological systems. In

order to establish resilience, it is essential to comprehend a system's social and ecological dynamics and create adaptive management techniques that tackle the intricate and interrelated issues confronting these systems. In conclusion, the researcher adds that the resilience concept evolved from an ecosystem-oriented ecology branch that acknowledged human actions' influence on ecosystem dynamics. This viewpoint differs from conventional ecology, which considers humans external agents and ignores their interaction with ecosystems. Models are used in the resilience viewpoint to comprehend and include actors and interest groups in adaptive management and learning of ecological processes. Lately, social scientists have significantly contributed to our knowledge of the dynamics of socio-ecological systems. However, research problems persist, such as elucidating the feedback of interconnected social-ecological systems and the role of adaptive ability in resilience building. The policy implications are enormous, necessitating mental models shifting toward human-in-the-environment viewpoints and developing incentives for adaptive governance for social-ecological resilience. Achieving transformations towards sustainable development pathways is a significant challenge for humanity.

Recent research by Dietz, T et al. “*Climate Change and Society*” examine diverse interactions between climate change and society [90]. The article covers various themes linked to climate change, such as its origins and effects, human and institutional reactions, and the possibility of mitigation and adaptation. The writers contend that climate change is a social and political issue as well as an environmental one. They investigate how human cultures have contributed to climate change and how its impacts have affected social systems. They also talk about the role of social institutions like governments and companies in dealing with climate change. They claim that climate change is a social and political concern as well as an environmental one. They analyze how human cultures have contributed to climate change and how its effects influence social systems. The function of social institutions like governments and companies in responding to climate change is also investigated. Authors touch base on diverse topics yet there are some that stand out more like climate change and queer ecology, climate change and disability, climate change and human-animal relationships. The study offers a perspective on how individuals, institutions, and societies can work together to address this global challenge and emphasizes the importance of *socio-ecological resilience* in achieving this goal.

3.2.3. Urban Resilience

Urban resilience refers to the capacity of an urban region or metropolis to absorb shocks and pressures, such as natural catastrophes, economic downturns, or social and political upheavals, and to recover. Resilient cities can absorb and adapt to unforeseen occurrences and maintain their effectiveness without jeopardizing their residents' welfare or long-term viability.

UN Urban Habitat defines *urban resilience* under the chapter “Urban Resilience Hub” as *the quantifiable capacity of any metropolitan system and its residents to preserve continuity through all shocks and stressors while constructively adapting and changing in the direction of sustainability* [91].

The Resilient Cities Network states that today, *cities are more densely populated and interconnected than ever, providing various social and economic benefits and increasing their vulnerabilities* [92]. To deal with this, new governance models are required to mitigate risks and respond to evolving challenges. They also state that *urban resilience* refers to a city's systems, companies, organizations, communities, and individual's ability to tolerate, adapt, and thrive in the face of numerous chronic stressors and abrupt shocks. *Climate change, urbanization, and globalization* are interconnected *global megatrends* driving this notion. In order to achieve urban resilience, cities must thoroughly examine their capacity and dangers and interact meaningfully with the most vulnerable people in their communities. It is a complex task. Cities must consider their capacities and dangers holistically, including genuine interaction with the most disadvantaged people in their communities. Achieving urban resilience is a challenging task but rather a process.

Nevertheless, to understand urban resilience, it is vital to get the essence of *urbanization*. The study of Henrik Ernstson et al. states that urbanization is a multifaceted and worldwide phenomenon becoming increasingly unpredictable due to climate change, migratory trends, and changes in an ecosystem service capacity [93]. In a more contemporary approach, modern urbanization is a complicated and quickly changing worldwide process that impacts human population density and land cover. However, our comprehension of this process and its effects must catch up to its speed. Furthermore, we confront growing unpredictability due to climate change, migration, and changes in ecosystem capacity. Conventional planning for the foreseeable future is insufficient and, in some cases, harmful. The article aims to establish

the foundation for urban planning and governance changes that enable cities to navigate through change effectively, build the capacity to withstand shocks and locate opportunities for experimentation and innovation amid uncertainty. The study emphasizes the significance of going beyond the conventional planning techniques that consider urban environments as fixed and predictable entities by providing different instances of regime shifts, slow variables, and system thresholds. A more flexible and adaptable approach is required, which acknowledges the uncertainties and dynamics of ecosystems that humans dominate. The authors believe that establishing urban resilience necessitates an integrated strategy incorporating ecological, social, and economic components while including stakeholders in planning and governance. The study presents a conceptual framework for understanding the problems and possibilities of urban transitions and insights for policymakers and decision-makers in creating more sustainable and resilient urban settings.

Sara Meerow et al. research "*Defining Urban Resilience: A Review*", on the other hand, attempts to give a complete analysis of the numerous definitions and conceptualizations of urban resilience that have developed in academic literature over the years [94]. According to the authors, the need for a defined definition of urban resilience has made it challenging to design effective policies and initiatives to improve it. The study examines over 100 scholarly publications and studies to uncover common themes and differences in urban resilience definitions. The authors distinguish three definitions: those that emphasize recovery from shocks and stressors, adaptation and transformation, and the significance of fairness and social justice in creating resilience. The study concludes by providing an integrated definition of urban resilience that incorporates all three defining elements. As per the authors, urban systems and communities should possess the capacity to preserve or quickly recover their desired operations in the event of a disruption, adjust to changes, and promptly modify systems that hinder current or future adaptability while advancing social equity and comprehensive urban growth. The authors propose that their definition of urban resilience can be used as a guideline or model for policymakers and practitioners to develop effective strategies to increase urban resilience. Their definition encompasses different aspects of resilience, such as infrastructure, social networks, equitable development, and adaptation and transformation, which can help policymakers and practitioners prioritize their efforts to promote resilience in cities. Ultimately, their framework can enhance cities' ability to withstand shocks and stresses and build the capacity to adapt to changing conditions.

While academics and scientists continue to discover the topic of resilience in an urban setting, the study of Leitner H. Et al. leads the framework in a new direction [95]. They state that critics and advocates for urban resilience share the belief that its nearly ubiquitous positive nature must be challenged through the following inquiries:

- Who determines what is considered desirable?
- Whose resilience takes precedence?
- Who is incorporated or excluded from the system?
- Is the resilience of particular regions given preference over others (spatial inequality)?
- Will improved resilience in one location lessen it in another (spatial connectivity)?

The authors examine the idea of urban resilience from a critical and geographical standpoint, demonstrating how neoliberal ideology and power relations form and affect the global urban resilience discourse. They look for an objective standpoint for urban resilience. According to the authors, the neoliberal approach to urban resilience frequently reinforces spatial and social inequalities. It is based on the assumption that cities are self-organizing, adaptive systems that can always bounce back from disturbances while ignoring the underlying structural causes of vulnerability and risk. The research emphasizes the significance of a more politically active and socially equitable approach to urban resilience that considers the local context, the diversity of urban experiences, and the importance of constructing social, economic, and environmental sustainability.

Another research, "*Urban Resilience: A Conceptual Framework*" by Riberio, G, and Gonçalves, J, presents a comprehensive conceptual framework for urban resilience that emphasizes the importance of community involvement, social equity, and inclusive urban development in the construction of resilient cities [96]. The framework identifies four key aspects: robustness, redundancy, resourcefulness, and speed. It also highlights the importance of having flexible governance systems, integrated planning and management, and solid institutional collaborations. The paper also includes case studies and practical examples to demonstrate how the framework might be utilized in various urban environments. The study emphasizes the need for proactive planning and community

participation in developing resilient communities capable of absorbing and recovering from shocks and pressures.

The article “*Urban Resilience Infrastructure: an Imperative in a Climate Uncertain World*” of Rockefeller Foundation on urban resilience informs readers that having infrastructure is a fundamental human need and that providing the 'correct' form of urban infrastructure necessitates knowing what cities demand today and forecasting what they may require in the future [97] [98]. As a result, the article emphasizes the significance of developing robust urban infrastructure in the face of climate change and other uncertainties. The essay presents a framework that aims to achieve urban resilience by highlighting the crucial features needed for it. It stresses the importance of adaptable governance systems, comprehensive planning and management, and strong collaborative relationships between institutions. The primary objective is to ensure that cities can withstand unexpected events and quickly recuperate from them, improving the quality of life for urban dwellers.

3.2.4. Economic Resilience

US EDA (Economic Development Administration) states that while some definitions of *economic resilience* focus solely on the ability to recover rapidly from a disruption, *economic growth* necessitates resilience that equips areas to foresee, resist, and recover from any shock, stress, or disruption [99]. They highlight the importance of developing economic resilience in a local or regional economy, which involves predicting risks, understanding how risks will affect critical economic assets, and establishing a responding capability. Disruptions to an area's economic base typically manifest themselves in three ways: national or international economic downturns that affect demand for locally made products and consumer spending, downturns in critical industries that account for a significant portion of the region's economic activity, and external shocks such as natural or manufactured disasters, military base closures, and the departure of significant employers the impacts of climate change. Overall, they state that it is a multifaceted process. They add that economic development organizations must consider their involvement in pre- and post-incident environments, including ongoing and reactive actions, to promote economic resilience. EDA calls the actions **steady-state** and **responsive** initiatives. Examples of steady-state economic resilience projects and responsive economic resilience initiatives are discussed in this article.

Steady-state initiatives involve long-term planning and actions to promote economic resilience, such as engaging the community in planning efforts, diversifying the industrial base, and promoting business continuity and preparedness. Responsive initiatives involve actions taken after an economic disruption to help businesses recover, such as pre-disaster recovery planning, establishing communication channels to share business community needs, and creating leadership succession plans for recovery efforts.

Penn State professor Adam Rose stated in his article that “*economic resilience*” can occur at three levels [100] :

(1) *microeconomic*, which refers to the behavior of individuals, firms, households, or organizations; (2) *mesoeconomic*, which refers to economic sectors, individual markets, or cooperative groups; and (3) *macroeconomic*, which refers to all individual units and markets combined. Nevertheless, due to the interaction impacts and intricate dynamics, the entire economy is not merely the sum of its components. He explains later that assessing resilience is critical since it allows scientists to analyze the success of disaster-resilience methods. It is crucial to account for resilience when calculating losses to avoid overestimating the impact of business disruption caused by disasters. Similarly, disregarding resilience in policy-making may result in missed chances to reduce losses further. In order to successfully address the economic costs of catastrophes, it is necessary to incorporate resilience into loss assessment and policy-making.

The study book of World Bank informs readers about defining and evaluating economic resilience [101]. Stating that the consequence of a disaster on well-being is not only assessed by the event's physical qualities or immediate repercussions, such as loss of life and property. The level to which a disaster impacts people's well-being is determined by factors other than the physical qualities of the event or the immediate losses suffered, such as loss of life and property. It is also impacted by the economy's ability to manage, recover, and rebuild itself, which can help to prevent total consumption losses. This capacity is known as macroeconomic resilience to natural disasters, and it is made up of two major components: immediate resilience and dynamic resilience. The effect on welfare is also affected by microeconomic resilience, which is determined by the distribution of losses, the vulnerability of households, and the social protection system. Lowering the economic welfare catastrophe risk by reducing exposure and susceptibility, increasing macroeconomic resilience, or increasing microeconomic resilience is feasible. The study suggests estimating

methodologies and strategies to boost resilience and a set of indicators for developing a resilience index. The purpose is to contribute to global development policy conversations by providing free access to research. The paper also describes the framework for evaluating welfare disaster risk shown below (Figure 3.1), which only considers economic consequences while neglecting other significant factors such as direct health impacts (as discussed in the conclusion section). The green boxes indicate economic characteristics, the blue boxes represent different resilience indicators, and the brown boxes indicate various measures of catastrophe risk.

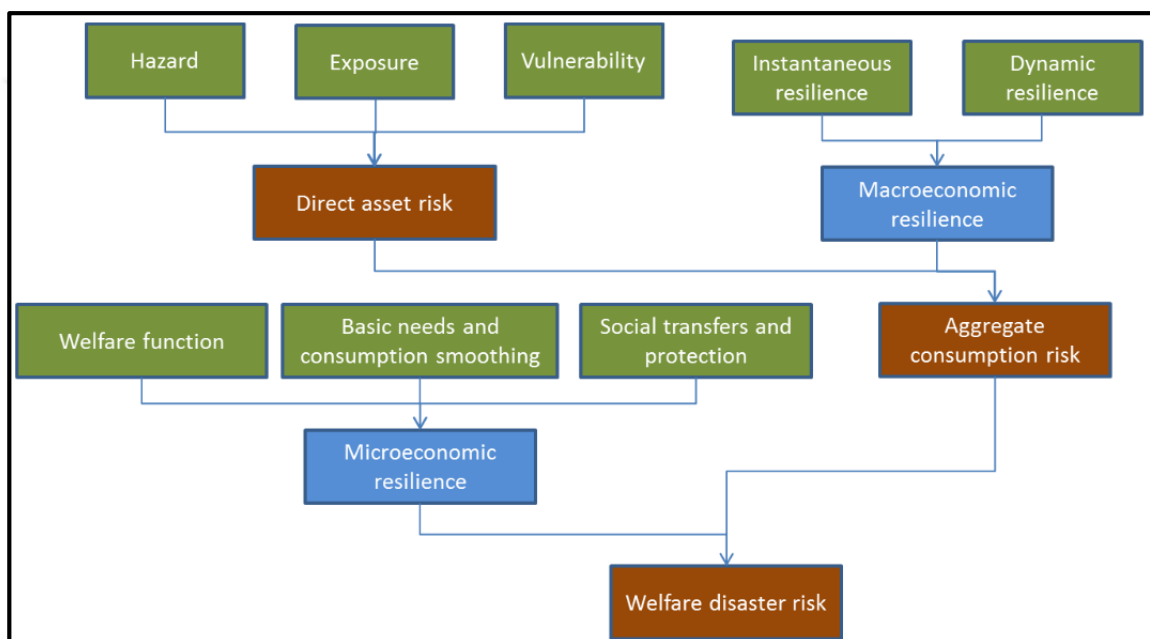


Figure 3.1. Welfare catastrophe risk assessment scheme [101].

The study of Simmie J and Martin R provides a novel way to understand regional economic resilience [102]. Authors believe resilience should be viewed as a dynamic process involving adapting economic systems across time rather than a static trait. They contend that resilience is generated by intricate interactions between economic players, institutions, and technology and that historical legacies and route dependencies impact it. The study also underlines the relevance of local elements in generating economic resilience, such as government quality, social networks, and cultural attitudes. Thus, the study aims to give a more nuanced understanding of economic resilience and insights into how regions might improve their ability to absorb economic shocks and adapt to changing conditions over time.

The research of Carleton T. and Hsiang M. summarizes climate change's social and economic implications worldwide [58]. The research analyzes the consequences of climate change using a range of methodologies, including statistical analysis, meta-analysis, and case studies. As the topic of interest, *Climate change* has considerable negative economic repercussions. Some examples are:

Reduced agricultural productivity: Climate change can majorly impact agricultural productivity, with rising temperatures and changing precipitation patterns reducing crop yields. The shift in climate can lead to higher food prices and reduced food security, particularly in low-income countries.

Increased healthcare costs: Climate change can lead to an increase in the incidence of diseases such as malaria and dengue fever, which can have significant economic impacts due to increased healthcare costs and reduced productivity.

Increased mortality rates: Climate change can lead to extreme weather events such as heatwaves, droughts, and floods, which can cause loss of life and high economic costs.

Increased infrastructure damage: Extreme weather events can cause significant damage to infrastructure such as buildings, roads, and bridges, leading to costly repairs and lost productivity.

Reduced economic growth: Climate change can lead to reduced economic growth due to the impacts mentioned above, as well as increased conflict and migration. So, climate change can significantly impact the global economy, particularly in low-income countries.

Energy supply and demand: Climate and energy are inextricably linked because climate change directly influences energy systems. High temperatures, for example, can boost energy demand while simultaneously straining supply and transmission. At the same time, energy is crucial to adaptation by enabling cooling, heating, irrigation, trade, and other essential activities. Nevertheless, energy use is the leading cause of manufactured climate change.

Labor supply and productivity: The influence of climate on labor is considered an essential factor affecting the overall economic response to climate change and its effects on agriculture. Increasing evidence supports the idea that high temperatures can negatively impact work performance, including reduced work intensity, decreased cognitive abilities,

and shorter work hours, particularly in sectors that heavily rely on outdoor conditions like construction and agriculture. The impact on manufacturing output has been observed in both high- and low-income settings. However, understanding the full extent of this impact requires a comprehensive analysis of how labor is reallocated within an economy. The overall economic response to temperature changes aligns with the role of labor effects. The theory suggests that labor productivity losses may be compounded by market responses that decrease the labor-intensive aspects of economic activities, thereby slowing overall production. While investments in climate-controlled work environments can partially mitigate the adverse effects on labor productivity, they come with significant costs, including increased energy expenses.

Overall, the economic impacts of climate change are substantial and far-reaching, affecting a wide range of sectors and countries. The study highlights the urgent need for action to mitigate these impacts and build resilience to future climate change-related shocks. Also, this scientific study emphasizes the crucial importance of resilience in the economy.

To summarize, economic resilience is a concept that begins with people and households and extends to more significant societal layers, and it is strongly linked to climate change.

3.3. RESILIENT URBAN DEVELOPMENT

According to the definition of the non-government organization *Urban Design Group*, the planning and design of urban areas, such as streets, buildings, and open spaces, is referred to as urban design or planning [103]. It entails a collaborative, interdisciplinary approach to building the physical environment for human living, intending to produce attractive and practical places. The scope of urban design includes the design of individual structures, groups of buildings, outdoor spaces, and the more outstanding landscape, emphasizing constructing frameworks and processes that will permit effective growth by varied groups of people across time. City and town centers, residential neighborhoods, suburban districts, industrial estates, and ignored areas surrounding transit hubs and rivers are all examples of urban planning. It entails defining design procedures and outputs, as well as determining the character of structures and the spaces that link them. It is possible to inspire, explain, and describe how a place might be improved or protected to benefit investors, developers, and society through urban design.

Another definition states that *urban planning* entails the coordination of urban design, land use regulation, and other areas of urban development that address the urban environment's physical form, economic function, and social influence [104]. It includes the positioning of various activities within the urban area and draws on engineering, architecture, social and political issues, and other disciplines. With this interdisciplinary approach, urban planning becomes a technical profession, a political and public involvement undertaking, and an academic study. Urban planning entails goal formulation, data collecting and analysis, forecasting, design, strategic thinking, and public participation. It is concerned with both open space development and the regeneration of existing metropolitan areas. It is also crucial to clarify that urban design and urban planning are interconnected since *the urban design is a subset of urban planning that deals with the physical design of the built environment, whereas urban planning deals with a more extensive range of topics, such as land use, transportation, housing, and environmental concerns*. The framework within which urban design functions are provided by urban planning and the two disciplines frequently interact closely to produce functional urban areas that are both functional and visually beautiful. Successful urban planning necessitates a thorough grasp of urban design principles. In contrast, effective urban design necessitates a thorough awareness of the larger environment in which it functions, such as zoning restrictions, land use policies, and community needs and wants.

As environmental balances are highly disrupted nowadays, we understand that developing and creating resilient urban architectures is critical. The outcomes sometimes being more challenging than ever, like significant floods and hurricanes of level 4. The ultimate solution to attain a better outcome is the importance of interconnecting architects and engineers.

The architect and urban designer, also the author of the book "*The Nature of Urban Design: A New York Perspective on Resilience*", Alexandros Washburn, states his opinions of the adverse outcomes, asking if relying solely on the strength of our community is enough to withstand such immense forces [105]. Referring to Hurricane Sandy, he states that the storm spans almost one thousand miles, and New Yorkers may be overestimating the citizens' resilience while underestimating the city's resilience. While the sense of community in New York City is undoubtedly robust, the city's physical infrastructure appears vulnerable in the face of these storms. As citizens, he adds that everyone must address the risks posed to the city and leave it exposed to these formidable forces. Although people may comfort

themselves with the belief that such storms only occur once a century, two have already hit New York City in a single year. These used to be once-in-a-century storms during the last century, but they will likely become more frequent in this century.

Another academic, David R. Godschalk, highlights the significance of establishing resilient cities that can survive natural hazards and calamities in his paper "*Urban Hazard Mitigation: Developing Resilient Cities*"[106]. He contends that urban planners and policymakers must proactively recognize and manage dangers before they become disasters. The mitigation process includes completing risk assessments, devising emergency response strategies, and investing in disaster-resistant infrastructure. Godschalk also underlines the need for community involvement in disaster mitigation initiatives and the necessity to address social vulnerability factors that might intensify catastrophe impacts on vulnerable populations. Finally, Godschalk contends that building resilient cities requires a multifaceted strategy incorporating physical, social, and economic considerations into urban design and development.

Along with these important scientific notices, the study of Mitchell D. et al. informs us of another important concept to emphasize: "*Climate Resilient Urban Development*" [107].

Climate resilient development is a similar notion in which development can absorb and recover from climate-related stressors and shocks. We shall use the phrase 'climate resilient urban development' in this debate to confine the conversation to urban development in present and future metropolitan regions.

Climate-resilient urban development necessitates addressing the local effects of increasing urbanization and climate change. According to the IPCC 2014, "*cities are made up of complex interconnected systems that may be exploited to help climate change adaptation through effective municipal governments backed by multi-level governance.*"

Below shown, Figure 3.2. illustrates that the connection between land governance and climate change adaptation is more conspicuous than the link between land governance and climate change mitigation. While climate change mitigation policies offer long-term global benefits by reducing greenhouse gas emissions, adaptation measures provide more immediate local benefits.

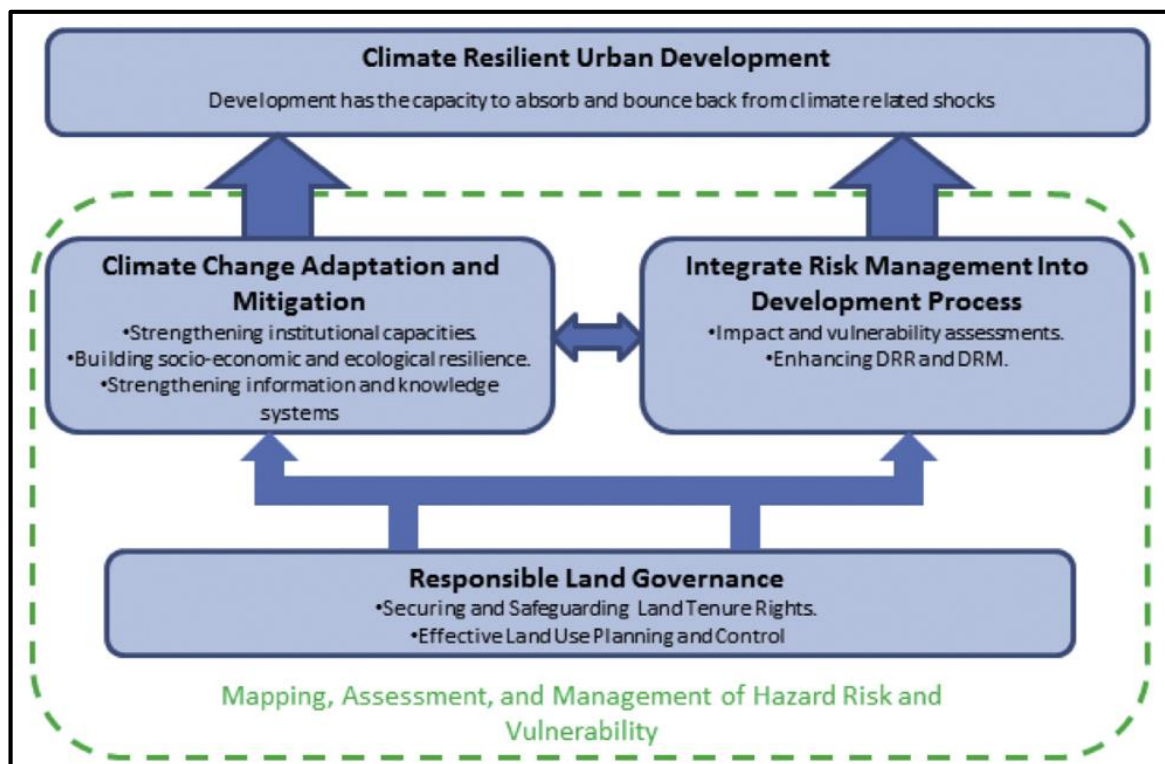


Figure.3.2. Responsible land governance underpins climate resilient urban development [13].

The IPCC 2022 Report Chapter 18 introduces readers to another terminology that is interlinked with *resilient urban development*, “*Climate-Resilient Development*” [13]. The report defines *development* as the formal and informal endeavors to enhance the standards of human well-being, particularly in areas historically disadvantaged by colonialism and other factors related to early global integration. While the SDGs are an internationally agreed-upon subset of objectives, development is not restricted to them.

There are diverse perspectives on development. The concept of development is about growth and improvement, but different people have different ideas about what and how to improve. This has resulted in the development of several metrics to track development, some of which are more significant in policymaking than others. Alternative development indicators seek a more nuanced link between economic progress and human well-being. However, many of these alternate measurements preserve the underlying ideals of progress and economic growth, making them less revolutionary than is required for sustainable development. Several viewpoints on development may be classified into five categories: economic growth, distributional improvements, participation, human capability expansion, and

transformational change. Considering increased attention to environmental problems and the role of grassroots movement and social movements in development, these attitudes have evolved. The report also states the crucial pinpoints of challenges on development and climate topic.

It states that development is a complex path with one objective, and planning for it requires considering multiple factors and processes simultaneously. The increasing focus on climate security exemplifies this. While the 5th Assessment Report had contradictory messages about the link between climate change and security, progress has been made in comprehending the risks climate change poses to security. Climate change can weaken human welfare and security by rendering populations more vulnerable to crises, increasing grievances and political tensions via indirect and sometimes unpredictable pathways. Therefore, it is crucial to consider the context, timing, and spatial distribution while reframing climate change and security as an issue of human security.

The connection between climate-related security risks and development is complex, especially in socially and politically fragile settings. Measures were undertaken to include these risks in institutional and national frameworks, mainly through NDCs and the creation of the UN Climate Security Mechanism in 2018. Still, some works need to be implemented to translate these concerns into practical responses. Emerging research suggests that adding adaptation and mitigation strategies to development plans may have unintended consequences and worsen the situation.

Overall, the Chapter 18 includes that climate adaptation and mitigation initiatives may have unanticipated effects on local development outcomes; thus, it is critical to reconsider how to apply this information to policy solutions to build a Climate-Resilient Development (CRD) approach. Recognizing the interdependence of climate change, security, and development is critical for CRD.

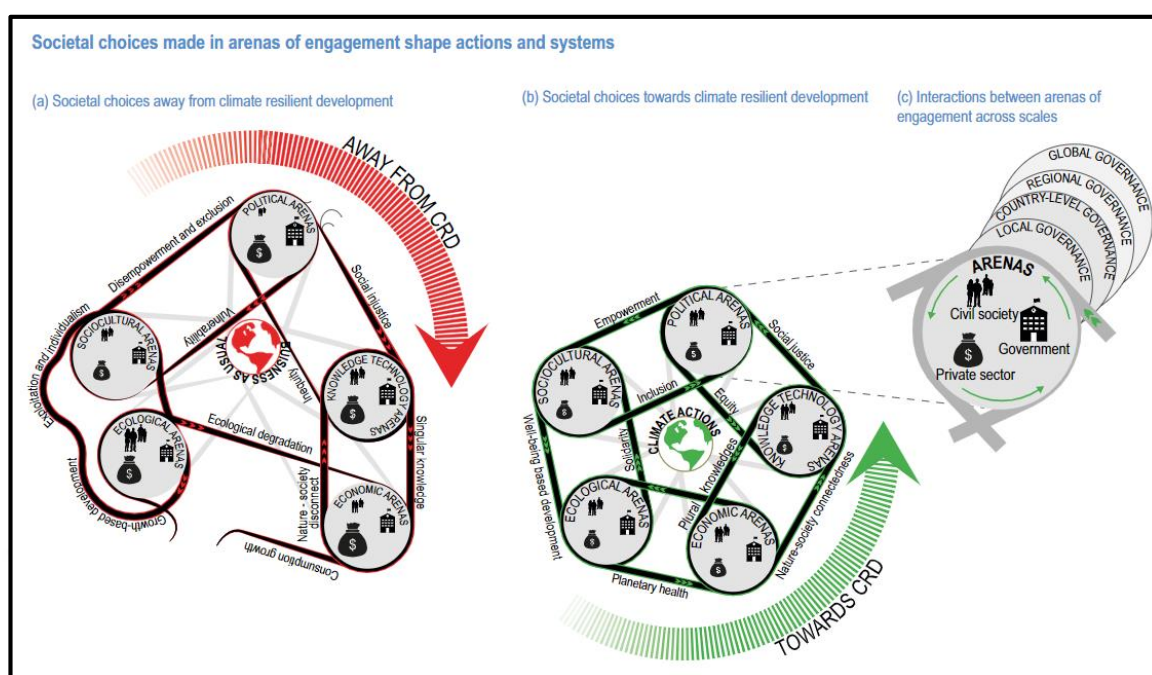


Figure 3.3. Societal decisions in participatory areas [13].

The Figure 3.3, taken from Chapter 18 of IPCC 2022 Report, informs that society's decisions in many areas of participation have an influence on behaviors and systems [13]. Political, economic, socio-cultural, ecological, knowledge-technology, and community situations where government, civil society, and the corporate sector interact are examples of these areas of interaction. They can be professional or informal, and they can be political battlegrounds. The quality of relationships in these areas has the potential to influence development outcomes that affect the Core characteristics that underpin the SDGs. Inequitable relationships and the dominance of certain actors over others can lead to societal decisions that are contrary to CRD, whereas inclusive and synchronous interactions and behaviors facilitate system transitions and transformational change toward CRD. These areas of participation occur at various sizes and, when combined, represent social choices that impact human well-being and global health. It is important to unlock the potential of these choices and associated actions to advance sustainability. In the figure below, CRD Pathways refer to strategies for sustainable development that effectively integrate initiatives aimed at reducing greenhouse gas (GHG) emissions and adapting to climate change impacts. These pathways aim to foster comprehensive and inclusive development while addressing the challenges of climate change (Figure 3.4).

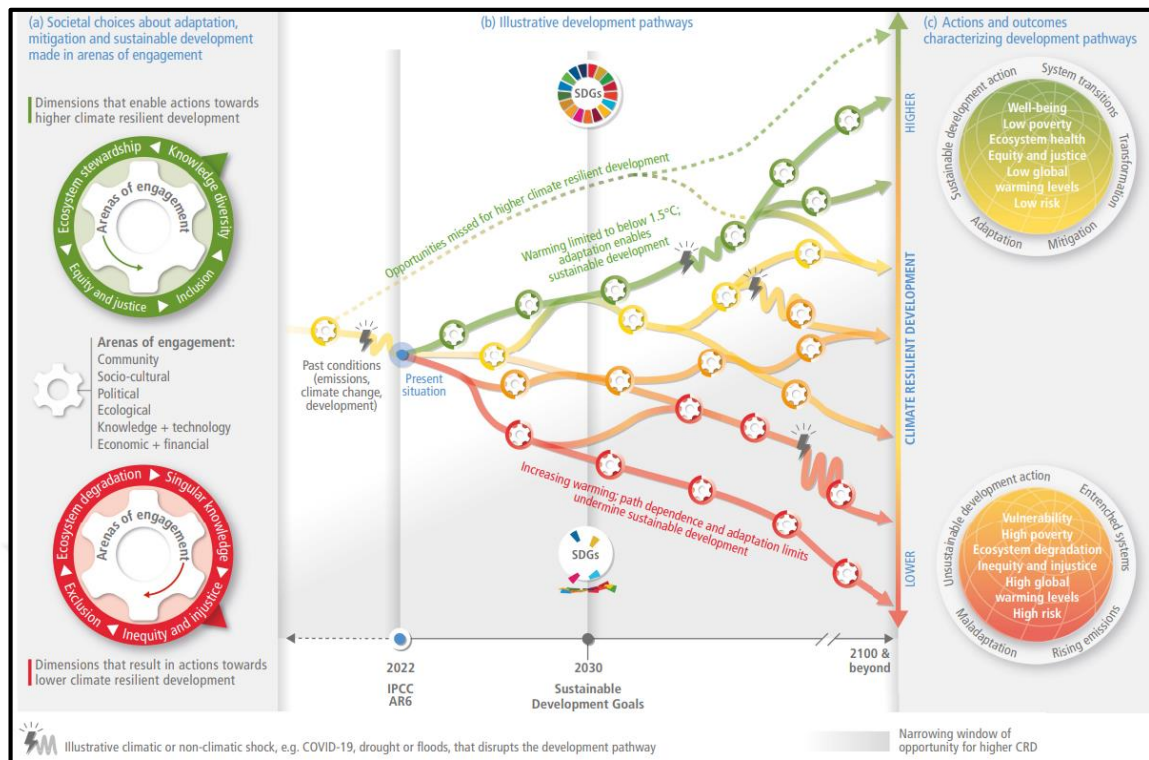


Figure. 3.4. CRD Pathways enable sustainable development through GHG mitigation and adaptation [13].

3.3.1. Resilient Urban Development in Physical Design

Alexandros Washburn, the former Chief Urban Designer of New York City, talked in detail about his experiences of Hurricane Sandy and the events that occurred aftermath in his book [105]. He contends that the design of cities, or urban design, is the first arena where a new connection may be formed, assuming success. According to the author, success in managing cities is closely linked to success in managing the environment, given the intertwined nature of cities and nature. The author believes it is crucial to quantify the interdependency between cities and nature, which challenges the traditional view of nature and humans as separate entities. The author also points out that the impact of cities on climate and vice versa is becoming increasingly apparent due to global warming, rising sea levels, and severe weather events such as Hurricane Katrina and Hurricane Sandy. So, the outcome is that urban design practice involves strategically modifying cities, directing their development towards new patterns that can more effectively address our contemporary challenges while enhancing our overall quality of life. He also has advocated for *resilient urban planning* to solve the issues

that cities face. He also states that urban resilience may be accomplished by building cities that adapt and evolve in response to various stresses, such as climate change, economic insecurity, and social inequity. He believes that creating a resilient urban environment requires a thorough approach that combines physical, ecological, and social systems to enhance the city's ability to withstand and bounce back from unexpected events. Additionally, he emphasizes the importance of involving residents in the planning and design stage to ensure that the resulting cityscape reflects their requirements and values.

Talking about the role of **physical design** in his book, the author raises concerns about the relevance of urban design in the light of cities' need to adapt to changing climates and reduce their impact to climate change. However, the author argues that the future of cities lies in creating a form of city that can withstand extreme weather conditions, support the needs of a growing population, reduce its contribution to climate change, and still provide a livable environment. The author believes that making cities livable is crucial to achieving a sustainable world. The author acknowledges that this idea may seem utopian but encourages putting idealism to the test without waiting.

According to Alexandros Washburn, urban designers must create more resilient cities facing challenges like budget constraints and extreme weather events while improving civic life. However, resilience alone is not enough to create a livable city. For example, a city that can withstand natural disasters while emitting no carbon would not succeed if it does not provide its residents with a good quality of life. Therefore, improving the quality of public space is a crucial step toward improving the overall quality of civic life. Based on the knowledge about how cities are shaped and their impact on climate change and understanding the ability of urban design to alter the form of cities to face these challenges, individuals who care about cities have the opportunity to envision a future city that can fulfill our requirements if citizens express them in the right way. The urban design aims to change the current state of things and leave the city in a better condition. The role of urban designers is not to design entire cities but to create the tools that can change and improve them. These tools are urban design outcomes and are practical, specific, and intended to bring about significant change. Examples of these tools include rules, plans, and pilot projects that can transform neighborhoods. It is only considered urban design if these tools lead to transformational change.

In her article, Claire Weisz, an urban designer and architect based in New York, seeks to demonstrate the relevance of resilient design and systems thinking as climate change solutions in her paper "*Resilient Design, Systems Thinking' as a Response to Climate Change*" [108]. She argues that due to the impacts of climate change, which include rising sea levels, extreme weather events, and heatwaves, there is a need for a new approach to design and planning that prioritizes the ability to withstand and adapt to changing environmental conditions, known as resilience. Buildings, infrastructure, and urban environments that are resilient to changing environmental circumstances are created through resilient design.

The author also underlines the value of systems thinking in dealing with climate change. Understanding how various components of a complex system are interrelated and how changes in one section of the system can have rippling effects across the entire system is what systems thinking entails. Weisz suggests that by applying systems thinking to urban design and planning, it is possible to create more resilient and sustainable cities in the face of climate change impacts. This approach involves understanding the interconnections between different parts of a complex system and how changes in one part can affect the entire system. By doing so, urban planners can develop strategies that enable cities to adapt and cope with the effects of climate change. Ultimately, Weisz's work emphasizes the need for a shift in how we approach climate change design and planning, highlighting the need for resilience and systems thinking. She states that more work needs to be done and that a few themes emerge when taking stock of some of North America's most innovative resilience initiatives and concepts. In her article, the author expresses her viewpoints and notes that small, interdisciplinary firms drive many initiatives embracing a systems thinking approach. These firms play a significant role in promoting resilient design practices. Large-scale projects, on the other hand, often arise from design competitions but need more financing prospects. Nonetheless, while modest in scale, completed projects hold the potential for regional application. The author acknowledges that these small firms' representation in the resilient design field needs to be more comprehensive. Major corporations also engage in large-scale engineering-focused resilience projects. However, the forefront of innovative and experimental initiatives is dominated by firms that employ systems thinking techniques. These businesses demonstrate agility in managing multidisciplinary teams and solving problems that arise at the intersection of complex systems. In essence, they excel in

designing amidst continual change. To illustrate this dynamic, the author draws upon a metaphor rooted in the teachings of Heraclitus. Heraclitus believed in the concept of constant change and interconnectedness, which he referred to as Logos. He considered Logos to be the fundamental unity of humankind, nature, and the universe, an indisputable reality often overlooked by most people. Despite being intricately linked to Logos, humanity often conflicts with it, opposing the natural flow of interconnectedness.

One of the world's recognized foundations, **Urban Land Institute** (ULI), cites in its mission statement that it aims to influence the future of urban development and positively impact communities worldwide [109]. They are a worldwide network of professionals involved in various aspects of real estate development and land use, including private and public sectors. They recently prepared crucial reports on establishing resilience and how mitigating climate change by building resilient cities would have a positive impact.

The report on “*Social Spaces, Resilient Communities*” examines the role of social infrastructure in increasing urban resilience and decreasing susceptibility to climatic risks [110]. Communities' locations to assemble and establish relationships are referred to as *social infrastructure* and might include sites such as *community centers, parks, and other gathering spots*. According to the paper, real estate professionals may consciously include high-quality social gathering areas as part of a climate and *Environmental, Social, and Governance* (ESG) Plan. Improved asset value, higher interest from community-minded end users, and more predictable long-term returns on investment are all part of the business case for social infrastructure investment. The paper offers advice on creating adequate social infrastructure and the characteristics of successful social infrastructure developers. It also covers numerous sorts of social infrastructure and project profiles. The key takeaways emphasize that social infrastructure is critical for resilience and has a strong business case for real estate investment, and it can be designed into multiple property types. Successful social infrastructure prioritizes social equity, access, and intentional attention to maintenance and programming.

The other report that may get readers' attention is the report by ULI and LaSalle Investment Management Company, “*How to Choose, Use, and Better Understand Climate-Risk Analytics*”, prepared on September 14, 2022 [111]. The paper assesses the growing impact of climate catastrophes on asset portfolios and the global implementation of new climate risk disclosure requirements. The physical risk associated with climate change presents

challenges for real estate managers, including a lack of industry norms or guidance for selecting physical-risk climate science data providers, evaluating products and the underlying science, and integrating information into real estate life-cycle decisions. To address these issues, ULI and LaSalle Investment Management worked to teach the land use sector how to evaluate climate-risk data, detect risks efficiently, and incorporate them into investment decisions across the investment life cycle. The research is organized into six sections that discuss physical climate risk, how analytics businesses quantify climate risk, how real estate managers evaluate physical-risk data, and how the real estate community and climate-risk data providers may enhance decision-making using physical climate risk.

Like other reviewed studies, these reports, books, and articles all demonstrate the importance of systems thinking in building resilience. Inclusivity and integration of all of the elements of the society (humans and living animals included), all of the infrastructural elements (transportation systems of all kinds included), and governance elements (local and central systems) should become part and united to form a resilient development system.

4. ASSESSMENT CRITERIA

This section of the thesis is allocated solely to the analysis and formation of a resilience assessment which will guide us while conducting the urban resilience examination, and help other researchers during their research studies.

Aside from scientific studies and books, The Resilience Alliance's "*Resilience Assessment*" has been a great resource. So, why was this institution created, and what are its functions?

The **Resilience Alliance** is an interdisciplinary research organization established in 1999 to study social-ecological systems and promote resilience, adaptive capacity, and transformation [112]. They distinguish themselves by conducting comparative research at a global scale based on local and regional studies. Their *three complementary strategies* involve *contributing to theoretical advances, testing theory through rigorous means, and developing guidelines and principles to assess resilience and develop sustainable policies*. They have experience engaging stakeholders in adaptive management and resilience assessment processes and are committed to exploring new ways of communicating and building connections among researchers and practitioners. Additionally, they publish a *peer-reviewed open-access journal, Ecology & Society*, and bring research findings to the attention of policy and decision-makers.

This organization has created a "*Resilience Assessment Workbook*", available for researchers working in the field of resilience and its diverse contents [113]. In addition to this helpful workbook, evaluations developed by the Rockefeller Foundation and Arup titled "*The City Resilience Index*" types of research will be used in developing the overall resilience assessment. UN Habitat's "*Guide to the City Resilience Profiling Tool*" is also used to synthesize the assessment.

As stated in their guide, UN-Habitat also emphasizes urban resilience. They state that cities face various shocks and stresses, both natural and human-made, such as earthquakes, flooding, immigration, and cyber-attacks [114]. To address this, the global community recognizes the need to build city resilience by empowering local governments, partners, and populations. UN-Habitat defines urban resilience as *the ability of an urban system and its inhabitants to maintain continuity despite shocks and stresses while positively adapting towards sustainability*. Global agreements such as the New Urban Agenda, Paris Agreement,

Sustainable Development Goals, and Sendai Framework have acknowledged the importance of urban resilience. Resilience serves as a crucial intersection between different paradigms in urban development, reducing risks by increasing capacities, addressing vulnerabilities, and mitigating impacts for effective response. Successful resilience agendas require partnerships among critical international actors and engagement with city players, promoting inclusive cooperation to build a shared resilient vision.

Some questions are helpful for everyone to ask themselves while doing this resilience assessment. These can be listed as follows:

- How can we utilize our current resources effectively?
- What areas require additional public funding?
- What are the cost implications of enhancing existing functions?
- How will physical assets be impacted?
- What spatial characteristics require changes?
- What organizational measures can be taken?
- How can resilience considerations be integrated into the city's regular activities?
- How can improvements be made without negatively impacting other aspects?
- How can all stakeholders be involved in implementing resilience strategies/actions throughout the city?

Indeed, it is possible to reflect on and analyze these questions by examining our work and social environment activities, beginning with our daily routines. Through evaluating how these questions apply to individuals' day-to-day lives, insights can be gained into integrating resilience strategies into regular activities and identifying areas where improvements can be made to enhance resilience without compromising other aspects of their work and social environment. Engaging all stakeholders in implementing resilience strategies can also be facilitated by considering these questions in our daily activities, ensuring inclusive involvement from all relevant parties.

This thesis study will include these questions in more detail, and what can be done under the categories will be examined. The study questionnaire and will be a synthesis of *Resilience Assessment Workbook* and *Guide to the City Resilience Profiling Tool* and will try to provide an updated assessment toolkit for the designated area which can also be expanded in content and implemented in various areas involving resilience studies [113] [114].

The first part of the assessment (shown in Table 4.1 below) will entail a summary of *the primary topics of concern for the assessment and the system's valued features*. It includes the three main elements to figure out as a result of this section. The first is the *primary concerns* which aim to exhibit the extant problems occurring for a certain amount of time. The second subcategory points out the significant sources of concern for this chapter. The third one is to list the valuable system characteristics, like what is advantageous in the designated area and any biodiversity or natural resource to point out.

Table 4.1. The summary of the primary topics of concern for the assessment.

4.1 .A summary of the primary topics of concern for the assessment and the system's valued features.		
PRIMARY CONCERNS	MAJOR SOURCE(S) OF CONCERN(S) FOR THE EVALUATION	HIGHLY APPRECIATED SYSTEM CHARACTERISTICS

The second part (shown in Table 4.2 below) is to identify *the direct and indirect uses of critical natural resources* supplied by the system and the stakeholders who rely on them.

Table 4.2. The direct and indirect uses of key natural resources.

4.2. Identify the direct and indirect uses of key natural resources that are supplied by the system, as well as the stakeholders who rely on them.	
NATURAL RESOURCE USAGES	
Direct Usage (elements that are in direct contact with the functioning of the park)	Indirect Usage (elements that facilitate the liveliness at the park)
STAKEHOLDERS	
Inside the system	Outside the system

This part consists of two separate parties, the first one which is *Natural Resource Usages* and the other one allocated to the *Stakeholders*, a group with an interest or concern in the project, company, or organization. Internal or external stakeholders, such as workers or management, might be internal or external, such as consumers, suppliers, shareholders, government agencies, or the community. Natural Resources are also divided into two subcategories such as *direct* and *indirect usage*. The Stakeholders also have two subcategories, *inside*

and *outside the system*, which aim to point out the hierarchy and the rank of importance of people involved in the project.

The third part of the evaluation (shown in Table 4.3 below) section will include the *list of target system disruptions and their characteristics*.

Table 4.3. The list of target system disruptions and their characteristics.

4.3. THE LIST OF TARGET SYSTEM DISRUPTIONS AND THEIR CHARACTERISTICS					
Disturbance (past/ present)	Unique / Recurrent	Occurence frequency	Recovery time between occurrences	Most impacted elements	The magnitude of the damage (1-5) (modest to severe)
Hurricanes					
Winter storms					
Tornadoes					
Flooding					
Earthquakes					
Heatwaves					
Thunderstorms					

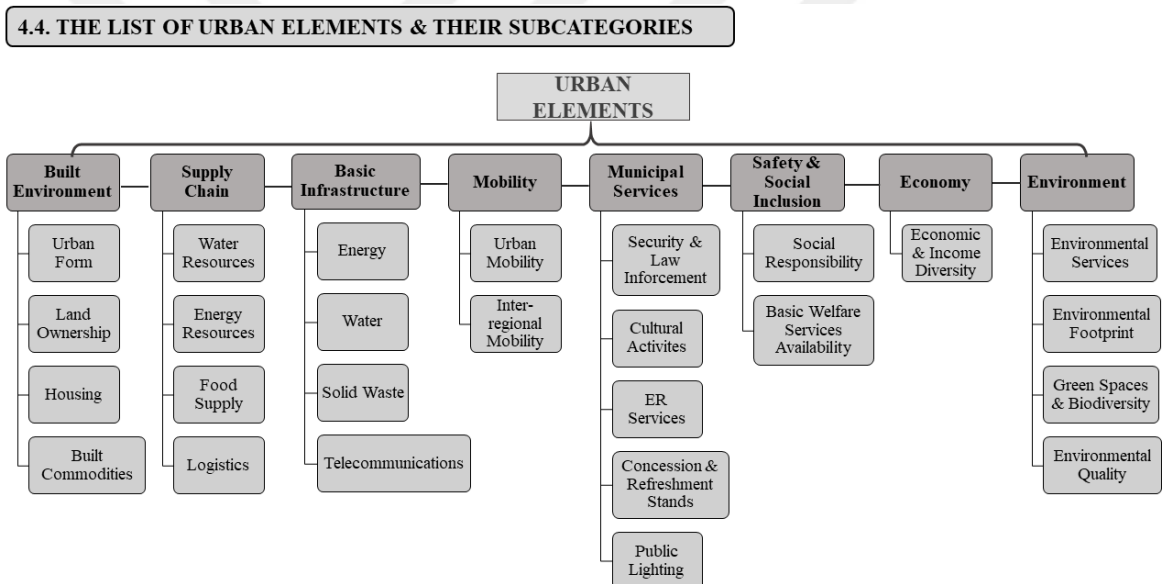
This section consists of six features that are interrelated and affect each other. The primary purpose of this section is to identify the complexities that occur within the system and to reveal what affects them the most. The six subcategories are cited as follows:

- *Disturbance*,

- *Unique/recurrent,*
- *Occurrence frequency,*
- *Recovery time between occurrences,*
- *Most impacted elements,*
- *The magnitude of the damage.*

The fourth part (shown in Table 4.4 below) is dedicated to list the *urban elements and their categories*.

Table 4.4. The list of urban elements & their subcategories.



The additional subcategories are:

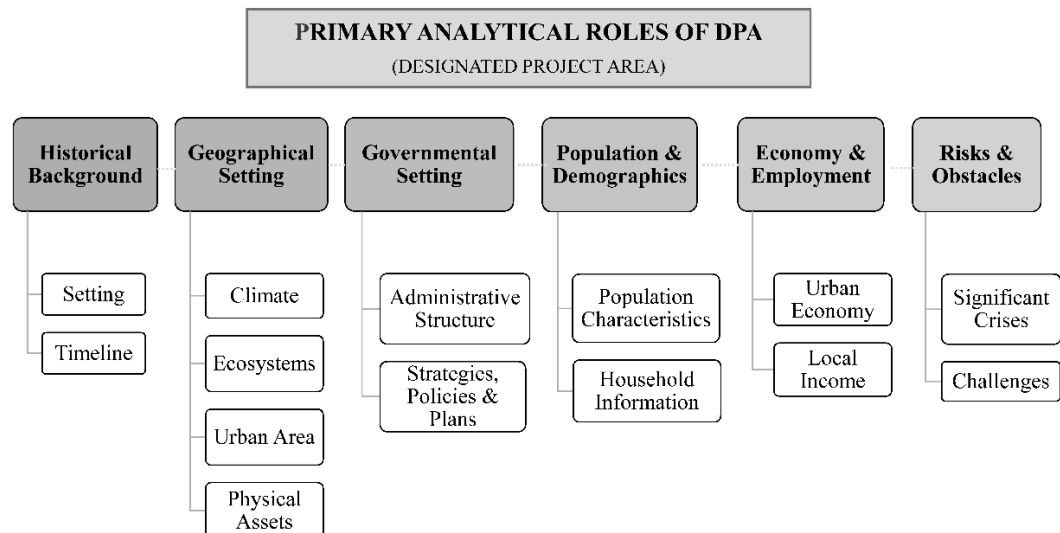
- Built Environment → *Urban form, land ownership, housing, and built commodities.*
- Supply Chain → *Water resources, energy resources, food supply, and logistics.*
- Basic Infrastructure → *Energy, waste, solid waste, and telecommunications.*
- Mobility → *Urban mobility and inter-regional mobility,*
- Municipal Services → *Security & law enforcement, cultural activities, er services, concession & refreshment stands and public lighting.*

- Safety & Social Inclusion → *Social responsibility and basic welfare services availability.*
- Economy → *Economic & income diversity.*
- Environment → *Environmental Services, Environmental Footprint, Green Spaces & Biodiversity and Environmental Quality.*

The fifth evaluation (shown in Table 4.5 below) will mainly include the *primary roles of the Designated Project Area*.

Table 4.5. The list of primary roles of dpa.

4.5. THE LIST OF PRIMARY ROLES OF DPA (DESIGNATED PROJECT AREA)



This part intends to explain the specs of the project area, to give information about the area and it's background. The main categories are listed as:

- *Historical Background*
- *Geographical Setting*
- *Governmental Setting*
- *Population & Demographics*
- *Economy & Employment*
- *Risks & Obstacles.*

Then these main categories will break down into subcategories in each section, such as:

Historical Background

- *Setting*
- *Timeline*

Geographical Setting

- *Climate*
- *Ecosystems*
- *Urban Area*
- *Physical Assets*

Governmental Setting

- *Administrative Structure*
- *Strategies, Policies & Plans*

Population & Demographics

- *Population Characteristics*
- *Household Information*

Economy & Employment

- *Urban Economy*
- *Local Income*

Risks & Obstacles

- *Significant Crises*
- *Challenges.*

This extensive appraisal provides a fundamental value to the project site and helps readers understand the local terrain better.

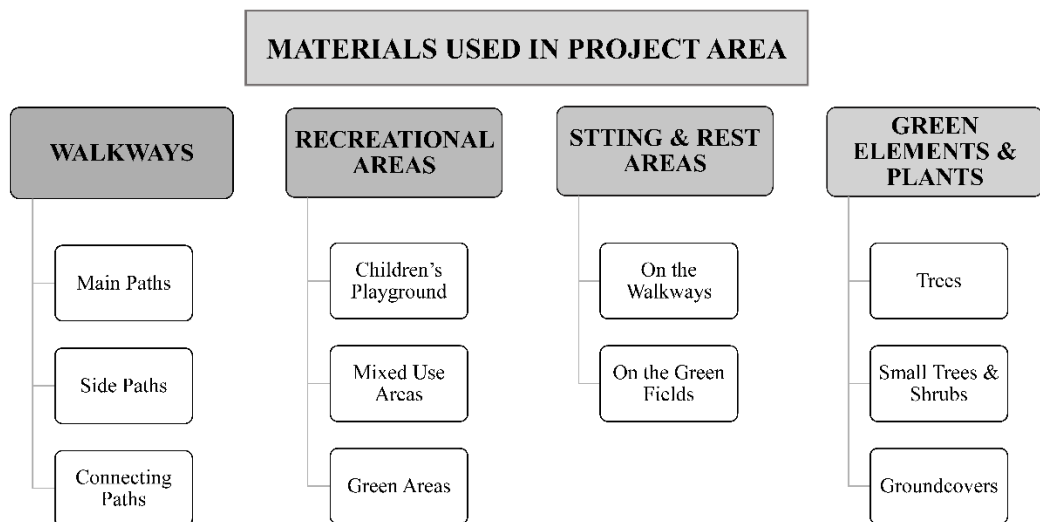
The sixth evaluation (shown in the Table 4.6 below) intends to explain the *Materials used in Project Area* thoroughly. This section also includes living elements such as plants and

shrubs. This section is analyzed into four main categories and ten subcategories. The main categories are cited as follows:

- *Walkways,*
- *Recreational Areas,*
- *Sitting & Rest Areas,*
- *Green Elements & Plants.*

Table 4.6. The Characteristics of materials used in the area.

4.6. THE CHARACTERISTICS OF MATERIALS & INFRASTRUCTURAL ELEMENTS USED IN DPA



Subcategories for this section is as follows:

Walkways

- *Main paths*
- *Side paths*
- *Connecting paths*

Recreational Areas

- *Children's Playground*
- *Mixed Use Areas*
- *Green Areas*

Sitting & Rest Areas

- *On the Walkways*
- *On the Green Fields*

Green Elements & Plants

- *Trees*
- *Small trees & shrubs*
- *Groundcovers*

Each of these evaluations has a unique context, yet they are all significant because they disclose the progress made regarding field assessment and resilience. In other words, these assessment forms were developed to aid in defining and determining the land used for the park and recreation area, examining the materials used, and preparing a park and recreation area that can resist and recover from any damage or disruption. When evaluating the park's resilience and preparation for future difficulties or hazards, these forms strive to consider all crucial elements.

The evaluation forms created in this section serve as the foundation for the project area research, which is the next stage of the thesis work, "*Urban resilience examination of New York City: A site analysis, Hunter's Point South Park.*"

5. URBAN RESILIENCE EXAMINATION OF NEW YORK CITY : A SITE ANALYSIS, HUNTER'S POINT SOUTH PARK

5.1. INTRODUCTION

Field analysis examinations will be conducted in this section of the thesis. *Hunter's Point South Park* in Long Island City, Queens, **New York City**, was chosen for the area analysis.

5.1.1. Scope and objectives

The park was selected because it represents an urban renewal initiative that places a high value on promoting resilience principles in its renovation efforts while safeguarding its original identity. Therefore, this thesis study aims to explore various aspects related to Hunter's Point South Park, mainly on a resilience-scaled basis, including its environmental impact, community engagement, historic preservation, design and architecture, and economic impact. The park's ability to promote ecological sustainability, reduce stormwater runoff, and improve community health and wellness will also be investigated. Additionally, the study will analyze the park's design and construction, historical context, and role in promoting economic development in the surrounding area. The research will consider the park's resilience, crucial in ensuring long-term sustainability and success.

While going through this chapter, the main objectives that can be highlighted include:

Resilience: Hunter's Point South Park was designed to prioritize resilience, which means its ability to withstand and recover from environmental stressors and natural disasters. The park incorporates wetlands and rain gardens that absorb and filter stormwater runoff, promoting ecological sustainability and resilience.

Revitalization: The park was built on an abandoned industrial site and transformed into a vibrant public space. The park's revitalization has positively impacted the surrounding community, promoting health and wellness by offering a safe and accessible outdoor space for exercise and recreation.

Community engagement: The park's design reflects the needs of the local community by incorporating recreational facilities such as a playground, soccer field, basketball court, and

bike path. It also provides stunning views of the East River and the Manhattan skyline, making it a popular spot for tourists and locals.

Historical preservation: The park incorporates features that pay tribute to the site's industrial past, preserving the area's historic character. This demonstrates how urban revitalization projects can prioritize sustainability and community needs while preserving a space's unique history and character.

Sustainability: The park was designed with sustainability in mind and incorporated environmentally-friendly features such as solar-powered lights, recycled materials, and native plant species. These valuable features promote the park's long-term ecological sustainability while reducing its carbon footprint.

Educational opportunities: The park offers various educational opportunities, including interpretive signs and guided tours that highlight the park's ecological and historical features, which provide visitors with an opportunity to learn more about the area's history and ecology, promoting environmental education and awareness.

Community connectivity: The park promotes community connectivity by providing a safe and accessible pedestrian and bike path that connects to other parks and neighborhoods. It improves access to outdoor spaces and promotes active transportation.

Overall, the objectives of Hunter's Point South Park are multifaceted and include resilience, revitalization, community engagement, historical preservation, sustainability, educational opportunities, and community connectivity. These objectives demonstrate how the design and construction of a public park can significantly impact the surrounding community and environment.

5.1.2. Methodology of the study

During the thesis study, there are various methodologies to be used. A few literature reviews will be added to clarify certain aspects of the resilience and resilient design of the area. The methods mentioned below are the main ones to be used:

- **Case study analysis:** A case study approach can be a valuable method to examine the park's design, construction, and impact on the community and environment.

Valuable information can be gathered through interviews, surveys, and observing park users.

- **Historical research:** Investigating the historic preservation aspect of the park, the study could use historical research methods such as archival research and oral history interviews to gather information about the site's industrial past and the park's design elements that celebrate this history.
- **Analysis of the environment:** The study aims to examine the ecological impact of the park. To achieve this, ecological analysis methods can be used to measure the diversity and abundance of plant and animal species, monitor water quality, and evaluate the effectiveness of the park's stormwater management systems.
- **Economic impact analysis:** Assessing economic impact is crucial in making informed decisions. It is essential to consider the effects of changes on the economy before implementing them. Therefore, evaluating these effects is essential to ensure a stable and prosperous economy in the long run.
- **Comparative analysis:** The study could compare Hunter's Point South Park with similar parks in design, construction, and impact on the community and environment.
- **Mixed-methods approach:** The study could use a mixed-methods approach that combines multiple research methods to provide a more comprehensive understanding of the park's impact on the community and environment.

5.2. NATURAL DATA

This chapter contains information on the project's location, including geography, terrain, climate, and catastrophe and recovery information relevant to the project site. This information is essential for project planning as well as for arranging evaluation studies.

5.2.1. Geographical Location

The geographical location of the project site in *New York City* and it is stated as initially known as *New Amsterdam* and sometimes referred to as New Orange, is a major city and port situated at the mouth of the Hudson River in southeastern New York State, in the **northeastern** region of the United States [115]. It is basically a 315-mile (507 km) river that originates in the Adirondack Mountains and flows through eastern New York State. The Hudson River empties into New York Bay, which is an arm of the Atlantic Ocean.

Five boroughs make up the city are:

- Manhattan,
- Brooklyn,
- The Bronx,
- Queens, and
- Staten Island.

Each borough has its unique lifestyle, contributing to the diverse and vibrant character of the city. With its considerable size and influence, New York City is the largest and most influential metropolis in the United States. Additionally, its urban area extends beyond the city's borders, encompassing parts of neighboring regions such as New York, New Jersey, and Connecticut. This expansive reach further adds to the city's cultural and economic impact.

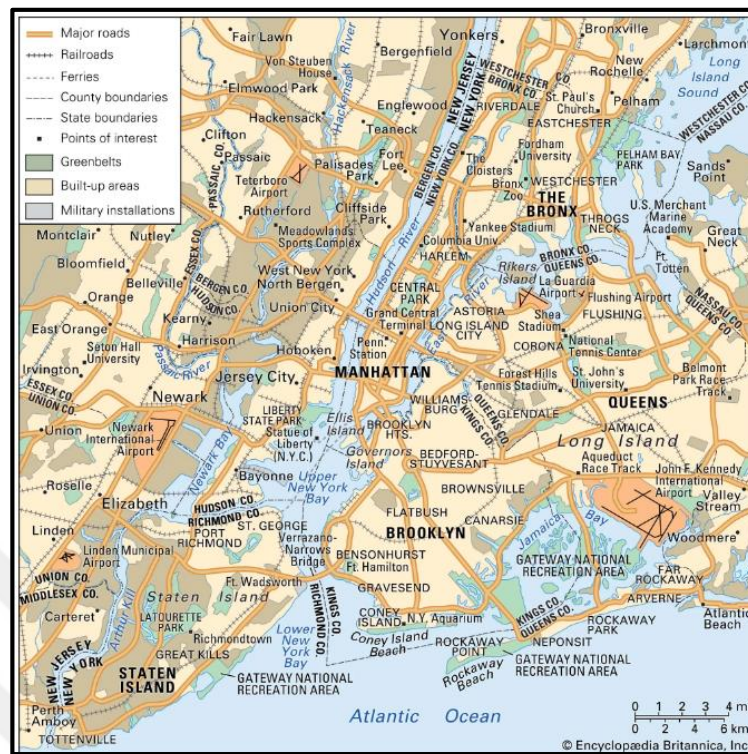


Figure 5.1. Map of New York City and it's boroughs [115].

New York City (shown in Figure 5.1) has several geographical location elements that contribute to its unique character and appeal. Here is a list of some crucial elements that define the city :

- **Rivers:** The Hudson River flows along the western boundary of Manhattan, while the East River separates Manhattan from Brooklyn and Queens.
- **Harbor:** New York Harbor, which connects the Hudson River to the Atlantic Ocean, has historically been an important port and transportation hub.
- **Islands:** There are several small islands in New York Harbor, including Governors Island, Liberty Island (home of the Statue of Liberty), Ellis Island (a former immigration center) and Roosevelt Island.
- **Central Park:** This large public park in the heart of Manhattan provides a green oasis amid the city's urban landscape.
- **Beaches:** There are several public beaches in New York City, including Coney Island in Brooklyn and Rockaway Beach in Queens.

5.2.2. Topography

In his book “*The Nature of Urban Design: A New York Perspective*,” Alexandros Washburn states that for many years before the Dutch arrived, the Lenape Indians were the inhabitants of Manhattan. They used controlled fires and non-linear cultivation methods to manage the landscape, which resulted in the creation of fifty unique ecosystems or habitats that could be compared to neighborhoods [105]. He also mentions thorough research in this area, which is essential for comprehending New York City's history and topography. This research study belongs to Eric Sanderson, a Senior Conservation and Landscape Ecologist working at the Wildlife Conservation Society who earned his Ph.D. in ecology, with a focus on ecosystem and landscape ecology, from the University of California, Davis [116]. He has been leading the "Landscape Ecology and Geographic Analysis" program, which aims to integrate landscape thinking and geographic analysis tools into the organization's conservation efforts. The *Mannahatta Project* at the Wildlife Conservation Society, where Sanderson has worked closely with Markley Boyer, unearthed the original ecosystem of Manhattan, one of New York City's five boroughs, after a decade of research (1999-2009) [117]. This project has been a milestone in topographic research conducted in this field regarding the meticulous and detailed studies presented while conducting it. The project aims to explain in detail what the city looked like before the 1600s and how it reshaped after Dutch settlers embarked on the lands of Lenape Indians. The project takes its name from the Lenape Native American word for the *island*, which means "island of many hills." The project's objective is to gain a comprehensive understanding of the natural environment and wildlife that existed on Manhattan Island in the 1600s, prior to the arrival of Europeans. The project collects historical documents, ecological data, and computer modeling. The researchers seek to build a thorough picture of the island's original ecosystem, including plant, animal, and microbe species. The Manhatta Project also seeks to demonstrate the importance of urban conservation and the potential for cities to support biodiversity. By highlighting the ecological history of Manhattan, the project aims to encourage people to think about how cities and nature can coexist and to inspire conservation efforts in other urban areas around the world.

So, according to the information provided along with research studies conducted by Sanderson and other scientists and researchers, the city's topography was formed with hills,

streams, and various species of plants and animals, which means rich in biodiversity. Below can be observed the *British Headquarters Map* (Figure 5.2.), which depicts the existing topographic elements of the era. The *Manhatta* Illustrations can be seen in Figure 5.3. and Figure 5.4.

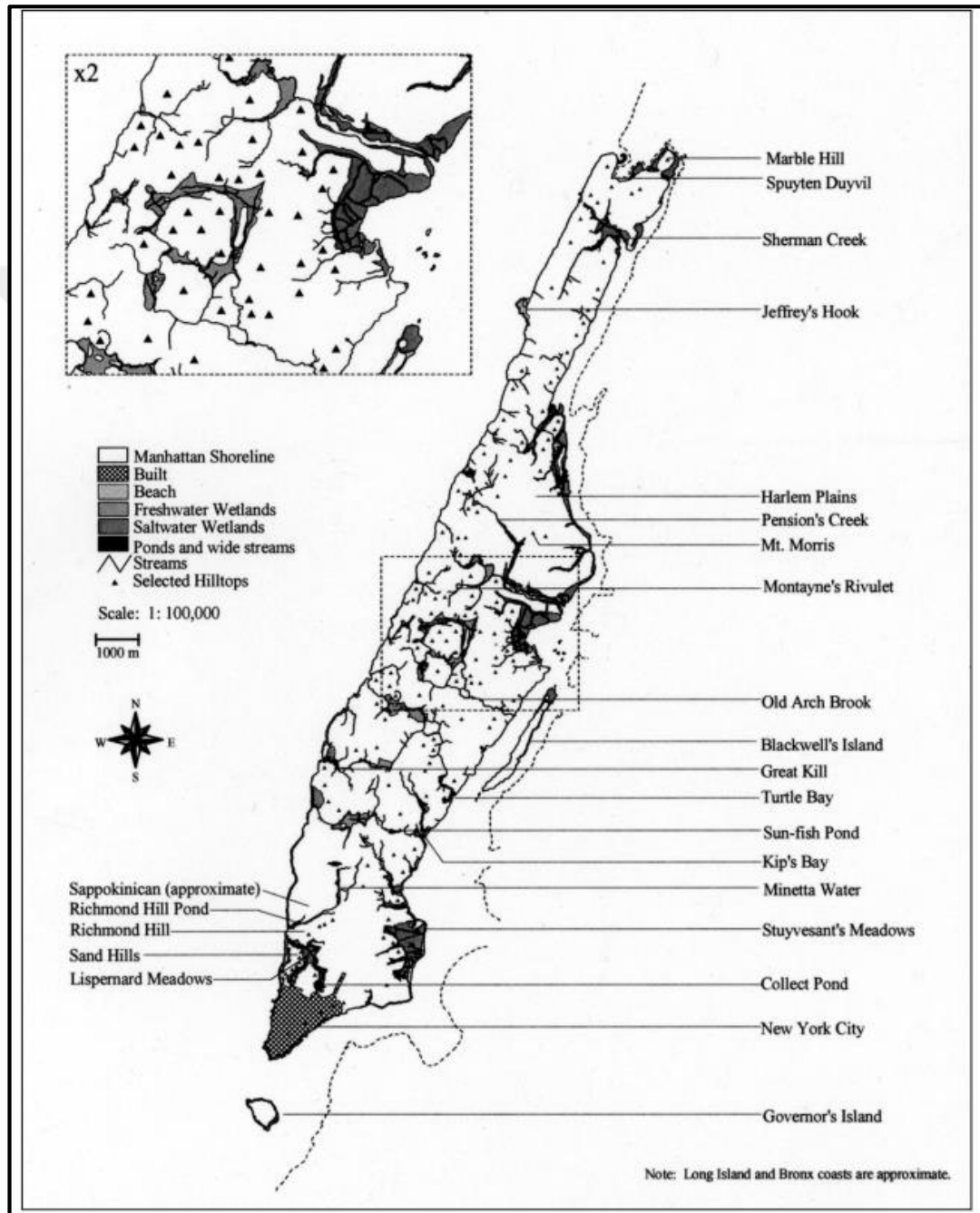


Figure 5.2. British Headquarters Map [115].



Figure 5.3. Manhatta Island Illustration [118].



Figure 5.4. A recreation of the lower west side Manhattan & The Battery Park City in 21st century [119].

5.2.3. Climate

According to data provided by the National Oceanic and Atmospheric Administration (NOAA), shown in Table 5.1, New York City experiences a humid subtropical climate characterized by hot and humid summers and relatively cold winters [120]. During the summer months, temperatures during the day range from 21°C (70°F) to 29°C (85°F) on average. The humidity can make it feel even hotter, which can be uncomfortable for some people. In contrast, winter temperatures during the day range from -4°C (25°F) to 4°C (40°F) on average and can sometimes drop below -18°C (0°F) during periods of extreme cold.

Spring and fall are transitional seasons, with daytime temperatures ranging from 50°F (10°C) to 70°F (21°C). These seasons are generally mild, and the weather can be pleasant with comfortable temperatures and lower humidity levels.

Precipitation is distributed relatively evenly throughout the year, with an average of about 1143 mm (45 inches) of rain and 711 mm (28 inches) of snow annually. The wettest months are typically April, May, and June, while the driest are January and February.

Despite experiencing relatively cold winters, the harbor in New York City rarely freezes due to the city's moderate climate. The average temperature in January is about 0°C (31°F), while in June, it is around 22°C (72°F). However, temperature extremes can occur, ranging from -26 to 41°C (-15 to 106°F).

Table 5.1. Climate Data for New York (1991-2020 Normals) [120].

Climate data for New York (Belvedere Castle, Central Park), 1991–2020 normals													[hide]
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean maximum °F (°C)	60.4 (15.8)	60.7 (15.9)	70.3 (21.3)	82.9 (28.3)	88.5 (31.4)	92.1 (33.4)	95.7 (35.4)	93.4 (34.1)	89.0 (31.7)	79.7 (26.5)	70.7 (21.5)	62.9 (17.2)	97.0 (36.1)
Average high °F (°C)	39.5 (4.2)	42.2 (5.7)	49.9 (9.9)	61.8 (16.6)	71.4 (21.9)	79.7 (26.5)	84.9 (29.4)	83.3 (28.5)	76.2 (24.6)	64.5 (18.1)	54.0 (12.2)	44.3 (6.8)	62.6 (17.0)
Daily mean °F (°C)	33.7 (0.9)	35.9 (2.2)	42.8 (6.0)	53.7 (12.1)	63.2 (17.3)	72.0 (22.2)	77.5 (25.3)	76.1 (24.5)	69.2 (20.7)	57.9 (14.4)	48.0 (8.9)	39.1 (3.9)	55.8 (13.2)
Average low °F (°C)	27.9 (-2.3)	29.5 (-1.4)	35.8 (2.1)	45.5 (7.5)	55.0 (12.8)	64.4 (18.0)	70.1 (21.2)	68.9 (20.5)	62.3 (16.8)	51.4 (10.8)	42.0 (5.6)	33.8 (1.0)	48.9 (9.4)
Mean minimum °F (°C)	9.8 (-12.3)	12.7 (-10.7)	19.7 (-6.8)	32.8 (0.4)	43.9 (6.6)	52.7 (11.5)	61.8 (16.6)	60.3 (15.7)	50.2 (10.1)	38.4 (3.6)	27.7 (-2.4)	18.0 (-7.8)	7.7 (-13.5)

New York City is also susceptible to hurricanes and tropical storms, particularly during the late summer and early fall months. While these events are infrequent, they can still significantly impact the city. For example, Hurricane Sandy in 2012 caused extensive damage and disruption to the city's infrastructure and transportation systems.

5.2.4. Disaster and Recovery Data

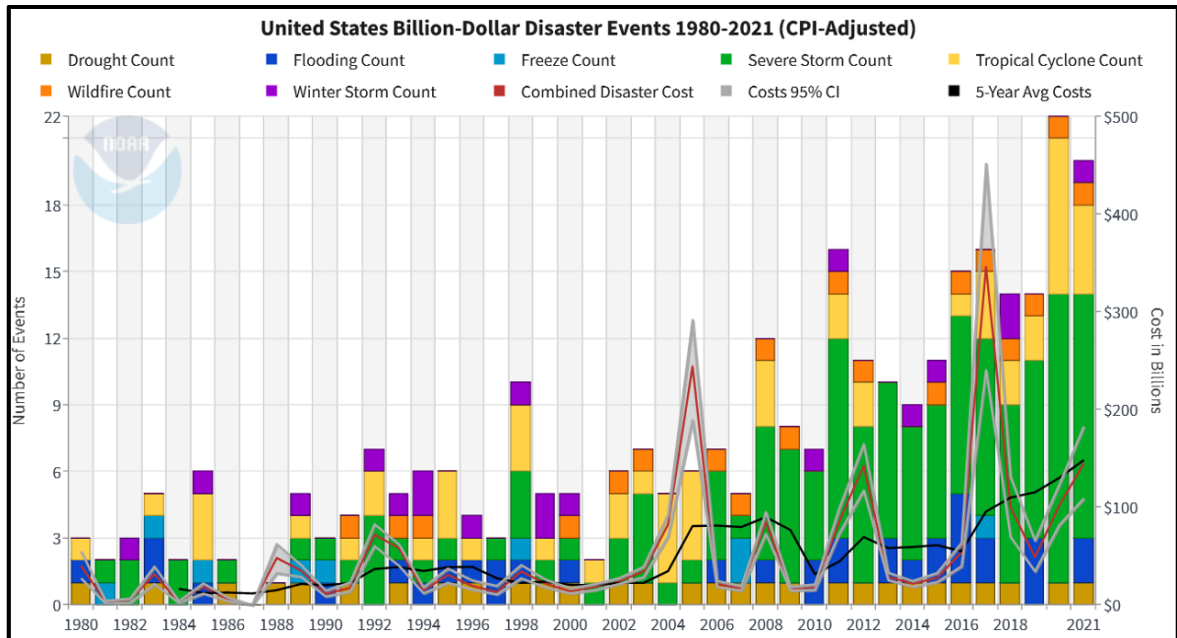


Figure 5.5. Disaster Data of US [121].

The Figure 5.5. shows a time frame of each year from 1980 through 2021; the history of billion-dollar catastrophes in the United States is shown, with event type (colors), frequency (left-hand vertical axis), and cost (right-hand vertical axis). The quantity and expense of weather and climate catastrophes are increasing due to a mix of population increase and development, as well as the impact of human-caused climate change on some types of severe occurrences that result in billion-dollar disasters [121].

According to the *United States Census Bureau*, New York, both as a state and mainly as a city, has the most people in America [122]. According to the US Bureau of Census, New York City will have about 9 million residents by 2021. This makes the city more vulnerable to natural events, mainly disasters. The city also has had its fair share of natural disasters.

Primal Survivor, a website that provides information and resources for people interested in wilderness survival, prepping, and homesteading and is also referenced by New York Times and other reliable online sources, gives specific information on how to act during the occurrence of disasters [123]. The website also provides tips and advice for emergency preparedness, including creating a bug-out bag, storing food and water, and developing

survival skills. In addition, the website features product reviews, gear recommendations, and interviews with experts in survival and preparedness. Overall, the primary purpose of the Primal Survivor website is to provide education and resources to help people become better prepared for emergencies and outdoor survival situations.

Recently, it has covered a whole topic on natural disasters and risks including it. In terms of risk, New York has a medium level of risk compared to other states in the US when it comes to natural disasters [124]. However, excluding COVID, the state has experienced 54 disaster declarations since 2000, of which 37 were declared significant disasters. Additionally, the state has been hit by numerous natural disasters that have caused over \$1 billion in damages. More than 56 events costing over \$1 billion have impacted the state since 2000.

The destructive natural disasters in New York since 2000, ranked by cost, include:

- Hurricane Sandy in 2012,
- Hurricane Ida in 2021,
- 2012 drought and heat wave,
- Hurricane Ivan in 2004, and
- The February 2021 winter storm and cold wave.

On the other hand, the worst natural disasters in terms of deaths include the February 2021 winter storm and cold wave, Hurricane Sandy in 2012, a 2012 drought and heat wave, Hurricane Ida in 2021, and the December 2021 tornado outbreak.

Some risks of disasters can be listed accordingly:

5.2.4.1. **Floods**

Compared to the rest of the country, New York State only has a negligible risk of flooding. However, because the state is densely populated, hundreds of thousands of people are at risk, and the damage potential is enormous.

As climate change causes rising sea levels and more severe rains in the region, the risk of flooding in New York will only increase. Approximately 13% of houses will be at high risk of flooding by 2050 [124].

New York Flood Stats

In 2020, 615,500 homes are at high danger.

Since 2000, there have been 571,600 FEMA flood damage claims.

By 2050, 998,600 houses will be under risk.

By 2050, 688,800 homes will be at high danger.

By 2050, 172,800 houses will be at risk.

Based on 2020 calculations: Hornell received 75%, Fire Island received 68%, Port Jervis received 66%, Conesus Lake received 60%, North Tonawanda received 59%, Southport received 59%, Elmira received 55%, and Ithaca received 53%.

5.2.4.2. *Hurricanes*

Although not as vulnerable as some southern states, New York still experiences hurricanes. Since 1851, 15 hurricanes have hit New York, making it the eighth state in the country for hurricane frequency. Of these, nine were Category 1 storms, the least intense, and three were Category 2, which are somewhat more intense.

Despite not being hit by hurricanes as frequently as some other states, the impact of hurricanes on New York can be especially severe because of the state's high population density. When a hurricane does hit New York, it can cause significant damages, as evidenced by Hurricane Sandy, which struck in 2012. Hurricane Sandy caused approximately \$19 billion in damages in New York City alone, making it one of the costliest natural disasters in the city's history.

5.2.4.3. *Snow blizzards & heavy snowfalls*

New York is ranked #7 in the US for the highest snowfall received annually, while it ranks #11 in terms of the number of days it snows.

The coastal region, including New York City, receives the most negligible snowfall in the state, averaging around 63,5 cm annually. The Adirondacks region gets the most snowfall, averaging 320.04 cm per year. Even large cities in New York, like Buffalo, get significant amounts of snow. These snowstorms or blizzards during winter can cause travel disruptions and economic losses.

The state has had eight winter storms since 2000 that have caused damage amounting to one billion dollars or more. Among these, the winter storm of December 2022 was particularly severe, leading to power outages and loss of life. The coldest temperature ever recorded in the state was -46.66°C in Old Forge in 1979. The highest snowfall on record was 114.3 cm in Watertown in 1900.

5.2.4.4. *Heavy rain & freezing*

Freezing rain is a type of precipitation that forms when the temperature of the air near the ground is below freezing, but the air higher up is warmer, which causes raindrops to freeze on contact with surfaces such as trees, power lines, roads, and sidewalks, forming a layer of ice that can be very dangerous.

New York is particularly at risk for freezing rain because of its climate. The Northeastern region of the United States, where New York is located, has cold winters and much moisture in the air, making it a perfect combination for freezing rain. In some areas of New York, there are over 21 hours of freezing rain each year, one of the country's highest rates.

Freezing rain in New York occurs primarily during winter, with December and January being busiest months. It causes slippery roads, car accidents, and power outages, leaving many without heat during the coldest time of the year.

5.2.4.5. *Drought & heat waves*

New York is experiencing a rise in heat days, with 5 dangerous heat days per year and an expected double to 10 by 2050. Additionally, there will be an increase in "Local Hot Days," which are days where temperatures reach or exceed the 98th percentile for the area. This increase in Regional Hot Days is linked to health issues like strokes and heat-related deaths, and increases in air conditioning usage, resulting in higher energy demands. Local Hot Days are anticipated to rise across New York, but Suffolk County is particularly vulnerable. Suffolk is anticipated to have 18 consecutive days with temperatures at or above 34.2°C by 2053.

Droughts are frequently associated with heat waves, which can severely impact New York's agricultural industry. In New York, heat waves enhance the risk of wildfire.

5.2.4.6. *Wildfires*

New York state may have an abundance of forests, but it would be a grave mistake to underestimate the threat of wildfires due to high precipitation rates and infrequent occurrences. Despite being typically contained rapidly, the peril of wildfires in New York is mounting with climate change. It is estimated that by 2050, a staggering 24% of all properties in the state will be at risk of wildfires, which is an issue of utmost concern.

As of 2021, New York has experienced 137 wildfires, resulting in the loss of a devastating 550 acres of land. With most of the state's land covered in forests, this situation is cause for alarm. There are currently 999,217 properties at high risk of being impacted by these wildfires.

5.2.5. **Open and Green Spaces**

New York City's urban landscape is enriched by its open and verdant spaces, which are essential to the city and treasured by its residents [141]. Residents and visitors can enjoy relaxation, recreation, and a connection to nature amidst the busy city. From Frank Law Olmsted's creation of Central Park to the innovative community project, the High Line, New York City embodies every urbanite's dream. However, according to a recent article by Murray, C. [142], New Yorkers face a severe health crisis caused by the lack of greenery in the city. Both physical and mental health issues are prevalent, and urgent action is needed to address this problem.

As a starter, it is crucial to evaluate the distribution of vegetation across the five boroughs. New York City is hugely densely populated — so densely populated that there is only 146 square feet of green space per person living in the city [142].

It is important to note that after the 2012 Hurricane Sandy disaster, there were several changes and initiatives related to green and open space design in New York City, focusing on increasing resilience and sustainability in the face of climate change. Here are some significant modifications that have taken place:

- **Resilient Park Design:** Green spaces have been redesigned to manage stormwater and reduce flood risk through features like permeable pavements, rain gardens, bioswales, and wetlands.

- **Living Shorelines:** Over the years, the idea of living shorelines has become more popular as an effective way to protect coastlines and prevent erosion. Living shoreline elements such as natural materials and vegetation have been incorporated into the design of some parks and waterfront areas to increase resilience against storm surges.
- **Elevated Park Features:** In flood-prone areas, parks incorporate elevated platforms, walkways, and seating for accessibility during and after floods.
- **Community Engagement:** There has been a growing emphasis on involving local communities in the design and planning of green spaces. This participatory approach helps ensure that parks meet the specific needs and preferences of the communities they serve.
- **Biodiversity Enhancement:** Efforts to increase biodiversity in parks include native plantings, birdhouses, and wildlife-friendly features, enhancing ecological value and resilience.
- **Educational Programming:** Green spaces offer educational programs and interpretive signage on climate change, resilience, and green infrastructure, raising awareness and engaging the public in sustainability efforts.
- **Increased Funding:** In the aftermath of Hurricane Sandy, government agencies and private organizations funded green infrastructure projects and park improvements. This financial assistance facilitated the implementation of innovative design elements.
- **Multi-Functional Design:** Parks are now designed to serve multiple functions, such as functioning as a flood control basin during heavy rains, providing dual benefits to the community.
- **Monitoring and Maintenance:** Ongoing maintenance of green spaces is critical for flood prevention.
- **Climate-Responsive Design Standards:** Design and construction standards are being updated to address climate change impacts, such as sea-level rise and extreme weather events. The measures described here guide the construction and renovation of green spaces.

- **Collaborative Initiatives:** Collaboration among government agencies, environmental organizations, urban planners, and landscape architects has become more common in designing and implementing green and open spaces with climate resilience in mind.

A few catch the eye when it comes to recently constructed parks. Awe-inspiring is the Pier 26 section (Figure 5.6) of the Hudson River Park, Little Island (Figure 5.7), which opened in spring 2021 on Pier 55, and the redesigned Battery Park (Figure 5.8), fortified to increase its resilience and flood protection.

When examined in more depth, these three parks have commonalities within them. These can be stated as:

- **Waterfront Locations:** All three parks are situated along the waterfront, providing visitors with picturesque views of the Hudson River and the surrounding cityscape.
- **Public Access:** Each of these parks is open to the public, providing free access to various recreational activities, cultural events, and green spaces.
- **Landscaped Green Areas:** Battery Park, Pier 26 Park, and Little Island feature meticulously landscaped areas with various plantings, trees, and greenery, creating inviting and serene environments for visitors.
- **Recreational Facilities:** These parks include recreational amenities such as walking paths, seating areas, and spaces for leisure and relaxation, enhancing their appeal as urban oases.
- **Cultural and Artistic Elements:** All three parks frequently host cultural and artistic events, performances, and installations, contributing to the cultural vibrancy of the city.
- **Unique Architectural and Design Features:** Each park showcases distinctive architectural and design elements that make them visually striking and architecturally significant.
- **Sustainability Initiatives:** These parks prioritize sustainability and environmental consciousness in their designs, incorporating eco-friendly features and green infrastructure to promote a greener urban environment.
- **Community Engagement:** Efforts are made to engage the local community and the broader public in the planning and programming these spaces, ensuring they cater to the diverse needs and interests of the city's residents and visitors.

- **Resilience to Climate and Flooding:** Given their waterfront locations, these parks incorporate resilient design features to mitigate flood risks and adapt to the challenges posed by climate change.
- **Philanthropic Support:** All three parks have benefited from charitable donations and private funding, which have played a pivotal role in their development and ongoing maintenance, ensuring their continued accessibility and appeal.



Figure 5.6. Pier 26 Park [138].



Figure 5.7. Little Island by night [139].



Figure 5.8. Battery Park by day [140].

5.3. CULTURAL DATA

In this part of the thesis, the cultural aspects of New York City, as well as its population and demographic structure are discussed.

5.3.1. History

When reflecting on the city's fascinating history, it is possible to see how European explorers seeking trade with the East stumbled upon the New World [115]. Giovanni da Verrazzano and Henry Hudson were among the first explorers to visit New York Harbor in 1524 and 1609. Based on their report, the Dutch West India Company established a trading post on the southern shore of Manna-hata Island, which eventually grew into the settlement of New Amsterdam in 1626. Peter Minuit and his successors focused on expanding Dutch access to furs and trade, which fueled the city's growth. Peter Stuyvesant, the director general of New Netherlands from 1647-64, is widely regarded as the most notable governor of the Dutch period (Figure 5.6.).

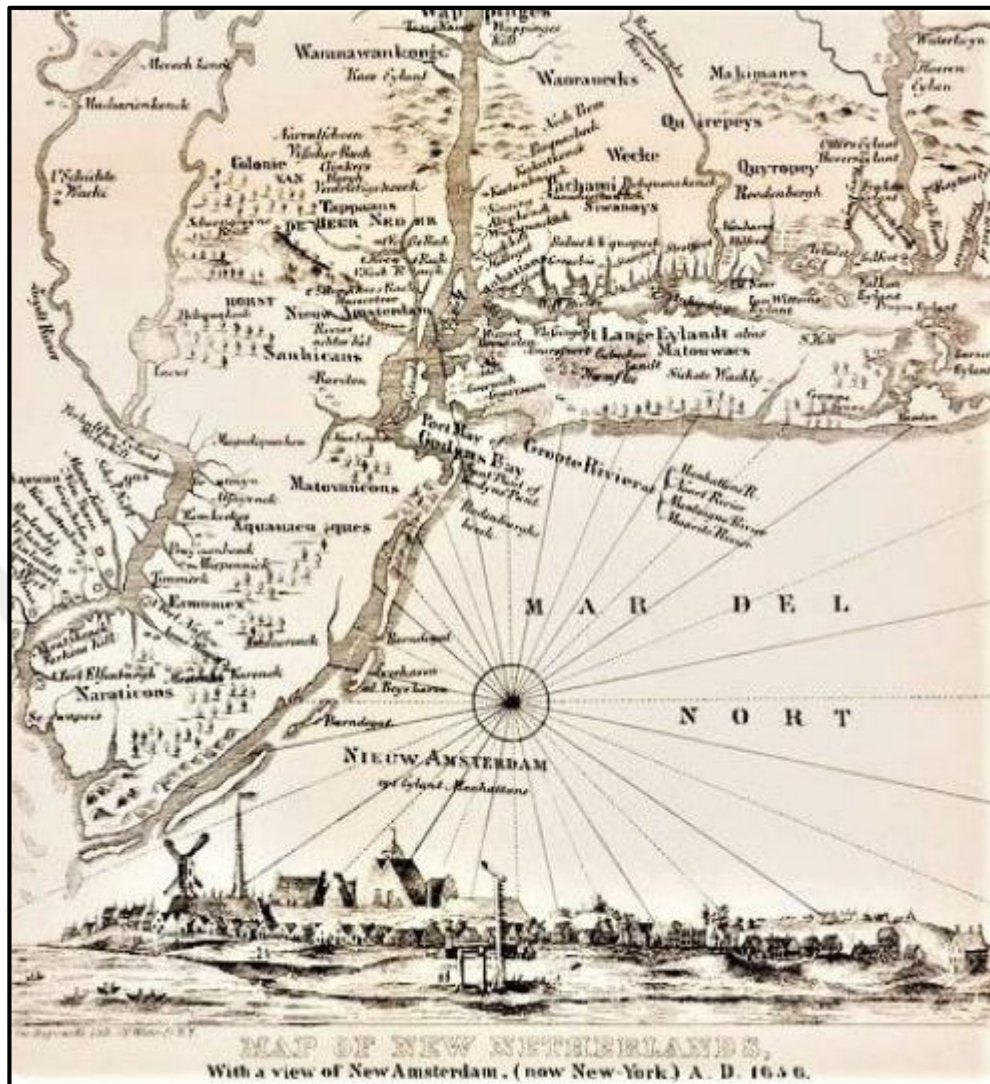


Figure 5.9. An engraved map of New Netherland from 1600's [115].

In 1653, [115], Thomas Dongan managed to turn a chaotic town into an independent city, but his efforts to impose religious conformity led to a conflict with the Quaker population in Flushing. He surrendered without resistance and pledged allegiance to the English crown. New York was governed by English rulers who sought to profit from its trade. In 1686, Thomas Dongan granted the city a royal charter encouraging religious tolerance and representative governance, but Jacob Leisler's brief term as governor after the Glorious Revolution resulted in another era of intolerance in the city. By 1700, the city's population had risen to almost 5,000 residents.

John Peter Zenger faced a libel lawsuit after his magazine criticized Gov. William Cosby's political actions, but a jury of his peers declared him not guilty in 1735. New York City

played a crucial role in the American Revolution, hosting the Stamp Act Congress in 1765, and the Sons of Liberty resorted to violence to oppose The Sons of Liberty engaged in frequent clashes with troops, resulting in the first "battle" of the American Revolution at Golden Hill in January 1770. The "tea party" followed in April 1774, and prior to the Declaration of Independence, New York residents issued a proclamation summoning the Continental Congress. George Washington was unable to defend New York City during battles from August to October 1776, resulting in population decline and multiple building fires. From 1785-1790, New York City served as the capital of the Confederation and state capital until 1797.

During the American Civil War, New York City was ravaged by its worst riots in July 1863. The Tweed ring corruption scandal saw tens, if not hundreds of millions of dollars embezzled into private hands [115]. Under John Kelly's leadership, the Tammany party transformed into a more structured and disciplined organization with a clear aim of eradicating corruption. Mayor William Strong's reform platform led to the Tammany machine losing control, but it regained power and oversaw the development of urban infrastructure, job growth. Following the conclusion of World War II, New York City faced numerous challenges in its urban society, such as the decline of the port and manufacturing industries and a considerable amount of debt. In 1965, John Lindsay won the mayoral election and attempted to bring order to the administration, but he needed help to control the city's rapidly increasing budget.

Abraham Beame was elected as mayor in 1973, and Edward Koch could turn the city's finances around in a single term. Rudolph Giuliani was elected in 1993 and pledged to lower taxes, privatize city services, and combat crime, but his policies did not impact social safety nets, freedom of speech, land use, or the rights of homeless individuals. During the 1990s, New York City experienced population growth and financial stability, but remained vulnerable to terrorism. After the 9/11 attacks, debris was cleared out from the fallen twin towers and the area was named "Ground Zero." Construction began in 2006, while the destroyed twin towers were transformed into a memorial. Today, New York City remains a top tourist destination, with ongoing building construction, including the completion of the Bank of America Tower and the New York Times Building.

In the 2010s, New York City experienced significant growth in "supertall" buildings, such as the One World Trade Center and One Vanderbilt. However, the recession led to the

downfall of banks and trading institutions, shook the foundations of Wall Street. In September 2011, the Occupy Wall Street movement emerged in Zuccotti Park, raising awareness about economic inequality and corporate influence in politics. Hurricane Sandy in 2012 caused widespread damage and highlighted infrastructure vulnerabilities, prompting efforts to enhance resilience against future extreme weather events.

The COVID-19 pandemic hit New York City in early 2020, with the first case reported on March 1st in a Manhattan residence. Tragically, nearly 10,000 New Yorkers lost their lives to the virus by April 14th. Governor Andrew Cuomo kept the public informed through daily briefings. Despite the immense challenges, New Yorkers adapted to the "new normal" and persevered.

5.3.2. Population and Demographical Structure

New York City is known for embracing its diverse multiculturalism, which adds vibrancy and depth to its heritage.

The demographic composition of New York City, has undergone significant changes since the late 20th century. As per the 2020 census, individuals of European descent accounted for 31% of the population, Hispanics/Latin comprised 28%, and African Americans constituted 20%. The Asian population experienced the most rapid growth, increasing from a small percentage in 1970 to over 15%. In the 2010s, most foreign migrants to New York City came from Latin America and Asia. The largest foreign-born groups were Dominicans, Chinese, Mexicans, Jamaicans, Guyanese, and Ecuadorians [129].

The Statue of Liberty symbolizes New York City's warm welcome to newcomers through its metaphorical "golden door." Each ethnic group has gone through the acculturation process, achieved their aspirations, and then expressed reservations about subsequent waves of immigrants arriving in the promised city. One of the earliest "history" books about New York was a satirical portrayal of the merchant elite and the city's Dutch origins, published in 1809. Dutch could still be heard spoken on the city's streets [129].

According to the 2020 United States Census, New York City's population was recorded as 8,804,190. The city's racial composition, including Hispanic or Latino ethnicity, is approximately 32.1% White, 24.3% Black or African American, 0.7% Native American,

13.9% Asian, 0.1% Pacific Islander, 24.5% from other races, and 4.4% belonging to two or more races. Regardless of race, individuals of Hispanic or Latino origin make up 29.1% of the city's population. The population's median age is 36.2 years, with about 21.7% under 18 years old and 14.3% aged 65 or older [129].

The city's gender distribution is approximately 52% female and 48% male. New York City boasts a significant immigrant population, with nearly 40% of residents being foreign-born. The city is also home to a substantial LGBTQ+ community, estimated at 574,000 individuals [129].

5.4. HUNTER'S POINT SOUTH PARK EXAMINATION

This chapter will thoroughly analyze *Hunter's Point South Park*, including its historical background and detailed assessment studies.

5.4.1. History of Hunter's Point South Park

The Hunter's Point South Waterfront Park in Queens, New York, is recognized by the *American Institute of Architects* (AIA) as a model for sustainable urban development and environmental protection [125]. The park spans 30 acres and includes 5,000 affordable housing units, two schools, and an extended ferry stop, with water surrounding it on three sides. Although the site used to be wetlands and had been neglected for years, the park now combines its various histories to create a resilient and eco-friendly space for recreation and culture while also providing protection against severe weather for the local neighborhood.

The park's design incorporates various natural elements, such as wetlands, paths, and bioswales, which link its various areas and activities. Its asymmetrical shape balances the scale of different features, such as a multi-use green oval, a continuous walkway with views of the Manhattan skyline, and a steel shade structure for the ferry terminal and concessions.

Hunter's Point South Park was originally a 210-acre farm owned by the Hunter family, after whom it was named [126]. The land was granted to the Dutch Reformed Minister, Dominie Everadus Bogardus, in 1643 and was located along Newton Creek and the East River, known as Dominie's Hook. After being taken over by the British in 1664, the property eventually

came into the possession of British sea captain George Hunter, who renamed it Hunter's Point in 1825.

After the landowner's death, he left his property to his three grandsons - Jacob, John B., and Richard - giving them the freedom to divide and sell it as they wished. In 1835, they sold Hunters Point to Eliphalet Nott, represented by Jeremiah Johnson, for a sum of \$100,000. At that time, Nott served as the president of Union College, located in Schenectady, NY. In 1840, Vernon Boulevard was constructed to connect Hunters Point with Ravenswood and Astoria. The prominent hill on the estate was leveled between 1852 and 1853, and the soil obtained from it was utilized to fill the reefs along the East River, extending from 5th Street to the present bulkhead line. Furthermore, during this period, the groundwork for future development was laid out, including building lots along fourteen east-west streets. As can be seen in Figure 5.10., gantries used to be a part of the city in early 20th century.

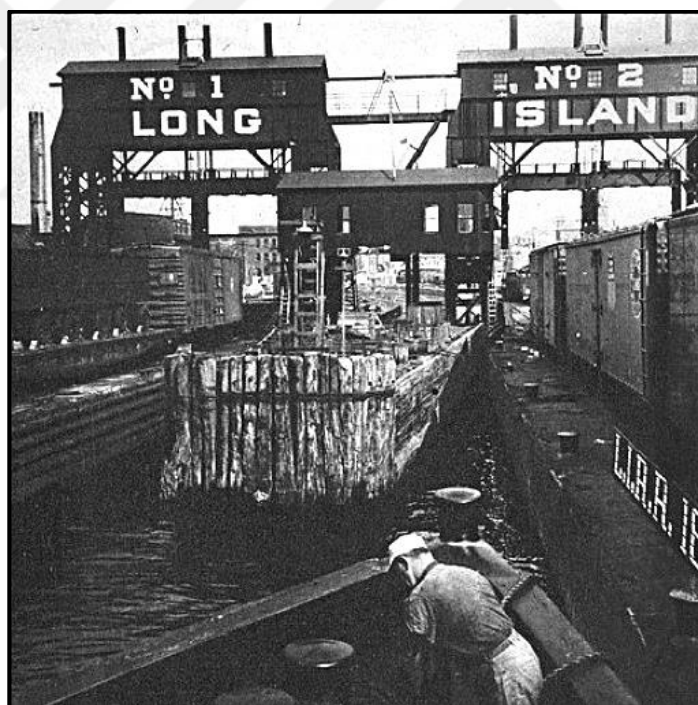


Figure 5.10. Long Island Gantries circa 1925 [143].

In 1861, a ferry service was established between Manhattan and Hunter's Point, leading to the transformation of Long Island City's farmland due to increased immigration and industrialization by 1869. The construction of the Long Island Rail Road (LIRR) terminal for both freight and passenger trains turned the once-quiet village into a major transportation

hub. The area saw the rise of hotels, saloons, restaurants, boarding houses, stores, lumber yards, and coal yards catering to both travelers and commercial interests. Street railways were introduced along Borden Avenue, Jackson Avenue, and Vernon Boulevard in 1869, connecting commuters from various parts of Queens to this significant transfer point. Hunter's Point quickly emerged as a unique commercial and industrial center in Queens due to its proximity to waterways and Manhattan, along with the rapid development that took place. The completion of the Queensboro Bridge in 1912 attracted numerous manufacturing companies to the area, leading to the concentration of hazardous industries in Hunter's Point. However, by the late 20th century, the city's economic landscape had changed, resulting in the abandonment of industrial buildings.

Between the 1860s and 1920s, the region became known as the oil refinery capital of the greater metropolitan area, hosting major industries such as Standard Oil, the New York Sugar Refinery, the New York Architectural Terra Cotta Company (Figure 5.11), as well as various paint and varnish works. The riverfront featured transfer bridges called gantries, which could rise up to 18 feet and handle 100-ton cars. These gantries facilitated the loading of boxcars onto car floats in New Jersey, which were then transported to float bridges along the Brooklyn, Queens, and Manhattan waterfronts as early as 1866. The existing gantries were constructed in 1904 and later rebuilt in 1925 by engineer James Benton French, who made several improvements, including the addition of a wide shed at the top to protect the lifting equipment and allowing the two separate decks to be lifted and lowered independently.



Figure 5.11. Old and new pictures of the New York Architectural Terra Cotta Company [127].

In 1990, the city designated Long Island City's waterfront for a mixed-use development, including residential housing and a new public park. This multi-agency initiative aimed to revitalize a long-underused area in Queens by developing seven parcels in phases.

Still, architecturally speaking, the government documents also show that the district contains examples of various architectural styles, such as Italianate, French Second Empire, Neo-Greek, and others from the 1890s. These buildings show the evolution of architectural history, ranging from fully developed expressions of the Italianate group to later interpretations. One of the outstanding features of the district is that it has been remarkably well-preserved, having been spared the changing uses and fashions that have destroyed the original character of architecture in many similar areas. The space is rectangular and oriented, with its head towards Twenty-third Street while the shaft extends towards the East River along Forty-Fifth Avenue. The Manhattan skyline provides a beautiful background as one looks down the long avenue with its trees, stoops, and brick and stone facades that have remained virtually unchanged since the 1890s. The LIRR circa 1920's can be seen in Figure 5.12.

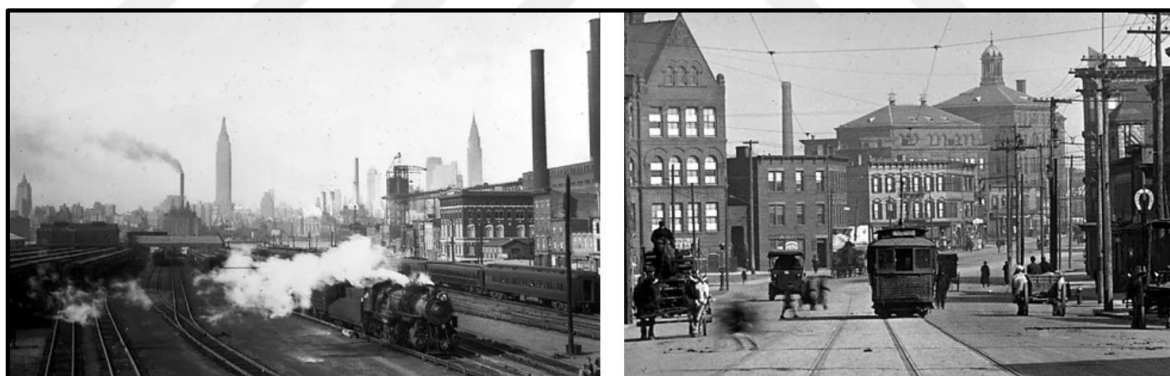


Figure 5.12. LIRR with Manhattan Skyline on the background (left picture), the houses and shops of Long Island City circa 1920's (right picture) [128].

5.4.2. Design Concept of the Park

Regarding the design concept of the park, as stated in Paisea's #12th edition, the city demanded that engineer-led teams submit proposals for the final phase of Queens West in 2009 [137]. This phase is officially recognized as Hunter's Point South Waterfront Park and Infrastructure. Recognizing the importance of an environmentally friendly approach, ARUP

collaborated with SWA/Balsley. They believed tackling the site's climate change challenges required a broader multidisciplinary approach and thus invited Weiss/Manfredi to join their team. The Hunter's Point South Waterfront Park is an unparalleled global model for sustainable design, brilliantly incorporating social, cultural, and ecological aspects. This project is one of the most comprehensive and ambitious initiatives in New York City in the last fifty years. The development area boasts 5,000 affordable housing units and 4.45 hectares of stunning waterfront parks. The park and infrastructure have been meticulously designed to incorporate various eco-friendly initiatives, ensuring a sustainable and environmentally conscious community. The abandoned site, with a history of long-term neglect, has been transformed into a fresh urban ecological model. The new development has undeniably injected life into the community and successfully revitalized the riverside habitat. Figure 5.13 clearly explains the park's environment, location, and neighboring areas, such as Brooklyn and Manhattan.

Figures on page 106, 5.14, and 5.15 depict Hunter's Point South Park design and construction processes. The sectional layouts in Figures 5.16 and 5.17 assertively display intricate details of the infrastructure elements used and those already existing.

One of the most critical issues of the design team is the waterfront resilience topic. (The same topic is also mentioned later in chapter 5.4.5, *The Use of Space and Purposes*.)

The design, which began in 2008 and was made public in 2018, restores the site's historical marshland character. It creates a dynamic recreational and cultural hub that connects the community, the river, and the outdoors. The group of architects, landscape architects, and green engineers used innovative techniques tested during Hurricane Sandy and are now considered exemplars of forward-thinking resiliency design.

The design adopts a new strategy for enhancing waterfront resilience, providing flood protection and social spaces for the community's sustainability. The tidal currents of the East River required the construction of a revetment to protect the newly established marsh. The causeway, which is environmentally friendly, safeguards nearly an acre of in-water habitat that was previously a contaminated landfill peninsula, ironically replacing a wetland marsh. The team has identified an opportunity to extend the causeway. The pathway is characterized by a narrow trail embellished with spartina plants, deliberately slowing one's progress as one embarks on a contemplative and thought-provoking journey from the urban environment.

This experience allows individuals to immerse themselves in an introspective encounter with the continuously changing panoramas while fostering meaningful interactions between the urban setting and the natural surroundings. The design team strategically positioned program elements and resilient infrastructures to optimize views and performance. The Pavilion serves as a critical public space, defining the most open part of the site. The oval is a recreational site and designed to safely collect flooding water and gradually release it into the river. The curved Pavilion frames the southern edge of the oval and extends to form a pleated steel canopy, providing shade for an outdoor café, and the East River Ferry stop. (Figure 5.18)



Figure 5.13. Hunter's Point South Park location and design [137].



Figure 5.14. Hunter's Point South Park design process along with the ongoing construction photograph [137].



Figure 5.15. Hunter's Point South Park 3D design template [137].



Figure 5.16. Hunter's Point South Park sectional diagram [137].

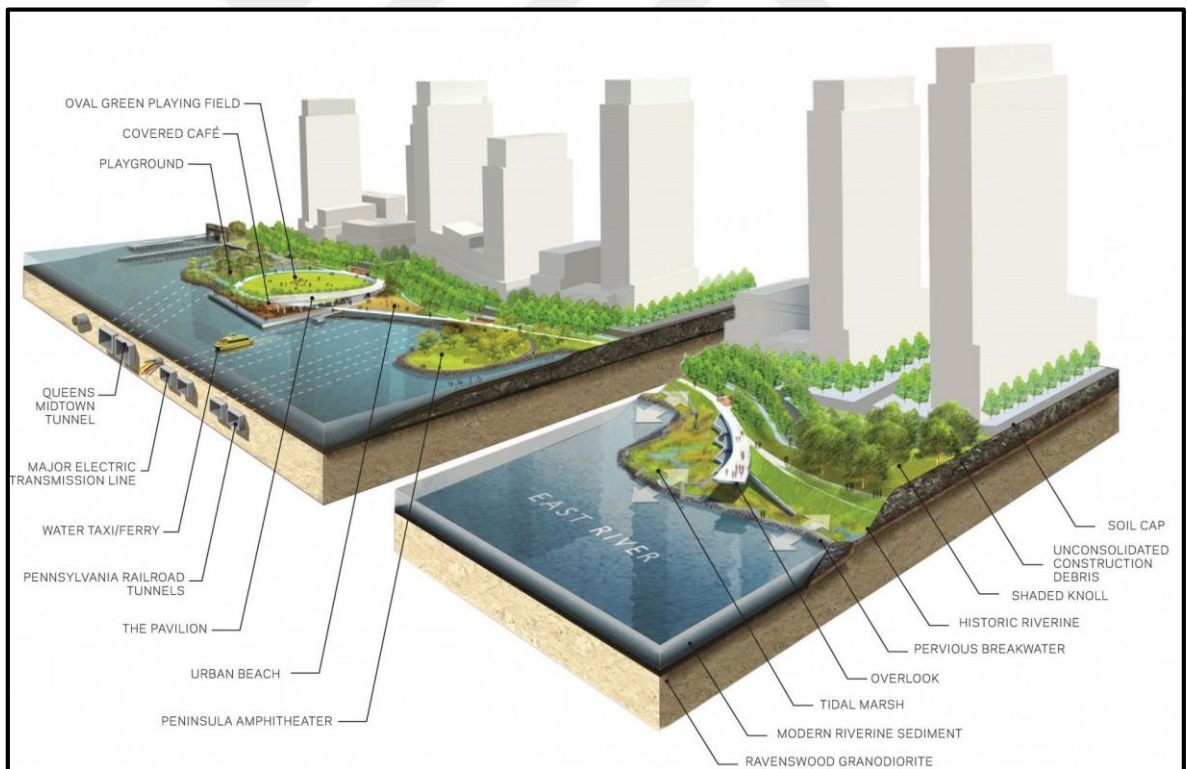


Figure 5.17. Hunter's Point South Park infrastructural layout [137].



Figure 5.18. The Pavillion ,the Green Lawn and the Oval areas [133]

5.4.3. Population and Demographic Structure

According to the latest statistics shared, Long Island City, where Hunter's Point South Park is also located, Long Island City has a population of 52,075 people, with a median age of 34.5. Males comprise 49.8% of the population, while females comprise 51.08%. Long Island City's resident pool is made up of 50.69% US-born citizens and 29.74% non-US-born residents [129]. Furthermore, non-citizens account for 19.58% of the population. The Figure 5.19 below show the stats as well.

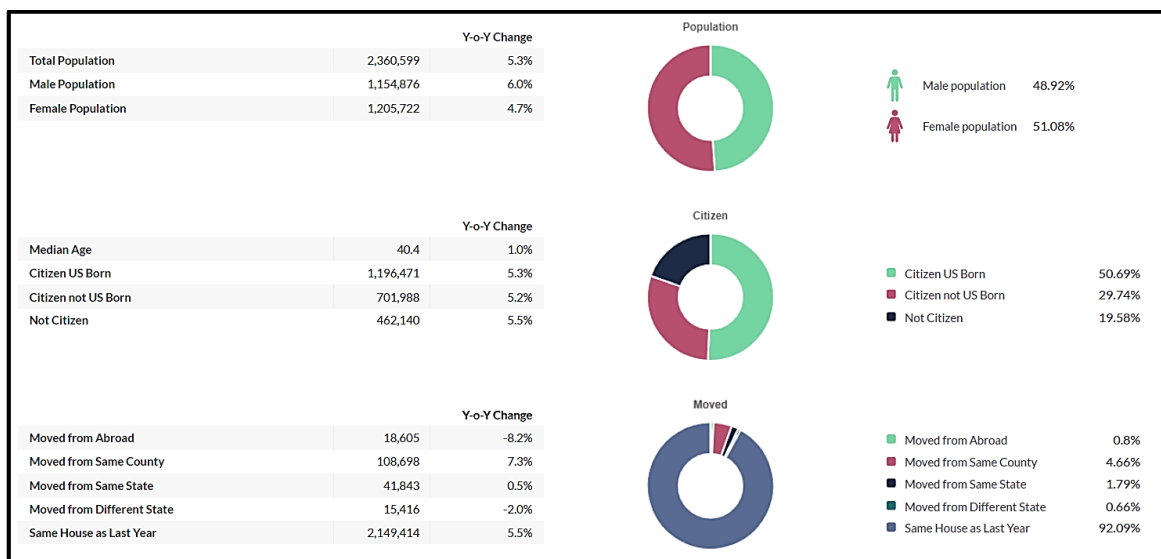


Figure 5.19. Long Island City population graphics [129].

Long Island City's working population is made up of 80.31% white-collar workers and 19.69% blue-collar workers. Long Island City also has 114,969 entrepreneurs (5.9% of the workforce), 773,983 workers in private firms (3.4%), and 162,188 persons working in government agencies (3.4%). The below Figure 5.20 shows the employment rates and sectors.

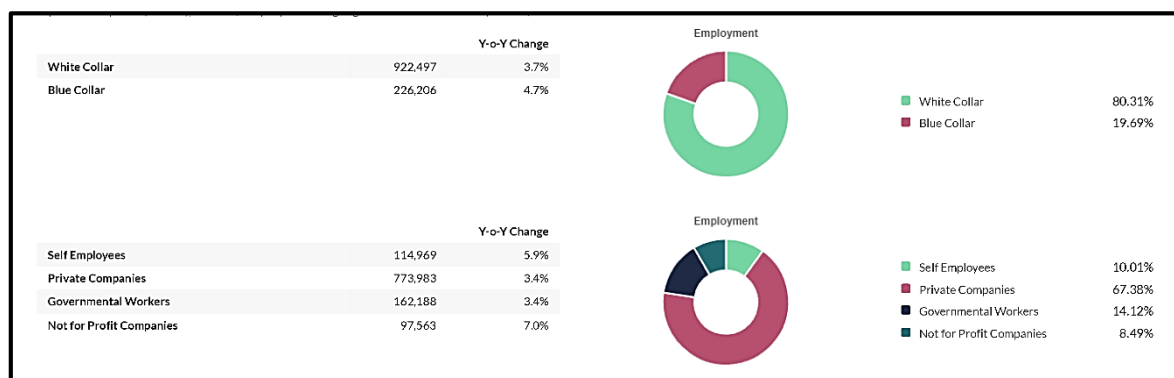


Figure 5.20. The employment statistics of Long Island City [129].

When it comes to learning about household information, Long Island City has a total of 795,645 households, each with around three people. Family households make up 67.4% of these Long Island City households, with non-family units accounting for the remaining 32.6%. The Figure 5.21 below shows the stats in detail.

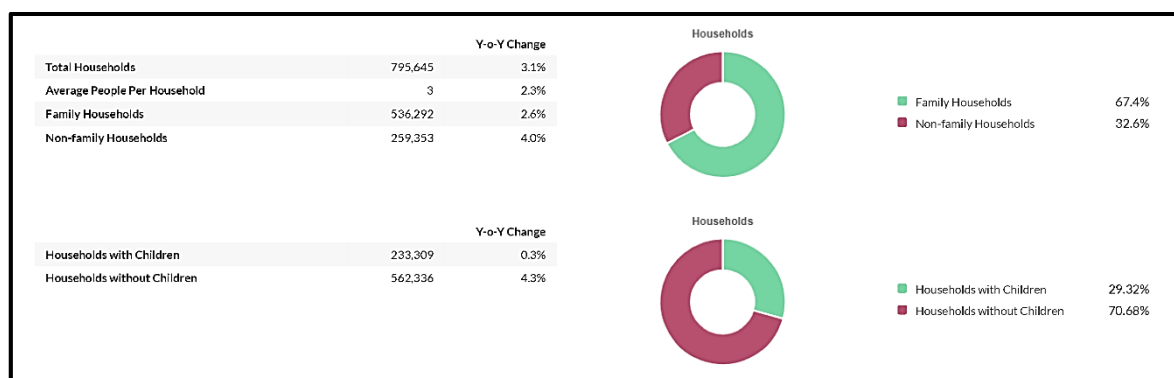


Figure 5.21. The household graphic of Long Island City[129].

Long Island City's average annual household income is \$92,735, while the median is \$80,751. Residents between the ages of 25 and 44 make \$89,989, while those between 45

and 64 earn \$86,838. In contrast, individuals under 25 and those over 65 earn less - \$58,411 and \$51,967, respectively. The Figure 5.22 below gives the stats in details.

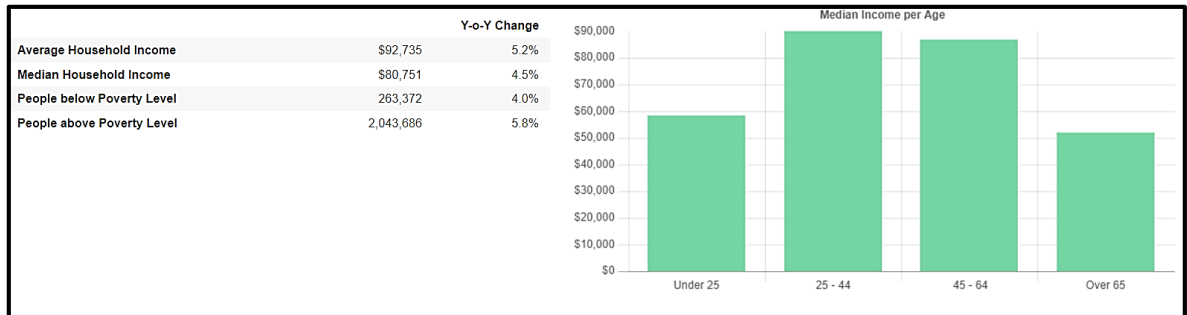


Figure 5.22. The household income graphic of Long Island City [129].

According to the analysts, the demographic information was gathered from the latest release of the US Census Bureau, which is the 2021 American Community Survey. In general, the area is a blend of people from different backgrounds, ethnicities, and professions.

5.4.4. Transportation Hubs

Long Island City / Hunter's Point South boasts a plethora of transportation resources that make it an attractive location for both residents and businesses. However, the neighborhood's public transit system becomes congested during rush hour, despite its already well-established presence. Furthermore, the streets in the area were not designed to accommodate the increased demand from pedestrians, cyclists, and drivers, leading to congestion during peak hours. The neighborhood's varied use and evolving nature, as well as the presence of various transportation infrastructure, also contribute to a feeling of disconnection in certain parts of the area.

Several transportation options are available for visitors to access Hunter's Point location, including by car, bus, subway, ferry, or bike. The transportation hubs in Long Island City's Hunter's Point location are noteworthy and easily accessible.

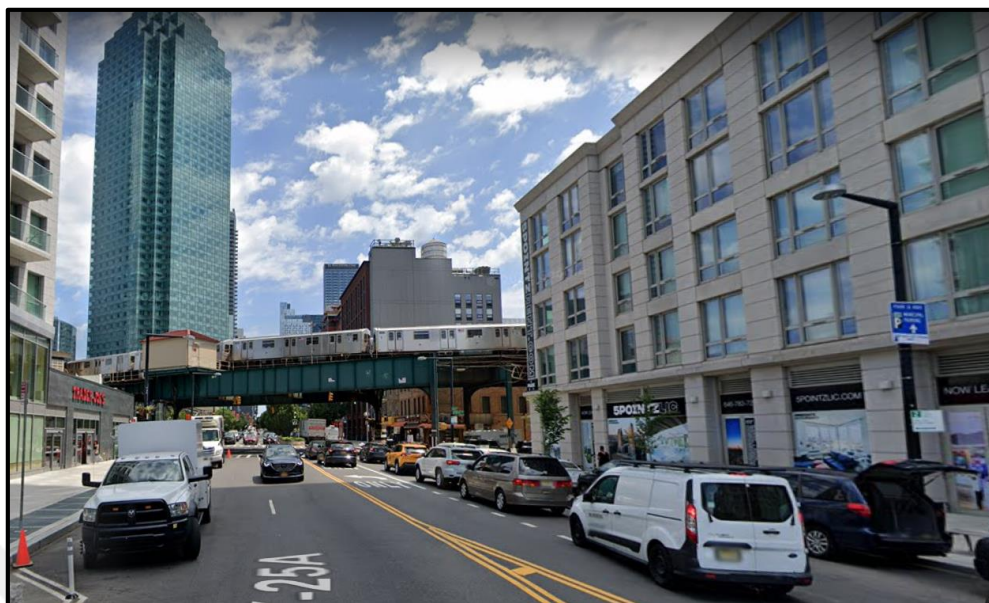


Figure 5.23. The train station of Long Island City (*taken by the writer*).

- By train, as can be seen the station in Figure 5.23.

Hunter's Point Avenue Station: This subway station is located on the 7 line and is served by local and express trains. It is situated in the western part of Long Island City and provides easy access to nearby neighborhoods such as Astoria and Sunnyside.

Vernon Boulevard-Jackson Avenue Station: This subway station is also on the 7 line and is served by local and express trains. It is located near the waterfront and provides access to several popular destinations in Long Island City, including Gantry Plaza State Park and MoMA PS1.

Court Square Station: This subway station is a central transportation hub in Long Island City, serving several subway lines and the Long Island Rail Road. The E, M, and G trains all stop at this station, in addition to the seven trains. The Long Island Rail Road provides direct access to destinations throughout Long Island and Penn Station in Manhattan.

- By ferry:

Long Island City Ferry Terminal: This ferry terminal is located on the East River and provides service to several destinations throughout New York City, including Wall Street/Pier 11 in Manhattan, Greenpoint in Brooklyn, and Astoria in Queens. The terminal is also located near several popular waterfront destinations in Long Island City, including

Gantry Plaza State Park and Hunter's Point South Park. The ferry station can be seen in Figure 5.24.



Figure 5.24. The ferry station of Long Island City (*taken by the writer*).

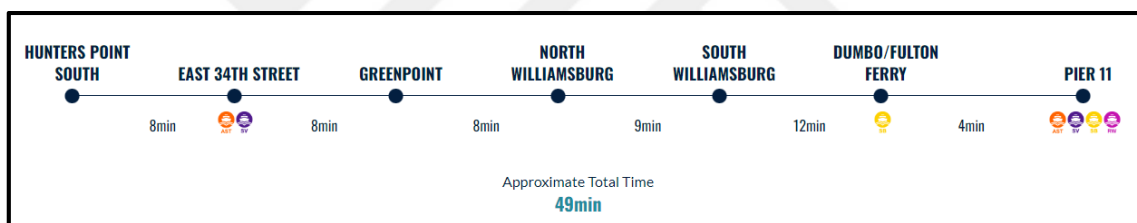


Figure 5.25. The ferry trips stops including LIC on the itinerary [130].

According to NY Ferry, the trips take about 50 minutes (as shown in the Figure 5.25) from the stop to the Manhattan Pier 11 stop [130]. They state that the current East River circuit of the NYC Ferry joins the East River's developing residential and corporate neighborhoods to communities in Midtown and the Financial District. It also is an example of a sustainable travel example.

By driving a car or using busses:

Queensboro Bridge: The Queensboro Bridge is a major bridge that spans the East River and connects Long Island City to Manhattan's Upper East Side (as shown in the Figure 5.17). The bridge has several lanes for cars, as well as dedicated bike and pedestrian paths. It provides convenient access to several popular destinations in Manhattan, including Central Park and the Museum of Modern Art.



Figure 5.26. The Queensboro Bridge at night (left), the bridge during day time [131].

As cited in their website, the NYC Government States that in March 1909, *the Queensboro Bridge* opened to connect Queens and Manhattan via the East River, and its unveiling was accompanied by grand festivities known as the "Queensboro Bridge Celebration" [131]. Although the bridge's initial regular users were horse-drawn carriages, it is now heavily trafficked by cars and trucks, spanning almost 3,800 feet and featuring two levels and ten lanes. It also passes over Roosevelt Island and is commonly called the toll-free 59th Street Bridge. (Fig. 5.26 shows the bridge by night and day.)

Overall, it's wise enough to state that Long Island City is accessible from a multitude of options, by car, trains and busses.

5.4.5. The Use of Space and Purposes

Hunter's Point South Park was once wetlands between the East River and Newtown Creek, as reported by "Architizer" in an article [132]. However, over time, the area transformed into an industrial and transportation hub, losing its natural characteristics.

Today, the site is a brownfield with a deteriorating shoreline and a Manhattan skyline view. The park's design incorporates the area's diverse history and presents a new model for waterfront resilience, using a "soft" approach to protect against flooding. The park features a walkway along the river's edge, marshland, landscaped grassland, and iconic park elements such as custom seating, a peninsula that has been reshaped into an island sanctuary, and a footbridge that showcases a site-specific art installation. The park also includes:

- Terraces for exercising and picnicking.
- A kayak launch.
- Lounges along the pathways.
- A cantilevered overlook suspended above the wetlands.

The design is innovative, flexible, and aspirational and aims to create a retreat and recreation place connecting with nature at the water's edge. Hunter's Point South Waterfront Park is a transformative project that brings together landscape, architecture, and engineering to create new relationships between people and nature.

Weiss/Manfredi envisions the park as a pioneering model of urban ecology worldwide, showcasing innovative and sustainable solutions while also functioning as a central hub for testing them [133]. Hunter's Point South Park covers an expansive 30-acre area and incorporates numerous environmentally friendly features, carefully planned to safeguard the nearby residential zone. The collaborative work of SWA/Balsley and Weiss/Manfredi, supported by ARUP's expertise in infrastructure design as a consultant, has resulted in a remarkable testament to the potential of innovation and environmental awareness.

SWA/Balsley, the collaborating architecture company along with Weiss/Manfredi, states that "this unique park combines landscape architecture, architecture, art, and engineering in a very collaborative approach [134]. A team drawing by the park's key creators, Thomas Balsley, Marion Weiss, and Michael Manfredi, is shown below. Arup's engineers were instrumental in the seamless integration of infrastructure. The park was designed as a whole and then tackled in two stages." It emphasizes the crucial collaboration explicitly while also making an homage to the industry's prominent, such as Arup, SWA/Balsley and Weiss/Manfredi. The design section of the park spans an area of 4.45 hectares.

The park's intricate design harmoniously blends its storied past and breathtaking surroundings, resulting in a comprehensive and versatile environment suitable for leisure and cultural activities.

It is important to note that there are numerous crucial institutions involved in the completion process of the park, in addition to the three main design and contractor companies. The technical data can be seen in Figure 5.27 below as titled "technical data."

Technical Data	
Project	Hunter's Point South Waterfront Park
Location	Long Island City. Queens. N.Y. USA
Clients	NYC Economic Development Corporation and NYC Department of Parks and Recreation
Park Designers	SWA/BALSLEY and WEISS/MANFREDI with ARUP
Collaborators	Halcrow & CH2M Hill , Marine Engineering E-Design Dynamics & Great Ecology , Ecological Systems and Restoration Ecologist SiteWorks , Landscape Construction Administration Nobuho Nagasawa , Public Art Suzanne Randolph Fine Arts , Artist Consultant A.G. Consulting Engineering, P.C. , MEPFP Engineering Yu & Associates , Environmental Engineer VJ Associates , Cost Estimator Naik Consulting Group , Survey and Utilities AKRF , Historical Researcher
Project management	SWA/BALSLEY : Chistian Gabriel, Brian Staesnick and Jacob Glazer WEISS/MANFREDI : Lee Lim and Michael Blasberg ARUP : Tim Kaiser, Matt Best, Michael Newey and James DeMarco
Construction management	The Liro Group
Surface area	4.45 hectares
date of project	2008-2018
cost	\$100.7 million
photography	Barrett Doherty David Lloyd Nobuho Nagasawa Jonnu Singleton Bill Tatham Albert Vecerka / Esto Wade Zimmerman Betsy Pinover Schiff Robert DiMaio

Figure 5.27. Technical data of Hunter's Point South Park [137].

The park site, before it's completion used to be a wetland for over 200 years. Also, as park's location was once an industrial zone, with factories, warehouses, and train yards dominating the shoreline, the city's economy changed away from heavy industry, however, many properties were eventually abandoned and left uninhabited.



Figure 5.28. The aerial view of Hunter's Point South Park [133].

Long Island City went through a massive transformation in the early 2000s with the ambitious redevelopment of Hunters Point South, creating a thriving mixed-use community. The project aimed to reinvigorate an industrial area into a bustling residential and commercial hub, all while prioritizing public access to waterfronts and preserving their natural beauty waterfront. It's important to mention that this park is entirely publicly funded and maintained. Having designed public spaces in NYC for years, the design team confidently selected sustainable, durable, and cost-effective materials that don't compromise comfort, performance, or aesthetics. Kebonized wood was used throughout for furniture and decking as an alternative to tropical hardwoods. Forgoing automatic irrigation, the team developed a plant palette of native, hardy, salt-tolerant grasses and trees, ensuring that this rich and diverse landscape will endure and mature naturally. Figure 5.28 shows the aerial view of the Hunter's Point South Park.



Figure 5.29. This photograph, taken in the 1980s, shows that the area comprises wetlands and a dump site [133].



Figure 5.30. This photograph, taken recently, shows that the area got regenerated from wetlands and the dump site [134].

The designers, *Weiss/Manfredi & Swa/Balsley* describe their plan by identifying key features and sharing that the park has been divided into two separate areas, each providing different recreational options. The northern district has been extensively designed, rendering it ideal for daily usage and capable of accommodating more visitors. The southern district, in contrast, features a more organic and subdued landscape, offering a peaceful environment for relaxation and contemplation.

The park features a central green area that can handle floodwaters and is surrounded by a pavilion and café, providing scenic river views. Visitors can enjoy various recreational activities such as an urban beach, rail garden, dog runs, and play areas along the water's edge. The waterfront promenade connects different landscapes, including a shaded grassy promontory, a pedestrian bridge leading to a new island, and a meandering causeway that provides a continuous walking path along the river while preserving nearly 0.607 hectares of newly established wetlands. The park's design also takes advantage of the site's unique topography with a cantilevered overlook that offers panoramic views of the wetlands. The sense of space gives it's visitors long hours of outside entertaining and relaxation. It's possible to state that *Hunter's Point South Park* is a public space that is both aesthetically pleasing and functional, incorporating sustainable design. It aims to create an inviting and lively atmosphere that improves the quality of life for those who live in or visit the area.



Figure 5.31. The aerial photograph depicting the first phase of the park [133].

The park's perimeter (shown in Figure 5.31) is designed to withstand floodwaters and boasts a diverse collection of native plants that can thrive in salty river water. Notable examples of these resilient plants include coastal little bluestem, seaside goldenrod, and purple coneflower. The 3D design below shows that the park is capable of enduring floodwaters and the difficulties associated with them.

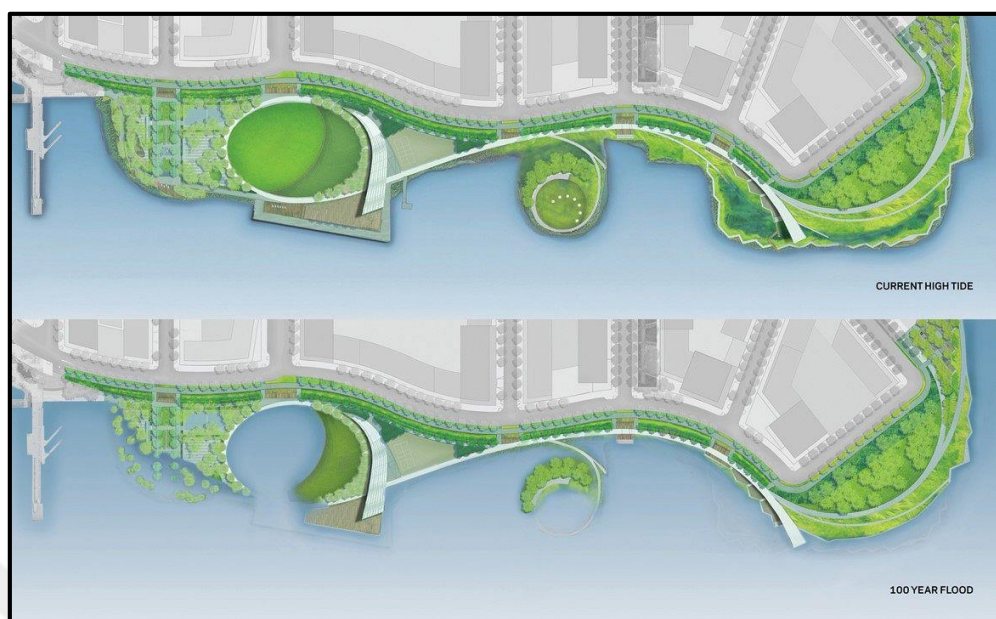


Figure 5.32. The 3D design that showcases the resilience to floodwaters [134].

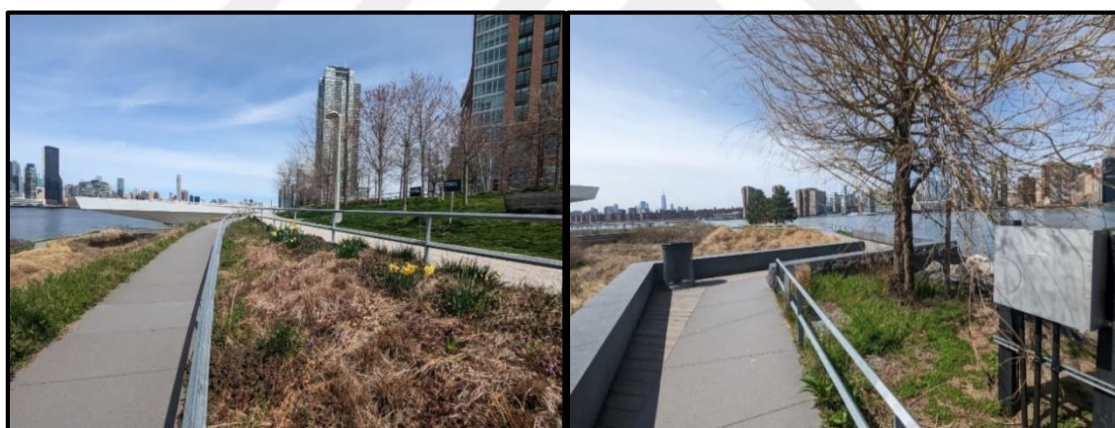


Figure 5.33. Walkways along the park (*taken by writer*).

As can be seen in the photographs above (Figures 5.32 and 5.33), linear strands, which are likely some linear features such as paths or plantings, are being used to create new ecological corridors in a park. These ecological corridors run parallel to the water's edge, likely following the park's natural topography. The purpose of these corridors is to provide multiple paths that connect the significant precincts and programs of the park. In other words, they are creating a network of pathways that allow people to move quickly between different areas of the park while supporting ecological connectivity between different habitats. The park's design takes into account both human use and ecological health.

The park has a multipurpose design that serves both resilience and recreational purposes. As shown by the sitting slabs, it also serves as flood-breakers.

The Hunter's Point South Park was built with a focus on durability and flexibility, as evidenced by the materials used and the detailed sketches and AutoCAD designs.

In order to have a clear view of the resilience purpose of the park, it is vital to state that the park has crucial resilience features [135]:

5.4.5.1. *Tidal salt marshes*

Tidal salt marshes are grassy areas found near the mouths of rivers, bays, and protected coastlines.

They are affected by ocean tides, which fill the marsh with salty water, causing the water level to fluctuate twice daily. The marsh is deeper during high tide and shallower during low tide. In Hunter's Point South Park, there is a constructed tidal marsh spanning 0.61 hectares, which serves the following purposes:

- It provides a habitat for various native plant and animal species, including migratory birds and essential organisms like ribbed mussels.
- It acts as a barrier, protecting the land from storm surges and rising sea levels.
- It helps prevent shoreline erosion.
- It absorbs excessive nutrients that could otherwise lower oxygen levels in the ocean and harm wildlife.



Figure 5.34. Tidal Marsh on high tide on the left, low tide on the right [135].

5.4.5.2. *Native vegetation*

Native vegetation includes all plant species that grow naturally in a particular location and play an important role in providing habitat for native insects and animals. These plants have coevolved to flourish in their unique environment, which includes soil, temperature, nutrients, and rainfall. A substantial fraction of the plants along the shoreline are natural flora, which provides the following benefits:

- They require fewer resources and are easier to maintain. Native plants have adapted to the local environment and typically require less water and no synthetic fertilizers.
- They possess natural resilience as they are well-suited to local conditions and have developed defenses against diseases and insect pests.
- They provide vital habitats for native birds and other species, contributing to the overall biodiversity of the area.
- They help conserve water and soil by reducing stormwater runoff and preventing soil erosion due to their extensive root systems.

Some examples of native species found in the park include black gum (*Nyssa sylvatica*), pitch pine (*Pinus rigida*), willow oak (*Quercus phellos*), beach plum (*Prunus maritima*), shrub rose (*Rosa blanca*), purple coneflower (*Echinacea purpurea*), seaside goldenrod (*Solidago sempervirens*), and many more. The Figure 5.37 below shows these plants used in the design .

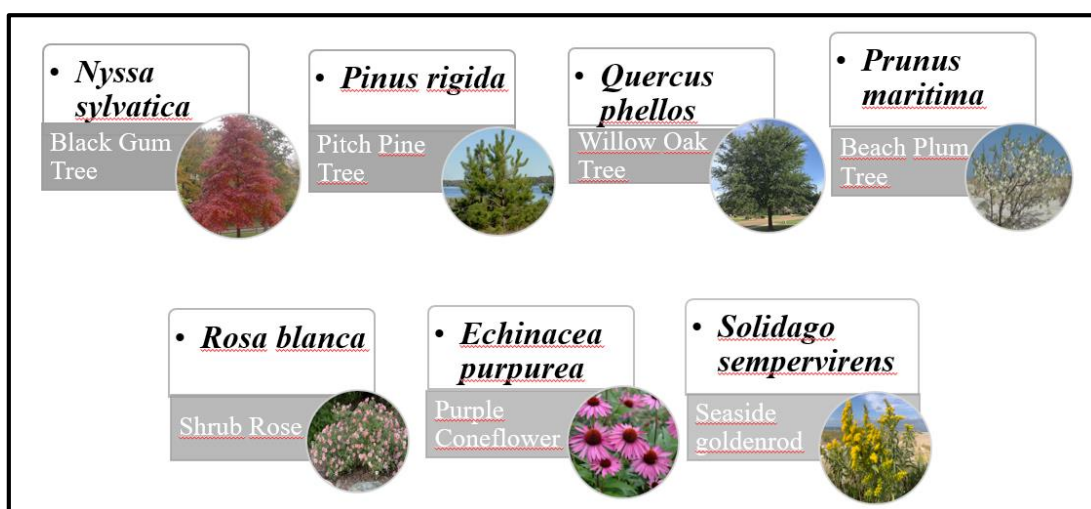


Figure 5.35. Some native plants used in the design (*prepared by writer*).

5.4.5.3. *Bioswale*

A bioswale is an element of landscaping created to decelerate, capture, absorb, and purify stormwater. Hunter's Point South Park is predominantly enclosed by bioswales, fulfilling the following objectives: They capture stormwater runoff from local streets and sidewalks, effectively filtering out heavy metals the water may have picked up. This helps prevent these pollutants from reaching local waterways. In Figure 5.36, an example of bioswales used in the park can be seen.

- They replace traditional sewage drains with aesthetically pleasing and easy-to-maintain habitats for wildlife, enhancing the ecological value of the park.
- They reduce the occurrence of flooding by effectively managing and absorbing stormwater runoff.
- By reducing standing water, bioswales also help minimize the presence of stagnant water that attracts insects, such as mosquitoes.
- Bioswales are crucial in redirecting stormwater away from New York City's Combined Sewer System (CSS), reducing Combined Sewer Overflows (CSOs). The CSS collects various types of wastewater, including stormwater runoff, domestic sewage, and industrial wastewater. However, heavy rain or excessive melting can overwhelm the sewer system, causing excess water discharge into nearby bodies of water. By implementing bioswales and green infrastructure, CSOs can be mitigated by effectively collecting stormwater and using filtration mechanisms to divert water away from the sewer system, preventing CSOs.



Figure 5.36. Bioswales [135].

5.4.5.4. *Rip-raps*

The term “rip-rap” refers to a durable and erosion-resistant ground cover of large, loose, angular stones. The majority of the shoreline in Hunter's Point South Park and Gantry Plaza State Park is lined with rip-rap, serving the following purposes:

- It protects against water erosion, safeguarding the park and the surrounding neighborhood from the damaging effects of waves and water currents.
- Rip-rap acts as a buffer by absorbing and deflecting the impact of storm surges and waves, reducing their potential to cause shoreline erosion.
- By preventing the settling of sediments, rip-rap can improve water quality. The stones create a barrier that helps keep the water near the shoreline clean and clear by minimizing sediment accumulation.

Overall, using riprap along the shoreline is crucial in maintaining the park's stability and protecting it from erosion while promoting better water quality in the adjacent areas.



Figure 5.37. Ripraps along the park (*taken by writer*)

The park was carefully designed to address resilience challenges and incorporates a critical infrastructure layout. The Architect's Newspaper article provides a visual about the layout design and existing elements [136]. In Figure 5.37, an example of ripraps used in the park can be seen.

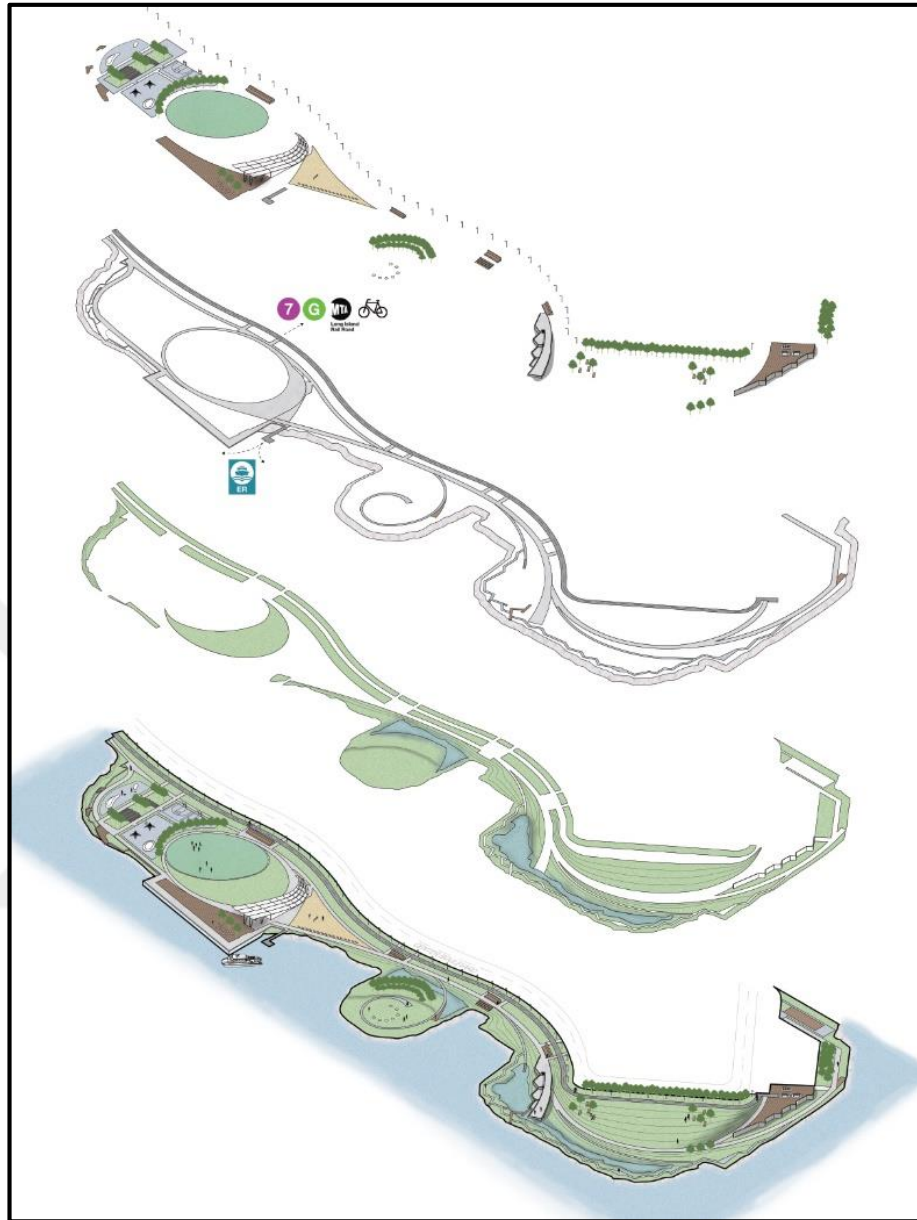


Figure 5.38. Design layers of Hunter's Point South Park [136].

The next chapter of the thesis study will examine the prepared assessments and present the details of each segment. In Figure 5.38, the multilayered design processes of the park can be seen.

5.4.6. The Examination of The Prepared Evaluations

These evaluation forms have been prepared to take into account the site area that was intended to cover in the project, the Resilience Alliance and IPCC notes, and The Paris Agreement and Sustainable Development Goals as guidance. Due to the harmful impacts of climate change and the resulting disasters, the evaluation criteria focused on *resilience*. The design features were assessed accordingly. Each table has a brief explanation, and some assessments have additional descriptions on the side.

Table 5.2. Assessment 4.1-Explained summary of the primary concerns (prepared by the writer)

4.1 .A summary of the primary topics of concern for the assessment and the system's valued features.		
PRIMARY CONCERNS	MAJOR SOURCE(S) OF CONCERN(S) FOR THE EVALUATION	HIGHLY APPRECIATED SYSTEM CHARACTERISTICS
East River -> Natural disasters	The location is adjacent to the East River, which increases the likelihood of flooding in the event of a natural disaster.	The park's design foresees the risks of natural disasters like hurricanes and lowers them to a bare minimum.
Hunter's Point Park site -> The size is large in proportion	The area is over 30 acres which makes it a challenge for maintenance and security.	Hunters Point Parks Conservancy, a nonprofit volunteer-run organization, expanded it's operations in 2014 and keeps working on a volunteer basis. The park closes at 10:00pm to ensure security.
Preserving the natural habitat and biodiversity of the park	The area used to be covered with wetlands before it's transformation.	This area is crucial for its diverse range of plant and animal life, thanks to the clever conversion of wetlands into thriving green vegetation.

The primary concerns cover three subcategories in this chapter. The evaluations are made, and the results are shown in Table 5.2 above. The primary concerns are formed considering the past events that occurred in the city. As concerns, during natural disasters like Hurricane Sandy, floods and overflows can cause significant issues as they disrupt the park area and its surroundings. So East River is a risk factor. Also, the park's size considering the maintenance is a challenge. As well as preserving the biodiversity of the park is essential.

Table 5.3. Assessment 4.2- Identification of direct and indirect uses (prepared by the writer).

4.2. Identify the direct and indirect uses of key natural resources that are supplied by the system, as well as the stakeholders who rely on them.	
NATURAL RESOURCE USAGES	
Direct Usage (elements that are in direct contact with the functioning of the park)	Indirect Usage (elements that facilitate the liveliness at the park)
Sunlight (solar panels)	Air quality
Water Resources (East River)	Water quality (the quality of East River which may affect the social interactions in the park)
Wetlands and Salty Marshes	Ecological growth of the park (plants adapting to the area and regenerating harmoniously)
Vegetation & Trees (Green elements)	Ecosystem interactions (animal-animal, plant-animal relations)
Recreational elements (walkways, running paths, sports fields, sitting areas)	
Wildlife (birds and other animals who come to the area to live)	
STAKEHOLDERS	
Inside the system	Outside the system
Local community (Residents and locals of the area)	Educational institutions (Schools, colleges, and universities can use the park's natural and recreational features as an educational resource for research and educational programs.)
Government bodies (section of the Municipality responsible for the park and its surroundings)	Tourism & Hospitality Industry
Park Administrators (park managers, staff and all other daily duties' officers)	Donors and Philanthropic Organizations (Donors and philanthropic organizations can provide financial support for specific projects to improve parks.)
Park Visitors	Advocacy Groups and Activists
Non-Government Organizations & Community Groups (Understanding visitor preferences helps improve park amenities and services.)	Government Agencies (Outside the Local Government)
Businesses and local shops (Local businesses and commercial entities can partner with the park to benefit from park visitors and contribute to its economy.)	

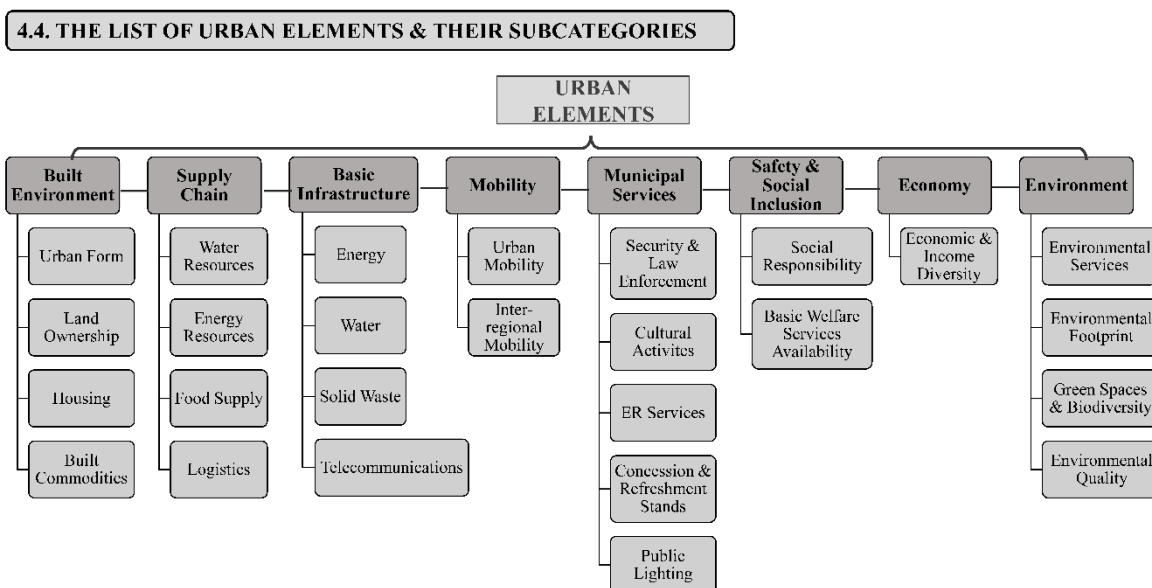
This section consists of two components: utilizing natural resources and stakeholders, individuals, or groups with an interest or concern in the project, company, or organization. Natural resources are subcategorized as direct & indirect usage of elements. The Table 5.3. illustrates the stakeholders in and outside of the system. This scheme outlines the hierarchy and relevance of the individuals involved in the project.

Table 5.4. Assessment 4.3- The list of target system disruptions (prepared by the writer).

4.3. THE LIST OF TARGET SYSTEM DISRUPTIONS AND THEIR CHARACTERISTICS					
Disturbance (past/ present)	Unique / Recurrent	Occurrence frequency	Recovery time between occurrences	Most impacted elements	The magnitude of the damage (1-5) (modest to severe)
Hurricanes	Recurrent	Every year with different impacts	Varies	Cities, mostly coastal lines. Infrastructures can be widely damaged.	Severe_5
Winter storms	Recurrent	Every year with different impacts	Within few days	Cities, built infrastructures and daily lives.	Severe_4-5
Tornadoes	Unique	Rarely happens	Varies	Cities, built infrastructures and daily lives.	Modest-severe_2-3
Flooding	Recurrent	Every year with different impacts	Varies	Cities, built infrastructures and daily lives.	Severe_4-5
Earthquakes	Unique	Rarely happens	N/A	Cities, built infrastructures and daily lives.	Severe_4-5
Heatwaves	Recurrent	Every year with different impacts, still severe in summer months	Varies	Cities, built infrastructures and daily lives & mostly humans lives.	Severe_5
Thunderstorms	Recurrent	Every year with different impacts, still severe in late spring to early autumn.	Varies	Cities, built infrastructures and daily lives & mostly humans lives.	Severe_5

This section encompasses six interconnected features that mutually influence one another. Its main objective is to identify and explore the intricacies inherent within the system, aiming to unveil the interdependencies and relationships between these features. The assessment seeks answers for *Disturbance*, *Unique/recurrent*, *Occurrence frequency*, *Recovery time between occurrences*, and *Most impacted elements*. As an overall outcome, hurricanes, winter storms, flooding, heat waves, and thunderstorms are recurrent and somewhat destructive to the area, all related to the detrimental effects of climate change.

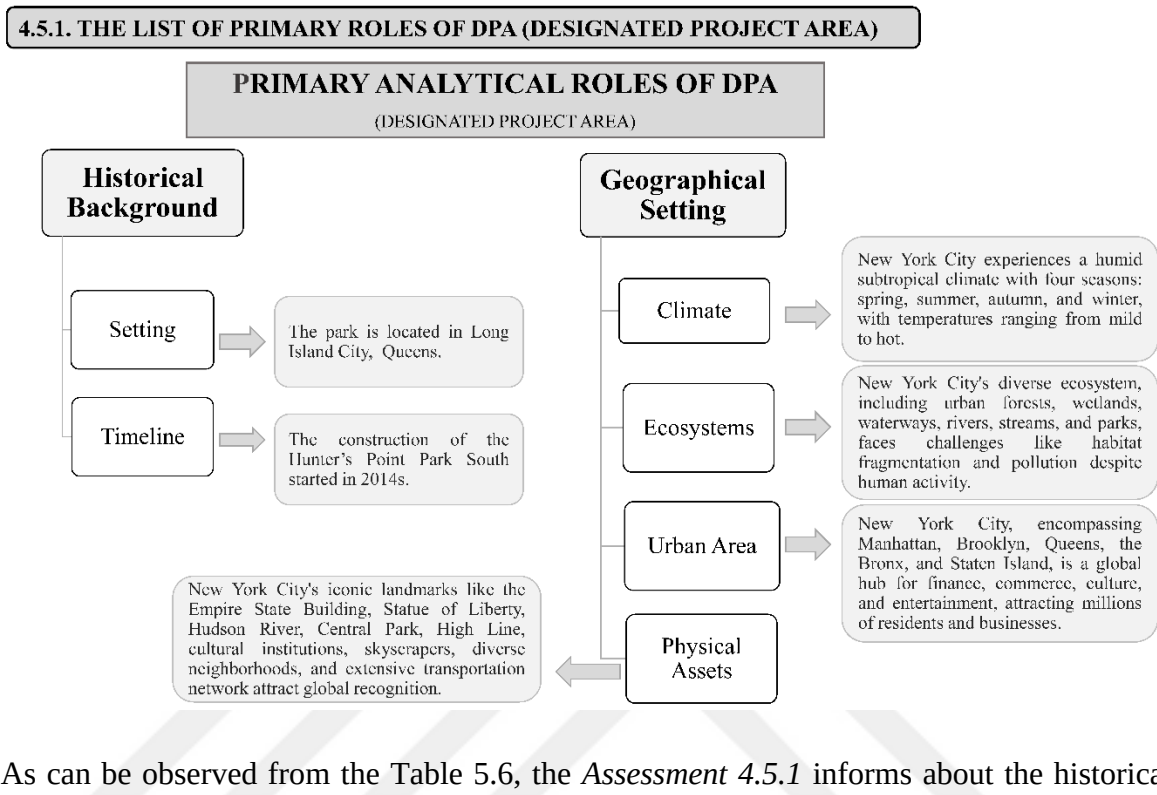
Table 5.5. Assessment 4.4- The list of urban elements and subcategories (prepared by the writer).



The table labeled "5.5" provides a comprehensive list of elements used in the design process of Hunter's Point South Park. As a reminder, the bulleted parts below show the subcategories of the urban elements vital for the project.

- Built Environment → *Urban form, land ownership, housing, and built commodities.*
- Supply Chain → *Water resources, energy resources, food supply, and logistics.*
- Basic Infrastructure → *Energy, waste, solid waste, and telecommunications.*
- Mobility → *Urban mobility and inter-regional mobility,*
- Municipal Services → *Security & law enforcement, cultural activities, er services, concession & refreshment stands and public lighting.*
- Safety & Social Inclusion → *Social responsibility and basic welfare services availability.*
- Economy → *Economic & income diversity.*
- Environment → *Environmental Services, Environmental Footprint, Green Spaces & Biodiversity and Environmental Quality.*

Table 5.6. Assessment 4.5.1 - The list of primary roles of the project area (prepared by the writer).



As can be observed from the Table 5.6, the *Assessment 4.5.1* informs about the historical background and the geographical setting of the project area, the parts that are thoroughly explained are:

Historical Background

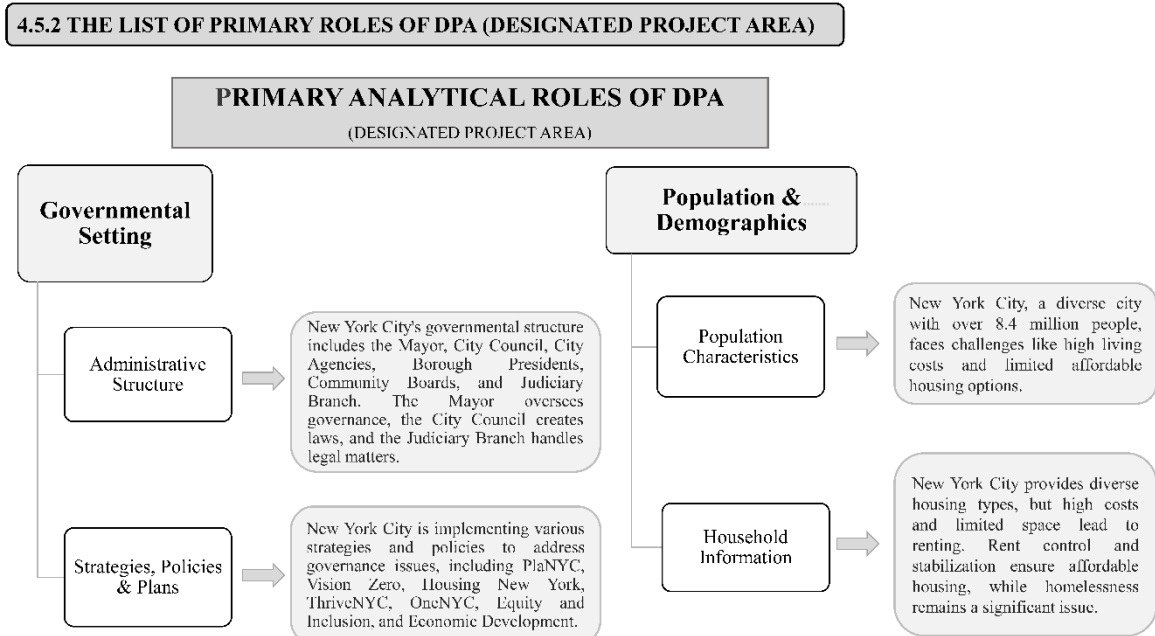
- *Setting*
- *Timeline*

Geographical Setting

- *Climate*
- *Ecosystems*
- *Urban Area*
- *Physical Assets*

The explanation parts shown in the boxes.

Table 5.7. Assessment 4.5.2 - The list of Primary Roles of the Project Area (prepared by the writer).



Above, in the table 5.7, the list of the designated project area continues as *Assessment 4.5.2*, and is explained as:

Governmental Setting

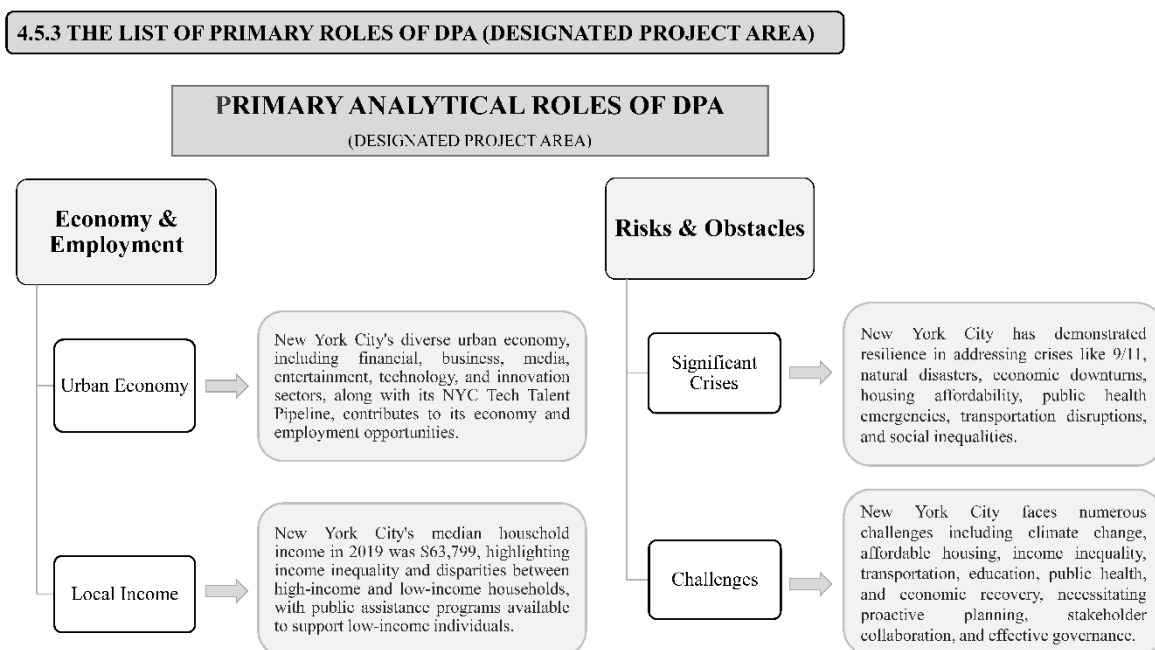
- *Administrative Structure*
- *Strategies, Policies & Plans*

Population & Demographics

- *Population Characteristics*
- *Household Information*

It is possible to observe the government setting and population and demographics are explained in the boxes in detail.

Table 5.8. Assessment 4.5.3 - The list of Primary Roles of the Project Area (prepared by the writer).



The Table 5.8, Assessment 4.5.3, the last explanatory part of the Primary Roles of DPA is thoroughly explained. The Economy & employment part is broken down in two subcategories and explained in blue boxes. Risks & obstacles are also subcategorized in two categories and shown as:

Economy & Employment

- *Urban Economy*
- *Local Income*

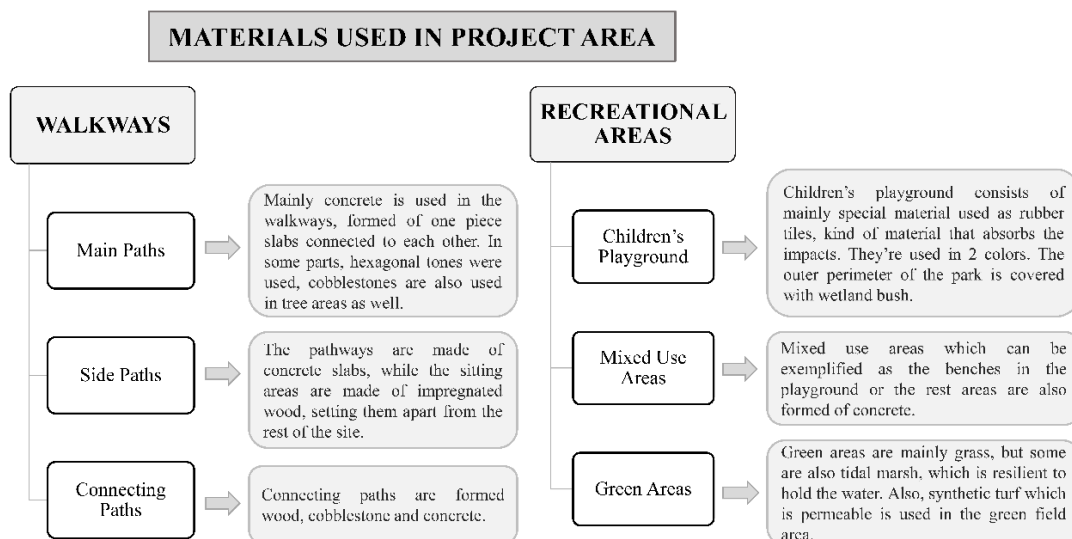
Risks & Obstacles

- *Significant Crises*
- *Challenges.*

The details are explained in the boxes.

Table 5.9. Assessment 4.6.1 – The characteristics of the materials and infrastructural elements (prepared by the writer).

4.6.1. THE CHARACTERISTICS OF MATERIALS & INFRASTRUCTURAL ELEMENTS USED IN DPA



The Table 5.9, Assessment 4.6.1, tries to explain in detail the characteristics of the materials and infrastructural elements that are used in the project area. It also aims to point out, what types of materials are used in the design as resilient materials or to to strengthen the resilience factor. The assessment 4.6.1, therefore, covers the first part of the materials used, which can be stated as:

Walkways

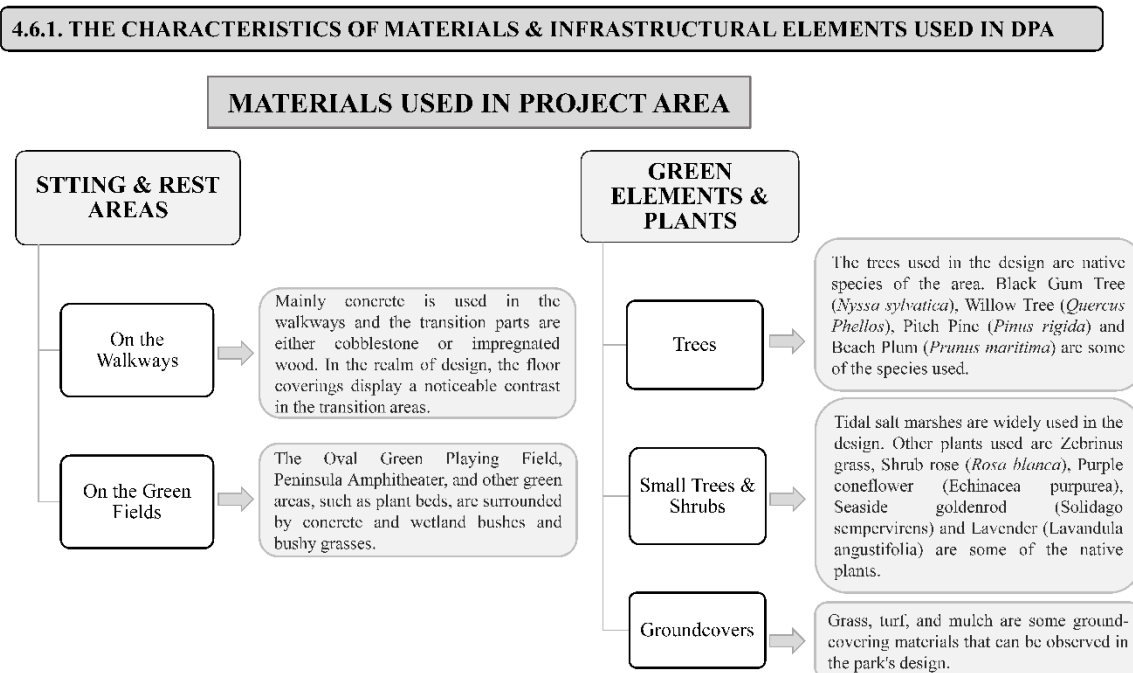
- Main paths
- Side paths
- Connecting paths

Recreational Areas

- Children's Playground
- Mixed Use Areas
- Green Areas.

The blue boxes aim to explain the subcategories in detail.

Table 5.10. Assessment 4.6.2 - The characteristics of the materials and infrastructural elements (prepared by the writer).



The Table 5.10, as a continuation of the previous table, intends to explain the materials used in sitting areas. Also, green elements and plants are explained. The primary aim of the discussion on planting was to determine the plants that exhibit resistance and those that can be employed in resilient designs. The assessment 4.6.2 covers the answers to the following elements:

Sitting & Rest Areas

- On the Walkways
- On the Green Fields

Green Elements & Plants

- Trees
- Small trees & shrubs
- Groundcovers.

The assessment results suggest that multiple systems should be incorporated throughout the design process, from start to finish. This information is vital for readers to consider. The involvement of the community members, local authorities, and the natural environment should be ensured during the process, seeking their input and considering them as integral parts of the development. As stakeholders in the project, their opinions and perspectives are valuable. It means every single stakeholder is interrelated with each other on this journey to implementing resilience. A systems thinking approach should commonly be utilized in a sustainable project design. This approach involves considering various factors and interconnections to create a resilient project. Durable, low-maintenance, and versatile materials are carefully selected to achieve this. Additionally, plant species and greenery that demand minimal upkeep are chosen to enhance the overall area. This project aims to ensure long-term sustainability, efficiency, and resilience by implementing these strategies.

5.4.7. The Assessment Results

When striving to create a resilient and sustainable project, it is imperative to seamlessly integrate multiple systems throughout the entire design process, from its inception to its conclusion. This holistic approach requires the active participation of various stakeholders, including community members and local authorities, who are essential to the development. Also, incorporating their input and perspectives is fundamental, as every stakeholder is interlinked on the journey toward achieving resilience. Embracing a systems thinking approach becomes paramount in this endeavor, as it entails a comprehensive evaluation of various factors and their intricate interconnections, thus laying the foundation for a genuinely resilient project.

In assessing the project site's resilience, it was imperative to consider many factors, including all stakeholders and relevant institutions. This comprehensive evaluation commenced by pinpointing the area's primary concerns and scrutinizing recurring natural disturbances, all while considering the conservation of natural resources and stakeholders' interests. The examination extended to encompass various urban elements, including the built environment and supply chain, with meticulous attention to detail regarding the principal roles of the selected project site while also acknowledging the contributions of other entities connected to the site. A detailed analysis of the site's design was conducted to extract insights into the

designers' achievements and establish a blueprint for future architects and planners. It is worth noting that surviving a natural disaster like Hurricane Sandy provided designers with invaluable on-site experience, informing their design initiatives and illustrating the potential consequences of inaction.

To turn this vision into a reality, it is imperative that we meticulously choose materials that are both durable and low-maintenance, as well as versatile enough to adapt to changing needs. Furthermore, designers must thoughtfully select plant species and greenery that require minimal upkeep to significantly enhance the area's sustainability and aesthetic appeal.

Ultimately, the overarching goal of this project should revolve around the assurance of long-term sustainability, efficiency, and resilience. It is possible to forge a more resilient and sustainable future by adhering to these strategies and principles.

6. CONCLUSION

Urban areas and their inhabitants have recently grappled with the devastating consequences of natural disasters and climate change-induced catastrophes. The influx of people from rural regions into cities in pursuit of better job prospects has led to heavily populated urban settings devoid of green spaces. This amalgamation of high population density and the greenhouse effect brought on by climate change has profoundly impacted the livability and sustainability of these regions. Furthermore, the cost burdens associated with upgrading insufficient infrastructure have exacerbated these issues, with even major metropolitan centers falling short of contemporary sustainability benchmarks.

Established in 1988, the Intergovernmental Panel on Climate Change (IPCC), a subsidiary of the United Nations, has diligently documented the detrimental consequences of climate change on both the environment and human health. This issue has assumed a central role in critical urbanization processes in the four decades since its inception. Dr. Alexander Leaf, a distinguished professor at Harvard University, has conducted extensive scientific research that corroborates the adverse health effects of climate change, encompassing ailments such as chronic heart-related conditions and waterborne diseases.

The most recent IPCC report from 2022 once again underscores the profound influence of human-induced climate change on the natural world and human populations. It accentuates the critical interdependencies among natural, social, and climate systems, which have given rise to extensive adverse outcomes. Therefore, a paramount imperative emerges—curbing global warming to a maximum of 1.5°C and embedding resilience as an integral component of sustainability.

Resilience encompasses diverse definitions, but at its core, it signifies a system's capacity to endure significant disruptions and recover while preserving its current state. In the context of urban environments, resilience pertains to the vital ability of an urban system to maintain and support its functions even when confronted with adversity or strain. This concept finds relevance in various domains, including ecology, socio-ecology, urban planning, and economics, and manifests its effects across various structures and systems. The criticality of incorporating resilience into urban design is increasingly evident, especially considering climate-related disasters have been responsible for most global catastrophes over the past

decade. This significance is further underscored by the reality that half of the world's population has migrated to cities primarily due to economic incentives.

With cities facing diverse challenges and calamitous events, including level 4 hurricanes and severe thunderstorms, the imperative of resilience in the urban environment becomes ever more apparent. Consequently, it is imperative to address resilient urban development by offering precise definitions of urban design and urban planning while accentuating their collaborative and interdisciplinary essence.

The ability of cities to withstand and recover from the severe consequences of climate change is of utmost importance. Achieving this goal requires climate-resilient urban development, which involves considering two key factors. Firstly, effective local governance, active community participation, and seamless integration of physical, social, and economic dimensions into urban planning and design for climate resilience are essential. Secondly, physical design plays a significant role in resilient urban development, emphasizing the need for urban design to adapt to changing climates while reducing cities' impact on climate change.

This study strongly emphasizes the challenges posed by climate change in urban environments. It centers on the execution of assessment studies aimed at comprehending the seamless integration of resilience into urban design practices. In this context, resilience pertains to a city or urban area's capability to respond, adapt, and recover from climate-related disruptions effectively. A highly suitable location was selected and thoroughly reevaluated based on meticulous research to serve as a robust case study for resilience research in urban areas affected by climate change. This selection was purposefully made to exemplify the typical challenges encountered in such areas. To uphold the research's credibility and rigor, the researcher sought guidance from the Resilience Alliance Group, an esteemed source of expertise in resilience. Subsequently, a comprehensive set of forms was created to streamline systematic and deliberate data collection during the assessment process. These forms adhered to established research methodologies, incorporating a structured approach to gather pertinent information. This meticulous data collection approach aimed to ensure consistency and accuracy, empowering the comprehensive study to draw meaningful conclusions regarding potential strategies and interventions to enhance resilience in urban design.

The choice of New York City as the focal case study area in this thesis was influenced by the profound impact of Hurricane Sandy in 2012. This natural calamity ranks among the most devastating ever experienced by a significant urban center. After this catastrophic event, an intensified commitment emerged to enhance resilience in the infrastructure of major cities across the globe, with particular emphasis on New York City. Hurricane Sandy served as a powerful wake-up call for individuals and decision-makers alike, underscoring the imperative of taking concerted action against climate change. It underscored the potential for an escalation in the frequency and intensity of extreme weather events, including hurricanes, attributable to global warming. This realization catalyzed a heightened sense of urgency in addressing climate change globally. The profound repercussions of Hurricane Sandy brought the issue of climate change to the forefront of public consciousness, elevating awareness and fostering a palpable sense of urgency and political determination that culminated in the endorsement of the Paris Agreement. This landmark accord represents a worldwide initiative aimed at combating climate change and mitigating the risks of future disasters akin to Hurricane Sandy.

Subsequently, the research study addressed the formulated assessments about the study area, Hunter's Point South Park. This location, nestled in the heart of New York City, was once an industrial site used as a dump site, but it now represents a precious and promising piece of land within the Long Island City neighborhood. The methodology for this assessment comprised six distinct components. First, it began by encapsulating the area's concerns in a succinct summary. Then, it identified the direct and indirect resource usages supported by the system and pinpointed the stakeholders who rely on them. Next, it enumerated the vulnerabilities and features that the focus area confronted in the context of natural disasters. The fourth assessment segment delved into urban elements and their subcategories, providing a clearer understanding of the intricate web of interconnected systems. The fifth section delved into the primary roles of the project area, encompassing its historical context, geographical attributes, governmental framework, population demographics, economic dynamics, employment landscape, and the inherent risks and challenges, all facets that operate on a human scale. The final stage of the evaluation entailed discerning the materials employed in the design of this designated project area, aligning them with the various resilience elements, and cataloging exemplary materials.

These assessments illuminate the intricate interplay among systems and underscore the inclusivity of every facet within the urban environment. This interconnectedness is vital to delineating pathways toward a sustainable future where resilience is paramount. From a design perspective, Hunter's Point South Park's blueprint is a testament to the pivotal role of a holistic strategy that accounts for all interlinked systems and elements to achieve resilience. The design strategy places a premium on using durable materials and low-maintenance vegetation to ensure the long-term sustainability of the project area. While ongoing academic inquiries into climate change and resilience persist, ample room remains for enhancement. The reservoir of knowledge necessitates augmentation, urging a more profound commitment to further research. To address this need, scientists and academics should adopt a more proactive stance in conducting field studies and research about climate change resilience. Their scientific contributions play an indispensable role in shaping sound development decisions.

In summary, this thesis conducted a comprehensive and painstaking examination of the prevailing literature, encompassing diverse sources, including books, peer-reviewed journals, and pertinent conference proceedings. This exhaustive exploration delved into the intricate and multifaceted realms of climate change and resilience. The culmination of this research brings into sharp relief the profound and multifarious challenges entailed by climate change, which manifest as substantial risks not only to our natural environment but also to the broader public health landscape. The realization emerges that the repercussions of climate change ripple across a broad spectrum of domains, enshrining environmental and health concerns while extending their influence to the intricate tapestry of urban resilience.

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