DEVELOPMENT OF URBAN SUSTAINABILITY INDICES FOR DISTRESSED PLACES

By

Azad Hassan

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Planning, Design and Construction – Doctor of Philosophy

2021

ABSTRACT

DEVELOPMENT OF URBAN SUSTAINABILITY INDICES FOR DISTRESSED PLACES

By

Azad Hassan

Since the beginning of the 20th century, scholars and urban policy makers have been gauging urban sustainability progress worldwide. However, an analysis of this notion in distressed places has not been investigated anywhere as yet. This dissertation aims to advance the knowledge of *distressed urban areas* and to comprehend the construction of an Urban Sustainability Index (USI) for such areas. This research study has proposed four primary research questions to achieve its goals: 1) What is the definition of a distressed place? 2) What are the characteristics of distressed places? 3) To what extent can a taxonomy be created of distressed places?; and 4) What is the methodological framework to be employed to construct an urban sustainability index for a distressed place?

Qualitative and quantitative approaches were employed to address the research questions. Specifically, preliminarily mixed-methods consist of systematic, holistic, multi-criteria, and integrated approaches. A two-stage exploratory design, a theoretical scenario, and a case study have been employed to validate the proposed framework to monitor urban sustainability progress. The theoretical scenario for a generic distressed place called X is provided with a step-by-step theoretical guide and a foundation on how to construct a USI for X's context.

Duhok City, located in Kurdistan Region in Northern Iraq, is used to develop a functional framework of indicators to assess and measure urban sustainability after the Kurdistan Region declared autonomy in 1991. This city is located in a distressed region that has experienced rapid

urbanization and expansion, geopolitical dilemmas, and socio-economic issues. This case study addresses several fundamental issues for sustainability measures in the city by investigating the key factors that influence the pattern of urban sustainability, and how can they be used to promote future sustainable practices?

The study found that distressed urban areas' typology takes two fundamental forms that present context-specific conditions in cities and socioeconomic and environmental conditions in communities. Most research has concentrated on challenges in urban settings without acknowledging that distressed urban areas' characteristics are heterogeneous. Therefore, this research argues that conditions caused by geopolitical stress and the global health crises could threaten the very fabric, dynamics, and quality of life of urban areas.

The study highlights nine urban sustainability indicators, from a total of 39 indicators, that played an essential role in navigating the general trend of urban sustainability in the city of Duhok and how they can be used to promote future sustainable practices. It also argues that distressed communities, like normal and healthy places, need to acknowledge when they succeed and fail. Monitoring the sustainability progress in such places will overcome interlinked socio-economic and environmental issues, and a vicious decline in urban life quality. Further investigations on comparative case studies can cover more distressed places. In other words, the role of political stability, government effectiveness, and the quality of planning regulations in achieving significant progress towards urban sustainability are vital for further research.

I dedicate this dissertation to the people below who supported and believed in me when I started the United States' journey in 2014.

Connie Kruger, Caroline Gear, Betsy Rider, Patricia Stacey, Vera V. Vlasenko

I always will be grateful for their help, friendship, and belief that there is always a second chance!

ACKNOWLEDGMENTS

This dissertation would not be possible without the assistance of many individuals to whom I owe my deepest gratitude. I want to express my sincere thanks to my Ph.D. committee members Dr. Mohamed El-Gafy and Professor Murari Suvedi for their constant guidance in this endeavor.

Special thanks go to my primary supervisor Professor Mark Wilson for the opportunity to work under his supervision. Also, I would like to express my heartfelt appreciation for Dr. Zeenat Kotval-Karamchandani for her unequivocal support and friendship during the course of this research. Both Professor Wilson and Dr. Kotval-Karamchandani have successfully transformed my weakness into my strength. I have learned many things from them, especially to be keen and kind with peers in academia.

I would take this opportunity to thank my dear friends and colleagues for their incredible support and push toward success. My deepest thanks to the two Ph.D. candidates Shruti Khandelwal, and Morna Hallsaxton, for their profound efforts in the weekly meetings to write our dissertations. In addition, I want to send my countless appreciation to Dr. Marie Ruemenapp, Dr. Ali Lahouti, Dr. Sirle Salmistu, Dr. Hogeun Park, and Dr. Robert Dalton for their pure friendship.

Lastly, a huge thank you to Lona Lieske for helping me in proofreading this dissertation. Also, I am deeply grateful to my parent, wife, and all family members who have immensely believed in me

TABLE OF CONTENTS

LIST OF TABLES ix

LIST OF FIGURES xi

KEY TO ABBREVIATIONS xii

Chapter 1: Introduction 1
1.1 Background and Problem Statement 1
1.2 Gap in Knowledge 5
1.3 Objectives and Research Questions 7
1.4 Significance of the Study 9
1.5 Research Design and Conceptual Framework 12
1.6 Contents of Dissertation 16
1.7 Summary 18

Chapter 2: Literature Review 21
2.1 Theoretical Background of Sustainable Development 21
2.2 Review of Urban Sustainability: Concept, Definitions, and Future Directions 27
2.3 Urban Sustainability Perspective: Strong vs. Weak 38
2.4 Sustainability Assessment and Indicators: Concepts and Types 41
2.5 Exiting Sustainability Assessment Systems: Challenges and Opportunities 54
2.6 Summary 62

Chapter 3: The Notion of Distressed Places and Communities in Urbanized World 64
3.1 Urbanization and its Consequences: General Background 65
3.2 Definitions and Characteristics of Distressed Places and Communities 67
3.3 Themes of Distressed Places and Communities 74
3.3.1 Theme one: Socioeconomic Distressed Urban Areas 74
3.3.2 Theme two: Environmental and Climate Change Distressed Urban Areas 79
3.4 Summary 81

Chapter 4: Research Design and Methodology 83
4.1 Stage One: Contemporary Concepts of Urban Sustainability and Distressed Areas 85
4.1.1 Step One: Systematic Scholarly Literature Scan 85
4.1.2 Step Two: Categorize Emergent Themes of Distressed Places 89
4.1.3 Step Three: Analyse the Emergent Themes 90
4.2 Stage Two: Conceptual and Methodological Framework for a Holistic Index 92
4.2.1 Step One: Establish an Analytical Framework 92

4.2.2 Step Two: Hierarchy of the Developed Methodological Framework 103
4.3 Stage Three: Validation of the Developed Methodological Framework 118
4.3.1 Step One: Theoretical Scenario 118
4.3.2 Step Two: Implementing the Conceptual and Methodological Framework 128
4.4 Summary 128

Chapter 5: Assessing Urban Sustainability for Distressed Urban Areas 130
5.1 Abstract 130
5.2 Introduction 131
5.3 Objectives and Research Questions 133
5.4 Materials and Methods 133
5.4.1 Review of Literature 134
5.4.2 The Objectives of Urban Sustainability 135
5.4.3 The Significance of Indicator-Based Sustainability Assessment 137
5.4.4 Weak and Strong Sustainability 139
5.4.5 The Case Study Area and Its Sustainability Objectives 140
5.5 Methodology to Develop the Urban Sustainability Framework for Duhok City 145
5.5.1 Step 1: Adopt DPSIR 145
5.5.2 Step 2: Finalize the List of Urban Sustainability Indicators 148
5.5.3 Step 2: Data Collection, Measuring, and Statistical Analyses 154

Chapter 6: Results and Discussion 156
6.1 Notion of Distressed Places 156
6.2 Urban Sustainability in Duhok City 163

Chapter 7: Recommendations and Conclusion 174

APPENDICES 182
APPENDIX A: Common Methods for Weighting 183
APPENDIX B: Common Methods for Aggregation 187
APPENDIX C: References for Urban Sustainability Programs 189
APPENDIX D: Data Collection Resources for the Case Study 217

BIBLIOGRAPHY 219

LIST OF TABLES

Table 1: Elements of Urban Sustainability 29

Table 2: Evolution of Urban Sustainability Definition 35

Table 3: Summary of Sustainability Indices 43

Table 4: Definition of Intrametropolitan and Intercity Hardship Index Indicators 73

Table 5: OECD Countries Indicators to Describe Distressed Urban Areas 76

Table 6: Coding Emergent Themes of Distressed Places 91

Table 7: The Methods of Measuring Urban Sustainability Systems 98

Table 8: The Characteristics of an Ideal Sustainability Assessment 105

Table 9: Summary of Sustainability Initiatives as References for the Study 108

Table 10: The Hierarchical Structure of the Final Framework 112

Table 11: A Theoretical Example of Integrating PSR Framework and Composite Indicator 123

Table 12: Examples of Tweaking Process 125

Table 13: Urban Area Growth Rate of Duhok City During 1947–2014 142

Table 14: Population Growth Rate of Duhok City During 1947–2014 142

Table 15: Initial Set of Indicators Reviewed by Category 147

Table 16: Urban Sustainability Framework of the City of Duhok 149

Table 17: Indicator Influenced on Urban Sustainability Trend, 1991–2010 167

Table 18: Common Methods for Indicator Weighting 184

Table 19: Common Methods for Indicator Aggregation 188

Table 20: The Indicators of Sustainable Seattle 190

Table 21: Mathematical Formulations of Composite Sustainability Indictors 191

Table 22: Central Texas Sustainability Indicators 192

Table 23: Santa Monica Sustainable City Plan Indicators 193

Table 24: Sustainability Plan for San Francisco Indicators 194

Table 25: Urban Sustainability Indicators for Taipei's Urban Sustainability 197

Table 26: Measuring the Sustainability in Cities 198

Table 27: Measuring Urban Sustainability in Europe 199

Table 28: United Nations Commissions on Human Settlements 200

Table 29: Malaysia's Set of Indicators 202

Table 30: Taiwan's Set of Indicators 204

Table 31: China's Set of Indicators 207

Table 32: Indicators of Urban Sustainability in Mexico 208

Table 33: Sustainable Cities Project in Malaysia 212

Table 34: Potential Indicators for Malaysia Sustainable Development 215

Table 35: List of Dataset Resources Used for the Case Study of Duhok 218

LIST OF FIGURES

Figure 1: The Framework of Research Design and the Methodology 15

Figure 2: Illustration of the 17 SDGs 26

Figure 3: Key Components of Sustainability and Their Relationship 39

Figure 4: Relationship Between Sustainability Actions and SIs 46

Figure 5: PSR & DPSIR Framework 50

Figure 6: Theme-based Indicator Framework 52

Figure 7: Review of Existing Sustainability Models from the Literature 55

Figure 8: Review of Urban Indicators Evolution 57

Figure 9: The Framework of Research Design and Methodology 84

Figure 10: Literature Selection Procedures for Stage One 86

Figure 11: Conceptual Scheme for Analyzing Urban Sustainability Indices 95

Figure 12: The Case Study Site 141

Figure 13: Urban Sustainability Index of Duhok City, KRG 1991–2010 164

Figure 14: Urban Sustainability Index by Categories of Duhok City, KRG 1990–2010 166

KEY TO ABBREVIATIONS

SD: Sustainable Development

SIs: Sustainability Indicators

USI: Urban Sustainability Index

USIs: Urban Sustainability Indices

PRISMA: Systematic Reviews and Meta-Analyses

KR: Kurdistan Region

US: United State

OECD: Organization for Economic Cooperation and Development

WCED: World Commission on Environment and Development

TBL: Triple Bottom Line

WSSD: World Summit on Sustainable Development

SDGs: Sustainable Development Goals

UN: United Nation

GSDR: Global Sustainable Development Report

UN-Habitat: United Nations Human Settlements Programme

UNCHS: United Nations Centre for Human Settlements

SCP: Sustainable City Program

DPSIR: Driving force–Pressure–State–Impact–Response framework

PSR: Pressure-State-Response framework

SMRT: Specific, Measurable, Achievable, Relevant, and Time-related

DCI: Distressed Communities Index

SWOT: Strengths, Weaknesses, Opportunities, and Threats

Chapter 1: Introduction[1]

1.1 Background and Problem Statement

Our world is becoming more urbanized and thus more complex. From the 1950s, cities started to expand, and, consequently, the number of urban inhabitants has been rising; it is expected to further increase by 30 percent by 2050 (Gonzalez-Garcia, Manteiga, Moreira, & Feijoo, 2018). Specifically, it is projected that by 2050, an estimated 70 percent of the world's population will live in cities (UN-Habitat, 2016). Due to the acceleration of the urban phenomena, contemporary societies face unexpected and diverse challenges (Gómez-Álvarez, López-Moreno, Bilsky, Ochoa, & Osorio, 2018). For instance, urban heat islands, air pollution, flooding, urban poverty, traffic congestion, crime, health issue, and violence are all consequences of the negative ecological and social impacts on cities' urbanization (Murayama & Estoque, 2020).

As a result of the negative urbanization impacts, contemporary cities should be committed to making their communities more sustainable. This is especially true of distressed urban areas since, worldwide, these areas are growing in many forms (Halász, 2019) and up to 20 percent of the world population may live in distressed urban areas (Conway & Konvitz, 2000). The regeneration of distressed urban areas is a priority in contemporary city planning (Levent, 2011). However, achieving more sustainable cities and communities is not always a straightforward task as cities tend to be complex and rigid systems (Braulio-Gonzalo, Bovea, &

[1] The following chapter contains material reproduced from an article published in the journal Sustainability with the citation: Hassan, A.; Kotval-K, Z. A Framework for Measuring Urban Sustainability in an Emerging Region: The City of Duhok as a Case Study. *Sustainability* **2019**, *11*, 5402.

Ruá, 2015). The big challenge of urbanization in recent time is sustainability (Kates, 2018). The term "sustainable development" (SD) has been in the literature debate arena since 1987 (Brundtland, 1987) and has become a 'keystone of the global dialogue about the human future' (Georgescu-Roegen, 2002). Since that time, it has been a popular term in various fields and sciences such as economics, environment, politics, and community development (Mori & Christodoulou, 2012). In this dissertation, the concept of sustainability and SD will be used interchangeably, and the study explicitly focuses on urban sustainability, which is a subset of a much larger body of sustainability (L. Huang, Wu, & Yan, 2015).

The concept of urban sustainability has become increasingly predominant in urban studies and political agendas (Vojnovic, 2014). In the second half of the 20th century, governmental interest in pursuing and advancing urban sustainability has increased (L. Huang et al., 2015). However, achieving urban sustainability goals is not an easy task. Cities and communities worldwide have been exploring innovative efforts and ways to implement more advanced sustainability in urban community settings (Gómez-Álvarez et al., 2018). As a result, such communities need to acknowledge multi-dimensional, complex, and embedded trade-offs (Gan et al., 2017; Wu, 2013). To this end, quantifying progress toward urban sustainability within an urbanized world will require the aid of relevant sustainability indicators (SIs) to help understand such a complex system (Verma & Raghubanshi, 2018). In other words, developing sustainable urban plans, policies, and implementations backed by SIs, can lead the urbanization process toward the desired status of urban sustainability (Shen, Ochoa, Shah, & Zhang, 2011). In recognition of this, a wide range of urban sustainability implementation efforts will be needed

across the diversity of different communities, cities, and regions (Deng, Liu, Wallis, Duncan, & McManus, 2017; Verma & Raghubanshi, 2018).

One way to gauge urban policies and implementations is to design urban sustainability indices (USIs). USIs have become increasingly essential to the body of urban studies (Gan et al., 2017) because of the need to benchmark and understand the nature and speed of sustainability impacts. That is, numerous and a wide range of different SIs and USI have been used in various contexts for diverse systems – primarily in developed and developing worlds (T Hák, Janoušková, Moldan, & Dahl, 2018). In particular, a set of indicators to measure sustainability progress in cities is increasingly being used to explain how and why specific trends occur in specified contexts (Agol, Latawiec, & Strassburg, 2014). However, a review of urban sustainability literature reveals that most existing SIs and USIs cannot provide an inclusive measurement in distressed places, creating an unfilled yet significant knowledge gap.

Most USIs are designed for places with access to resources and consistent data, yet places under stressful urban phenomena face many unique urban crises and challenges to understanding their environmental conditions. Sources of stress include natural disasters (famines, floods, earthquakes, hurricanes, sea-level rise); social change (migration, violence); and political change (repression, wars). For instance, Haiti's earthquakes in 2010 and Nepal in 2015 destroyed cities and forced their communities to cope with extreme stress and seek refuge in informal places (OECD, 2017). Another example, in 2015, about two-thirds of the world population suffered from water stress that causing consequential water conflicts that might lead to ‘water wars’ in the future, such as in Israel, Jordan, Syria, Turkey, Iraq, Egypt, and Ethiopia (Halász, 2019).

Generally speaking, urban dynamics have become increasingly challenging due to extreme stress, in response to which systems need to elaborate more active policies to battle concentrated social, economic, and environmental issues. Places subject to climate stress, political crises, war, financial hardship, and natural disasters are highly likely to be in need of a policy-based urban sustainability framework to overcome the consequences of such stresses. This notion was recognized in the 2030 Agenda for SD - the eleventh SD's goal, and the New Urban Agenda, where notably the goal is to "make cities and human settlements inclusive, safe, resilient and sustainable" (Secretariat, 2017, p. 107; UN, 2017).

In summary, distressed urban areas fundamentally involve different mechanisms and dynamics than areas in ordinary contexts. Responding to these places brings concerns about what kinds of meaningful urban policies and implementations are needed to fight unforeseen urban crises. Thus, distinctive USIs and urban policy measures are desired and should be considered for distressed urban agglomerations. This dissertation aims to investigate the notion of distressed places and communities in the urbanized world. Furthermore, it proposes a conceptual and methodological framework to develop a USI for the contexts in question. The USIs for distressed urban areas developed herein will shed light on unique urban phenomena for which the body of urban studies does not provide much knowledge.

1.2 Gap in Knowledge

During the last decade, academic interest in the quality of life in distressed urban areas has risen (Dekker, 2007). Although the notion of such an ambiguous concept - distressed urban areas - has already been discussed, there is a need for grounded definitions, principles, and characteristics from a holistic perspective (U. Habitat, 2006; OECD, 1998, 2017). An analysis of this notion from environmental and socio-economic aspects leads to elaborating more significant urban policies (OECD, 1998). The researcher's literature review on urban sustainability and distressed urban areas has identified a gap in knowledge that this study highlights and aims to bridge. Fundamentally, the gap hovers between a holistic understanding of the distressed urban areas concept and how stakeholders use benchmarks to battle its inevitable consequences.

First, among the different studies in distressed urban areas, there is still a lack of knowledge on how policy initiatives can mitigate the effect of urban stress on creating more sustainable cities and communities. Consequently, there is a high demand for research creating a holistic solution of economic and ecological factors for the overall issue of distressed urban areas (Tuczek et al., 2019). Moreover, most of the literature discussion does not provide stakeholders with an adaptable set of SIs and USIs to guide sustainable urban policies and plans to alter the status quo.

SIs and USIs, in general, may be inadequate for stakeholders as decision-support tools if misleading approaches are followed to construct new sustainability indices (Mischen et al., 2019). Several research papers are outlining the need for well-designed conceptual frameworks to develop USIs (Bell & Morse, 2018; Dizdaroglu, 2015; Gan et al., 2017; Gómez-Álvarez et al.,

2018; T Hák et al., 2018; Hiremath, Balachandra, Kumar, Bansode, & Murali, 2013; L. Huang et al., 2015; Meijering, Tobi, & Kern, 2018; Merino-Saum, Halla, Superti, Boesch, & Binder, 2020; Mischen et al., 2019; Mori & Christodoulou, 2012; Verma & Raghubanshi, 2018).

As such, this study argues that existing urban sustainability indices such as Ecological Footprint (Wackernagel & Rees, 1997), Green City Index (Shields, Langer, Watson, & Stelzner, 2009), City Development Index (UNCHS, 2001), Human Development Index (UNDP, 2005), and Sustainable Society Index (Van de Kerk & Manuel, 2008) not only are compromised in the context of distressed places but also are poorly representing their circumstances. (T Hák et al., 2018, p. 194), for example, call for "immediate concerted action" to develop a set of sustainability indicators and implement them systematically and extensively.

Thus, better indicators are needed to overcome the complicated causes of urban stress issues, which have complicated the design and implementation of urban policy (Conway & Konvitz, 2000). Most of the urban sustainability studies that have been conducted using SIs and USIs were for contemporary city planning to combat issues other than those in areas under concern. Furthermore, these studies have not agreed on the ultimate methodology for building a framework of USI by which urban sustainability progress can be measured.

In summary, although the notion of distressed places has been investigated, more comprehensive grounded concepts, characteristics, and definitions are desired. Furthermore, they seek SIs and indices to help urban policymakers draw sustainable policies, plans, and implementations to remedy the consequences of urban dilemmas. The existing SIs and USIs are designed for places with access to resources that have no burden of urban stress. Thus, unique

USIs for distressed urban areas could alter consequences and make distressed places livable and beneficial to residents' well-being.

1.3 Objectives and Research Questions

This dissertation focuses on advancing our understanding of all kinds of distressed urban areas in the urbanized world, identifying the factors to recognize distressed places from others, and designing a methodological and conceptual framework of USI to determine the urban policy implications that will accelerate urban sustainability progress. Specifically, this research has three broad objectives as follows.

Objective one: Advancing the Knowledge of Distressed Urban Areas

In order to investigate all kinds of distressed urban areas in the urbanized world and identify factors that distinguish distressed places from others, this study proposes three primary research questions that align with such objective:

1) *What is the definition of a distressed place?*
2) *What are the characteristics of distressed places?*
3) *To what extent can a taxonomy be created of distressed places?*

To address these questions, this study used a content analysis methodology supported by the Systematic Reviews and Meta-Analyses (PRISMA) flowchart (Liberati et al., 2009). This systematic review of the urban studies literature enhanced the researcher's understanding of all aspects and perspectives on distressed urban areas and how different parts of the world tackle this phenomenon from different lenses.

Objective Two: Understanding the Process of Constructing a USI for Distressed Urban Areas

In order to advance our understanding of the methods of selecting urban sustainability indicators to monitor and observe urban sustainability progress for distressed places, this dissertation sought to address the following question:

What is the methodological framework to be employed to construct an urban sustainability index for a distressed place?

Among the various studies on urban sustainability, there is no consensus on selecting indicators and the methodologies followed for the assessment of urban sustainability progress (Shen et al., 2011). As a result, the researcher used a participatory, systematic, holistic, multi-criteria analysis and integrated approach to developing a conceptual and methodological framework to construct a USI mainly designed for distressed urban areas. Furthermore, a theoretical implementation and a case study were applied to validate the proposed framework. The theoretical scenario was for a generic distressed place called X. This scenario gives a step-by-step theoretical guide and foundation on constructing a USI for the context in question.

Objective Three: Implementing a Case Study to Validate the Results in Objective Two

Next, a case study was used for Duhok City, one of the Kurdistan Region's cities in northern Iraq. Duhok's case study offers a practical example of USI's use in a distressed region that experiences rapid urbanization and growth, geopolitical dilemmas, and socio-economic issues.

This case study's objective was to develop a functional framework of indicators to assess and measure urban sustainability for Duhok City after KR’s declaration of autonomy in 1991. As

such, this case study addressed several fundamental issues for sustainability measures in the city through investigating the following research questions:

1) What kind of urban sustainability progress has the city achieved?
2) How is urban growth affecting sustainability in Duhok City? In other words, what are the key factors that influence the pattern of urban sustainability, and how can they be used to promote future sustainable practices?

The approach adopted was to assess previous urban plans and policies that were drawn by the city's local government and decision-makers. The case study underlines the appropriate urban policies that the city's authorities, urban planners, and decision-makers could use to make Duhok City more sustainable. Embracing the proposed policies would conserve and enhance local resources, safeguard human health and the environment, maintain a healthy and diverse economy, and improve the city's residents' livability and quality of life.

1.4 Significance of the Study

The urbanized and turbulent world poses difficulties for sustaining our cities and communities. The 11th Sustainable Development Goals (SDG) of the United Nations for sustainable cities and communities aims "to make cities inclusive, safe, resilient and sustainable" (Ruá, Huedo, Civera, & Agost-Felip, 2019, p. 1). To succeed, stakeholders from diverse backgrounds such as urban policymakers, city planners, community development practitioners, and even international aid agencies need to put action points toward achieving sustainability goals. Urban issues are driven by environmental stress such as pollution and socio-economic stress such as crime, social isolation, and poverty, leading to poor quality of life in

distressed urban areas (Musterd, 2005). As a result, dissatisfied residents who have no financial ability to relocate will be concentrated in certain parts and, in turn, will exacerbate the social, economic, and physical problems (Dekker & Van Kempen, 2004). Therefore, sustainable urban policies and active action plans are needed to overcome the possibility for a place being abandoned by its residents.

A set of indicators - SIs will help the stakeholders put these action points into practice, monitor the progress, design plan, and urban policy to maintain the system's envisioned sustainability goal under consideration. In fact, SIs plays a significant role in the process of knowing whether designing particular policies will not harm the future of the place (Bell & Morse, 2012). The central idea behind the use of SIs is that they are designed to answer one fundamental question often posed by stakeholders: "How might I know objectively whether things are getting better or getting worse?" (Lawrence 1997, p.179). Establishing a particular USI framework for distressed places using suitable SIs will cover all the places' sustainability aspects.

Sustainable urban policy for distressed urban areas is more than just a policy for places that suffer from urban problems. It can reduce the incidence of distressed areas and integrate them into the place's social, economic, and physical fabric by using preventive and remedial measures (OECD, 1998). A systematic literature analysis of the notion of distressed places within an urbanized world will help all kinds of stakeholders acknowledge how to address crucial concerns and design active urban policies for the places in question. For example, one must identify the characteristics of distressed places. As such, stakeholders may pose questions such as:

1) Are there reliable indicators for identifying distressed places in order to distinguish them from others?
2) To design a sustainable urban policy, plan, and implementation for such places, is there a simple urban sustainability framework by which a places' path toward the goal of sustainability can be contemplated?

Such concerns are inevitable, and policymakers must address them systematically. Resilient cities have been identified as those that have "the ability to absorb, recover and prepare for future shocks (environmental, economic, social and institutional), while they encourage sustainable development, prosperity, and comprehensive growth." (Kounani & Skanavis, 2019, p. 1; OECD, 2015). Thus, a grounded definition, principles, and characteristics of distressed places, as well as a unique USI framework to measure sustainable goals, will equip scholars in urban studies, policymakers, decision-makers, and even the international community with knowledge-based tools to highlight urgent urban needs. Therefore, places with increasingly challenging urban issues can be easily recognized from those that may need less attention or different kinds of action points. This study, therefore, will identify which SIs are most relevant for such a context. In addition, it will provide a well-constructed application of USIs to a distressed areas and the methods of SIs revisions.

1.5 Research Design and Conceptual Framework

The conceptual framework of this study and the research design behind this dissertation have been discussed. In support of achieving the dissertation objectives and addressing its questions, the researcher has adopted a mixed methodology**.** Specifically, the study is based on a systematic, holistic, multi-criteria analysis and an integrated approach.

The researcher followed an approach to integrating qualitative and quantitative data by which theoretical frameworks may yield further information beyond what this approach provides (Creswell & Creswell, 2017). Furthermore, the researcher used a case study as it could be "…. a community; a specific policy; and so on." (Merriam 1998, p.27). Thus, the case study in this research is used as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin 1993, p.13).

As mentioned above, the study methods are preliminarily mixed methods and consist of a systematic, holistic, multi-criteria, and integrated approach. A two-stage exploratory design, a theoretical scenario, and a Case Study have been employed to address the study questions and their objectives. Based on the challenges and arguments that have emerged from the literature review of urban sustainability within the notion of distressed urban areas (which will be presented in chapters two and four) and in order to address the fundamental dissertation questions mentioned earlier, this study has developed a conceptual framework for exploring approaches to address these issues.

Brink (1998, p.312) defines an exploratory study as one that "frequently results from an examination of the literature in which the researcher can not find the answer to the question." Also, they mentioned its purpose as "to study that which has not been previously studied." Subsequently, a theoretical implementation and a case study were employed since the researcher was "looking for new knowledge, new insights, new understanding, and new meaning. The intent is to be holistic in the approach to whatever is being studied." (Brink 1998, p.312). Each stage was designed to conclude different objectives and to lead to the next stage.

The first stage explores the contemporary concepts of distressed places and urban sustainability in scholarly literature and answers the following research questions:

1) *What is the definition of a distressed place?*
2) *What are the characteristics of distressed places?*
3) *To what extent can a taxonomy be created of distressed places?*

To investigate and address these particular research questions, the researcher used three consistent steps as follows:

- Step one: Systematic Scholarly Literature Scan
- Step two: Categorize Emergent Themes of Distressed Places
- Step three: Analyse the Emergent Themes

The second stage through which the fourth research question is answered develops a conceptual and methodological framework for a holistic Urban Sustainability Index use in distressed urban areas. The fourth research question is:

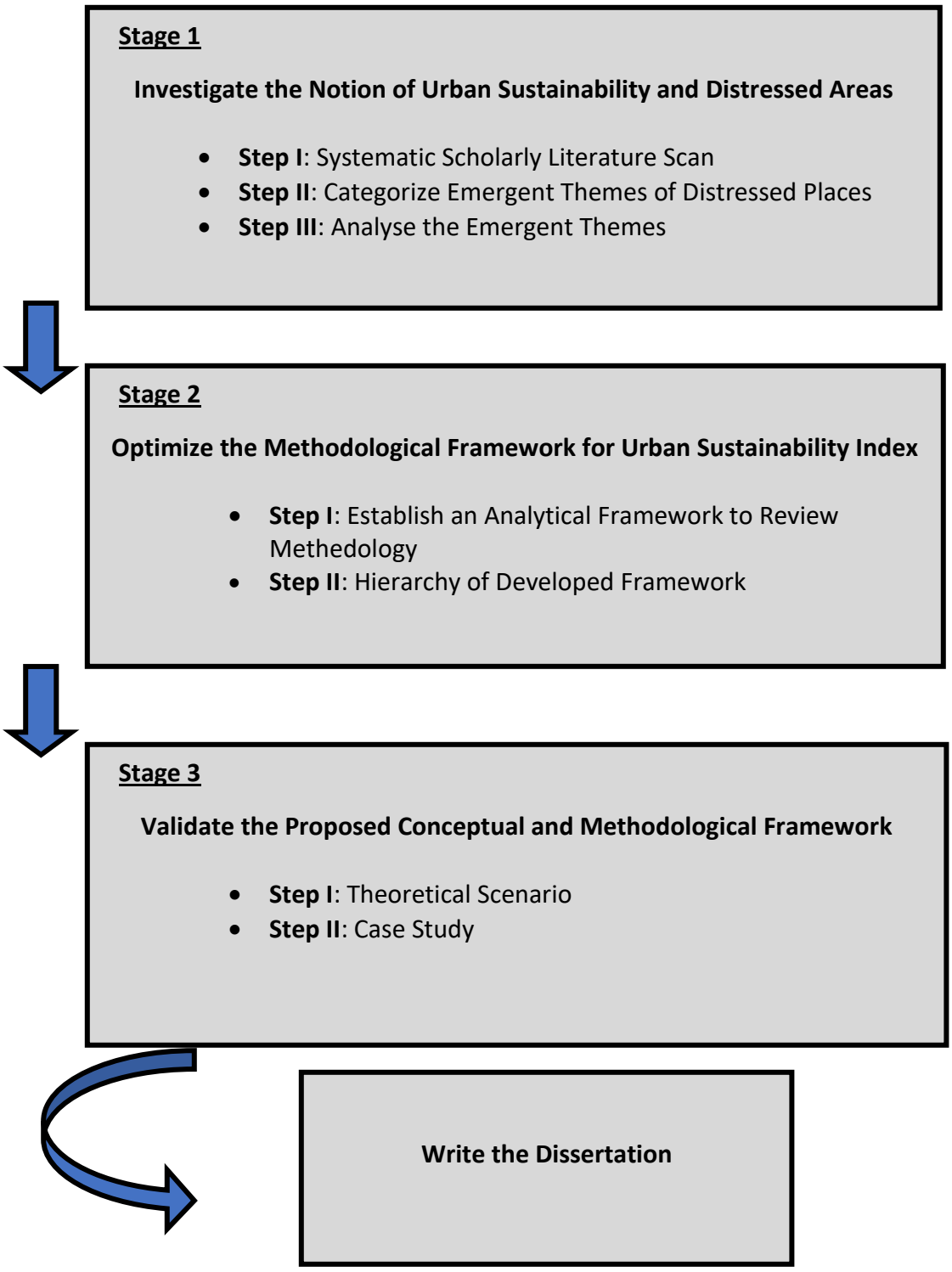
What is the conceptual and methodological framework to be employed to construct an urban sustainability index for a distressed place?

Two steps were concluded to address this research question as follows:

- Step one: Establish an Analytical Framework to Review State – of – Art in Methodology
- Step two: Hierarchy of the Developed Conceptual and Methodological Framework

Lastly, to delineate and validate the usage of the proposed conceptual and methodological framework to construct the USI mentioned in stage two, the researcher used a theoretical scenario and a case study as the third stage of this study, reinforcing the findings of the previous stage. While the theoretical scenario is for a generic distressed place called "X", Duhok City is the researcher's empirical case study. Figure 1 illustrates a visual overview of the methodological steps and stages. More details about the approaches and methodologies used in each stage and step will be provided in Chapter Four – the methodology.

Figure 1: The Framework of Research Design and the Methodology



1.6 Contents of Dissertation

This dissertation is composed of five chapters. Chapter One Introduced the motivation for the research and outlined the agenda employed to answer research questions. Brief details about the remaining chapters follow:

- ***Chapter Two: Literature Review***

Chapter Two provides a theoretical foundation of the concept of SD in general and urban sustainability in particular. It gives a broad overview of the use of SI and Indices and their role in drawing sustainable urban policies. Furthermore, the chapter sheds light on the kinds of sustainability the body of urban studies has been arguing. This chapter helps the researcher broadly frame what is essential to consider when investigating SI and USIs. The knowledge it provides helped the researcher design the methodology and approach to conducting this study that will mainly be presented in Chapter Four.

- ***Chapter Three: The Notion of Distressed Places and Communities in Urbanized World***

This chapter reflects the first set of findings of this study. It provides definitions of distressed urban areas from a holistic and comprehensive viewpoint. Additionally, it clarifies such places' landscape - what the characteristics and factors should exist to identify a place as distressed. This chapter is the fruit of the first three research questions investigated. It includes a systematic review of distressed urban areas and all their types that align with the urban sustainability pillars – environmental, economic, and social.

- ***Chapter Four: Research Design and Methodology***

Chapter four provides in-depth details about how the researcher conducted this study. In this regard, this chapter explicitly explains how the researcher addressed and investigated the research questions and reached its objectives and goals. The chapter has listed the stages, steps, and even sub-steps the researcher adopted, followed, and designed.

- ***Chapter Five: Assessing Urban Sustainability for Distressed Urban Areas: The City of Duhok as a Case Study***

This chapter presents the case study to validate and examine the proposed conceptual and methodological framework mentioned in Chapter Four. The study used the city of Duhok in Iraq, one of the Kurdistan Region's (KR) main cities, which has experienced stress associated with rapid urbanization and growth, and geopolitical issues. Besides, the city is in a region that has consistently experienced social conflicts and wars. As such, Duhok City represents an ideal candidate to be considered as a distressed city (see (A. O. Mohammed, 2013; Munoz & Shanks, 2019a; Omer, 2016) for more details). The researcher developed an adaptable framework of indicators to assess and measure urban sustainability for the city after Kurdistan Region declares autonomy in 1991 until 2010. The case study highlights nine USIs, from a total of 39 indicators, which played an essential role in navigating the urban sustainability path in the city and how they can be used to promote future sustainable practices.

- ***Chapter Six: Results and Discussion***

Chapter six addresses the essential research questions presented in Chapters One and Four. It covers the results and discussion drawn from both the case study of Duhok City and the

systematic literature review done in Chapter three. The chapter also provides a comprehensive discussion of the notion of urban sustainability for distressed urban areas. Specifically, this chapter gives evidence whether the urban sustainability Index being used and the conceptual and methodological framework behind it is holistic, reliable, and valid to be used in any distressed place.

- ***Chapter Seven: Recommendations and Conclusion***

Chapter seven concludes this study with recommendations for the next steps and potential research to enhance our understanding of urban sustainability in distressed places continually. Furthermore, this chapter highlights the key factors affecting the pattern of urban sustainability in Duhok City and how to promote sustainable future practices. Ultimately, the researcher provides a few inevitable limitations and challenges that affected this research.

1.7 Summary

In summary, this dissertation aims to investigate the notion of distressed places and communities in the urbanized world. Furthermore, it proposes a conceptual and methodological framework to develop a USI for the contexts in question. The USIs for distressed urban areas developed herein will shed light on unique urban phenomena for which the body of urban studies does not provide much knowledge.

This dissertation focuses on advancing our understanding of all kinds of distressed urban areas in the urbanized world, identifying the factors to recognize distressed places from others, and designing a methodological and conceptual framework of USI to determine the urban policy

implications that will accelerate urban sustainability progress. To achieves these goals, this research has three broad objectives as follows.

Objective one: Advancing the Knowledge of Distressed Urban Areas

Three primary research questions were proposed to investigate all kinds of distressed urban areas in the urbanized world and identify factors that distinguish distressed places from others:

1) *What is the definition of a distressed place?*
2) *What are the characteristics of distressed places?*
3) *To what extent can a taxonomy be created of distressed places?*

To address these questions, this study used a content analysis methodology supported by the Systematic Reviews and Meta-Analyses (PRISMA) flowchart (Liberati et al., 2009).

Objective Two: Understanding the Process of Constructing a USI for Distressed Urban Areas

In order to advance our understanding of the methods of selecting urban sustainability indicators to monitor and observe urban sustainability progress for distressed places, this dissertation sought to address the following question:

What is the methodological framework to be employed to construct an urban sustainability index for a distressed place?

The researcher used a participatory, systematic, holistic, multi-criteria analysis and integrated approach to developing a conceptual and methodological framework to construct a USI mainly designed for distressed urban areas. Furthermore, a theoretical implementation and a case study were applied to validate the proposed framework. The theoretical scenario was for

a generic distressed place called X. This scenario provides a step-by-step theoretical guide and foundation on constructing a USI for the context in question.

Objective Three: Implementing a Case Study to Validate the Results in Objective Two

A case study was used for Duhok City, one of the Kurdistan Region's cities in northern Iraq. Duhok's case study offers a practical example of USI's use in a distressed region that experiences rapid urbanization and growth, geopolitical dilemmas, and socio-economic issues. In general, the application of Duhok's case study reiterates the main contribution of this research study as the application of USIs to distressed areas and the methods used for SIs revisions.

Chapter 2: Literature Review[2]

This chapter provides a theoretical foundation for the evolution of the concept of SD in general and urban sustainability in particular. It provides a broad overview of the use of SIs and USIs and their role in creating sustainable urban policies. The chapter also sheds light on the kinds of sustainability the body of urban studies provides. In this spirit, this chapter reviews the generations of USIs and the calls for building a better urban sustainability framework. As such, challenges and opportunities are addressed to guide the researcher in investigating the following chapters further.

Alongside the above, this chapter frames what is essential to consider when investigating SIs and USIs. The foundational knowledge it provides supports the resulting conceptual advances and informs the methodology and approach to conducting the study presented in Chapter Three.

2.1 Theoretical Background of Sustainable Development

To begin with, the origin of the SD concept can be traced back to far before the birth of the term (Stearns & Almeida, 2004). As Choi (2010) mentions, from the 1960s to 1970s many industrialized countries enacted national environmental laws (e.g., the National Environmental Protection Act, 1969 in US) and established environmental institutions (e.g., Environmental Protection Agency, 1970 in US) to address the impact of industrialization. Then in 1972, the United Nations (UN) Conference on the Human Environment - Stockholm Conference was held

[2] The following chapter contains material reproduced from an article published in the journal Sustainability with the citation: Hassan, A.; Kotval-K, Z. A Framework for Measuring Urban Sustainability in an Emerging Region: The City of Duhok as a Case Study. *Sustainability* **2019**, *11*, 5402.

to respond to the global impact of economic growth on the environment (Dresner, 2008). After that point, the term SD was discussed among various disciplines but became a significant part of the environmentalist lexicon (Dresner, 2008). However, the meaning of SD began to change due to the realization of the matter of disorganized environmental conventions and the fact that the World Convention Strategy failed in integrating economics with the environment (Choi, 2010; Dresner, 2008; Stearns & Almeida, 2004). The real transformation into the contemporary discourse of SD was accomplished when the report entitled Our Common Future (also called the Brundtland Report) was published in 1987 by the World Commission on Environment and Development (WCED) and the former Prime Minister of Norway, Gro Harlen Brundtland (Brundtland, 1987; Dresner, 2008). That report defines SD as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987, p.43).

According to this definition, SD has three essential components called the Triple Bottom Line (TBL) (OECD, 2001; Waas et al., 2014; Yigitcanlar, Dur, & Dizdaroglu, 2015) that comprise:

1) The environmental, including the protection of ecosystems and natural resources;
2) The economic, including economic vitality and growth; and
3) The sociocultural equity, including issues of equity and social well-being

The Brundtland Report produces three primary dimensions which Holden, Linnerud, and Banister (2014, p.131) listed as follows:

1) Safeguarding long-term ecological sustainability;
2) Satisfying basic human needs; and,

3) Promoting intergeneration and intergenerational equity

These three SD dimensions are “fundamental objective values, not subjective individual preferences.” (Daly 2008, p.47). As a result of these developments, SD experienced a significant research milestone and enhanced its key concepts. In addition, ongoing summits and conferences have taken place to seek advanced sustainability goals, action plans, and implementation. All of them sought a long-term commitment to take actions and measures to make SD a reality (Dresner, 2008; P. W. G. Newman, 1999; Vojnovic, 2014). Huang, Wu, and Yan (2015) listed the widely recognized milestone in sustainability research.

As mentioned earlier, in 1972 and 1987, the international community met at a United Nations conference where global and environmental challenges were discussed and a broad SD definition and guide for the global community were offered. Then, in 1992, the Rio Earth Summit called for developing SIs for designing better sustainable policies and adopted the Rio Declaration and Agenda 21 (Pelling, 2008). More importantly, it was the Rio summit that asserted the notion that moving toward sustainability can only occur with community-based approaches that take local cultures seriously (P. W. G. Newman, 1999). Consequently, ever since that summit, the concept of SD has exerted significant influence on policy and planning at the local level (S.-L. Huang, Wong, & Chen, 1998).

Following the Rio summit, The World Summit on Sustainable Development (WSSD) – 2002, also called the Johannesburg Declaration, was held. The primary objectives of WSSD – 2000 were to draft strategies for a more significant and more effective implementation of Agenda 21 (Hens & Nath, 2003). Most of the attendees were concerned with why such insignificant

progress had been made toward achieving the Rio goals of SD and indicated both environmental quality and sustainability have further deteriorated since the Rio Summit of 1992 (Hens & Nath, 2003). La Viña, Hoff, and DeRose (2003) mentioned in their article in which WSSD – 2000 outcomes were analyzed that a troubling common narrative was shared by various attendees (9101 delegates from 191 governments and 8227 representatives of major groups) as

> a world community confronted with immense poverty and serious environmental problems, struggling to find common solutions in pursuit of sustainable development; of governments divided by competing visions of development and globalization, and paralyzed by lack of political will; and of civil society, including indigenous peoples and local communities, asserting their right to participate meaningfully in environmental and development decisions, increasingly holding governments accountable for the consequences of such decisions, and implementing sustainable development on the ground, with or without official sanction (La Viña et al., 2003, p. 54).

In the face of insufficient actions 20 years after the Rio Declaration and Agenda 21, world leaders met in 2012 at the Rio +20 Earth Summit in an effort to advance SD (Haines, Alleyne, Kickbusch, & Dora, 2012). Haines et al. (2012) mentioned that Rio +20 reaffirmed the vision of the 1992 Earth Summit's contention that "Human beings are at the center of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature." (Kovar 1993, p.124). As a result, its major outcomes resulted in declaring the urgent need for comprehensive practical measures (SIs) for implementing SD (Biermann, 2013). In

2015, another significant step happened. World leaders agreed on 17 Sustainable Development Goals (SDGs) to be achieved by 2030. These SDGs (see Figure 2) came into force on January 1, 2016 (Janoušková, Hák, & Moldan, 2018). The 17 SDGs goals cover comprehensive aspects of sustainability and are signficiant steps toward essential SD targets (Fleming, Wise, Hansen, & Sams, 2017). The 17 SDGs are as follows (adopted from Leal Filho, 2020, p. 208, based on Nations, 2015):

1) No poverty
2) Zero hunger
3) Good health and well-being
4) Quality education
5) Gender equality
6) Clean water and sanitation
7) Affordable and clean energy
8) Decent work and economic growth
9) Industry, innovation, and infrastructure
10) Reducing inequality
11) Sustainable cities and communities
12) Responsible consumption and production
13) Climate action
14) Life below water
15) Life on land
16) Peace, justice and strong institutions; and,

17) Partnerships to achieve the goals

Figure 2: Illustration of the 17 SDGs

***Source**: Adopted from (Morton, Pencheon, & Squires, 2017, p. 86)*

Although these 17 SDGs are highly ambitious initiatives, sustainability and knowledge gaps have been identified. Zimm, Sperling, and Busch (2018) asserted that even though it has been 30 years since SDGs were identified, not all have been met, nor are they interpreted holistically. The 17 SDGs influenced the Agenda 2030 through 169 targets and 232 quantifiable indicators, but these indicators are still challenging since reliable data from the UN is only available for a few indicators (Koch & Krellenberg, 2018).

Recently, heads of state and government gathered at the UN Summit in New York for the first time since the 2030 Agenda adopted in 2015. The WSDS 2019 comprehensively reviewed progress in implementing the 2030 Agenda for SD and the 17 SDGs (SDG Summit 2019). Senior

government officials from 14 cities worldwide provided their perspectives in sharing a city-specific agenda for scaling local SDGs implementation and refining high-value practices (Pipa, 2019). Although the 2030 Agenda has successfully raised awareness within stakeholders to put countries on an SD path, a growing gap between what needs to happen and what is actually being done is inevitable (Messerli, Kim, et al., 2019). In their independent Global Sustainable Development Report (GSDR), Messerli, Murniningtyas, et al (2019), argued that many SDGs are off track and that some display even negative trends, including those related to tackling climate change, inequalities, and biodiversity loss.

As such, active policies and implementations are urgently needed to facilitate SD in the next decade and stakeholders quickly must make available the best policy-relevant knowledge to guide these actions (Messerli, Kim, et al., 2019; Pipa, 2019).

2.2 Review of Urban Sustainability: Concept, Definitions, and Future Directions

Urban sustainability (sometimes also called sustainable urban development) has become a distinct subcategory of SD, and urban studies have been maintaining its conceptualization. As a result, it has become a global theme on any agenda through serious initiatives, summits, and conferences.

From a global perspective, the first conference focusing on the notion of urban sustainability through human settlements was held in Vancouver, Canada in 1976 after the 1972 UN Conference on the Human Environment (L. Huang et al., 2015). Notably, in 1972, the first definition of urban sustainability as identified by the United Nations Human Settlements Programme (UN-Habitat) stated that

> Sustainable development of human settlements combines economic development, social development, and environmental protection, with full respect for all human rights and fundamental freedoms, including the right to development, and offers a means of achieving a world of greater stability and peace, built on an ethical and spiritual vision. Democracy, respect for human rights, transparent, representative and accountable government and administration in all sectors of society, as well as effective participation by civil society, are indispensable foundations for the realization of sustainable development. (U. N. Habitat, 1996; L. Huang et al., 2015, p. 1176).

The above definition leads many scholars, such as Verma & Raghubanshi, (2018), to argue that urban sustainability works as a cross-cutting dilemma across social, economic, and environmental sustainability. The authors mentioned that all aspects of urban sustainability arise from human activities and their relation to a system's capacity. This dissertation adopts the comprehensive aspects of urban sustainability as Verma & Raghubanshi, (2018) conclude in their research. Table 1 identifies these aspects based on Anand & Sen, 2000; Black, 2004; Booth, Zipper, Loheide II, & Kucharik, 2016; Gilbert, Stevenson, Girardet, & Stren, 2013; Grytten, 2020; Longoni & Cagliano, 2015; Moldan, Janoušková, & Hák, 2012.

Table 1: Elements of Urban Sustainability

Theme	Urban Sustainability
Economic	• It should focus on human-made, natural, human, and social capital. • Resource utilization should not affect future income. • Intergenerational equity for resources. • Economic activity should consider the ecological basis • Intergenerational equity, distributional equity, optimal growth
Social	• Should address the perpetuity of social values, identities, relationships, and institutions • Common goals and social cohesion • Health, education, food, water, housing should be sustained for each individual
Environmental	• Social and economic development should have a sound environmental foundation. • Natural resource management should have high priority • Tipping points, thresholds (air, water pollution levels), sudden changes should be well understood.

***Source**: Adopted from (Verma & Raghubanshi, 2018, p. 283)*

However, ever since Rio Summit, several initiatives were launched at the local level to develop definitions and programs to infuse an urban sustainability agenda into the local government (Vojnovic, 2014). In 1991, the Sustainable Cities Project was initiated by the European Commission (Wu, 2014). Simultaneously, the United Nations Centre for Human Settlements (UNCHS) Sustainable Cities Programme attempted to define a sustainable city as

> a city where achievements in social, economic, and physical development are made to last and where there is a lasting supply of the natural resources on which its development depends" (Rakodi, Nunan, & McCallum, 2002, p. 6).

In 1992, the Rio Summit declared 27 principles to guide the global pursuit of advanced sustainability by adopting Agenda 21 as an action plan (United Nations, 2013). As such, crucial roles were given to more than 2000 municipalities to implement agenda 21 (United Nations,

2013; Vojnovic, 2014). In this regard, in 1995, the European Environment Agency adopted five urban sustainability goals (Stanners & Bourdeau, 1995; Wu, 2010):

1) Minimizing the consumption of space and natural resources;
2) Rationalizing and efficiently managing urban flows;
3) Protecting the health of the urban population;
4) Ensuring equal access to resources and services; and
5) Maintaining cultural and social diversity.

Subsequently, in 1996, the second UN-Habitat (Habitat II) declared its first holistic definition and program that focused on developing an international consensus for pursuing advanced urban sustainability (U. N. Habitat, 1996; L. Huang et al., 2015; Vojnovic, 2014). Simultaneously, the European Commission published its report in 1996 (Vojnovic, 2014; Wu, 2010, 2014). As a result, achieving urban sustainability has mushroomed across the globe at different goals and emphases (Vojnovic, 2014). However, it emerges with enormous challenges.

Since the definition of urban sustainability has always been driven by Brundtland's definition, which is still ambiguous and extremely broad, many interpretations can be found in the literature on sustainability (Janoušková et al., 2018; Mori & Christodoulou, 2012). However, most urban sustainability definitions are particularly focused on improving long-term human well-being. L. Huang et al., (2015) mentioned that this could be achieved through

1) Balancing the three dimensions of urban sustainability: environment, social, and economical;
2) Minimizing natural resources consumption, which leads to environmental damage; and,

3) Ensuring equity and democracy.

Hardoy & Satterthwaite (1991) and Vojnovic (2014) pointed out that over eighty different definitions of sustainability were already in sustainability literature after a decade of announcing Brundtland's definition. This, besides a wide range of practices and implementations, leads to confusion regarding monitoring urban sustainability as measures inherently rely on the way sustainability is defined (Seabrooke, Yeung, Ma, & Li, 2004; Shen et al., 2011).

The concept of sustainable cities and their links with SD have been discussed since the early 1990s (UN, 2013). The general mainstream focused on the idea that sustainable cities should meet their "inhabitants' development needs without imposing unsustainable demands on local or global natural resources and systems" (Satterthwaite, 1992, p. 3). For instance, the United Nations Centre for Human Settlements (UNCHS) Sustainable Cities Programme (SCP) attempted to define a sustainable city as ''a city where achievements in social, economic, and physical development are made to last and where there is a lasting supply of the natural resources on which its development depends.'' (UN, 2013, p. 61).

At the same time, however, Rees (1992) argued that this definition was still general and neglected the core notion of a sustainable city - a city whose ecological footprint must be reduced into future generations. In contrast, local community-based efforts tend to put more emphasis on the participation of urban citizens. Munier's definition (2007) backed this notion that a sustainable city is "one in which the community has agreed on a set of sustainability

principles and has further agreed to pursue their attainment'' (Munier, 2007, p. 43; J. Zhao, 2011, p. 2).

In spite of the above, recent overall definitions of urban sustainability concentration have shifted toward seeking more well-being fulfillment. Specifically, the mainstream of urban sustainability for the 21st century asserts that we must "think global, act local" (Vojnovic, 2012). This new emphasis is the product of comprehensive reports produced from the summits mentioned earlier which showed significant inks between local actions and global interests in pursuing more advanced urban sustainability (Vojnovic, 2014).

According to L. Huang et al (2015) and Wu (2010), the enhancement of deep-rooted human well-being could be achieved by strengthening the coherence of the TBL of Sustainability. This can be fulfilled through the following:

1) Sufficiently reducing the consumption of natural resources and environmental damage;
2) Ensuring democracy and equity between inter/intergeneration; and,
3) Maximizing resource use efficiency.

Vojnovic (2014) mentioned that the conceptualization of urban sustainability based on city culture, values, and unique urban stress is the recent trend urban sustainability studies seem to focus on. Specifically, the recent goals of urban sustainability have shifted toward maintaining the mechanism of human well-being and ecosystem services (Elmqvist et al., 2013; L. Huang et al., 2015; Nassauer, Wu, & Xiang, 2014; Wu, 2010, 2014). In other words, the recent mainstream of urban sustainability focuses on the interchangeable relationship between well-being and total capitals; sustainability and well-being increase as the total capital of the system increase

(Wilson & Wu, 2017). Thus, a growing number of urban sustainability studies have focused on the interrelationship between ecological service and human well-being (Elmqvist et al., 2013; L. Huang et al., 2015; Nassauer et al., 2014; Wu, 2010).

This new trend was embraced by Wu (2014) when they argued that the relationship between ecosystem services and society is an essential component of urban sustainability, which means the ecosystem would not be a service without acknowledging the importance to human well-being. In this regard, they defined urban sustainability as ‘‘an adaptive process of facilitating and maintaining a virtual cycle between ecosystem services and human well-being through concerted ecological, economic, and social actions in response to changes within and beyond the urban landscape.’’ (Wu, 2014, p. 213). For example, Zhao et al (2009) also showed that a sustainable city maintained sustainable welfare for its inhabitants with the capacity to maintain and enhance its ecosystem services. They asserted that “a sustainable city requires that a city provides its residents with sustainable welfare, i.e., the total amount of welfare befit and per-capita welfare will not decrease as time goes by.” (J. Z. Zhao et al., 2009, p. 2).

Despite these breakthrough trends, several authors found a lack of study on the relations of well-being with urban sustainability (Yarime, Takeda, & Kajikawa, 2010). To achieve the goal of maintaining the mechanism of human well-being and ecosystem service in cities, profound understanding in the urban context is desired and needed (Wilson & Wu, 2017; Wu, 2010, 2014; Yarime et al., 2010) which means much work is yet to be done.

Theories suggest that for well-being to be sustained, ecosystem services must also contribute to compatible and cohesive wellness (Bakar, Osman, Bachok, Zen, & Abdullah, 2017;

Yarime et al., 2010). That is, urban sustainability is becoming “an inevitable goal” (L. Huang et al., 2015; Wu, 2010, 2014). As a result, as cities have grown and become more urbanized, they play an increasingly vital role in meeting the goals of urban sustainability (Dresner, 2008; Munier, 2007).

In addition to all the above, Mcgranahan & Satterthwaite (2002) argued that that low-income population, due to limited industries and low resources consumption, have the least transfer of environmental burden. The study showed that wealthy cities, mainly aggregated in the developed world, maintain a high level of environmental burdens, unlike the low-income cities. In other words, the environmental burden on cities that SD and urban sustainability have been striving for decades to reduce is shifting over time.

Cities have changed dramatically over the centuries. Current cities are the hub of social, economic, and technological innovations, which generate unprecedented environmental and socio-economic burdens (Vojnovic, 2014). As a result, an emerging urban sustainability paradigm with the ultimate goal of sustaining cities cannot be achieved by any traditional disciple and approach alone (Wu, 2014). Therefore, this dissertation presents the evolution of urban sustainability and the milestone of developing a sense of it and the various ways of its interpretation. In Table 2, definitions and goals of urban sustainability have been stated based on the literature review analysis. The table shows that the notion of urban sustainability has been shifted from just maintaining an ecosystem to promoting democracy and improving well-being.

Table 2: Evolution of Urban Sustainability Definition

Definition	Year	Goals	Source
"A sustainable city is a city where achievements in social, economic, and physical development are made to last and where there is a lasting supply of the natural resources on which its development depends."	1997	Maintains lasting security from environmental hazards that may threaten development achievements by allowing only for acceptable risk.	(UN, 2013, p. 61)
"Sustainable urban development may be defined as a process of synergetic integration and co-evolution among the great subsystems making up a city (economic, social, physical and environmental), which guarantees the local population a non-decreasing level of well-being in the long term, without compromising the possibilities of development of surrounding areas and contributing by this towards reducing the harmful effects of development on the biosphere.''	1998	Maintains the ecosystem by reducing the harmlessness of rapid development.	(Camagni, 1998, p. 1)
"A sustainable city is one which succeeds in balancing economic, environmental and socio-cultural progress through processes of active citizen participation."	1998	Creating a homogeneous relationship among the TBL.	(Mega & Pedersen, 1998, p. 2)
Urban sustainability is ''the process of developing a built environment that meets people's needs whilst avoiding unacceptable social or environmental impacts.''	2002	Reducing social and environmental impact by sustained built environment.	(Hamilton, Mitchell, & Yli-Karjanmaa, 2002, p. 109)

Table 2 (cont'd)

Definition	Year	Goals	Source
"A sustainable city is one in which the community has agreed on a set of sustainability principles and has further agreed to pursue their attainment. These principles should provide the citizenry with a good quality of life, in a livable city, with affordable education, healthcare, housing, and transportation."	2006	Promote democracy and affordability.	(Munier, 2007, p. 43; J. Zhao, 2011, p. 2)
"A city moving toward sustainability improves public health and well-being, lowers its environmental impacts, increasingly recycles its materials, and uses energy with growing efficiency."	2007	Human well-being that lowers the environmental impacts.	(Starke, 2007, p. 6)
"A sustainable city is one that can provide and ensure sustainable welfare for its residents with the capacity of maintaining and improving its ecosystem services."	2011	Improving ecosystem and well-being.	(J. Zhao, 2011, p. 2)
Urban sustainability is ''an adaptive process of facilitating and maintaining a virtual cycle between ecosystem services and human well-being through concerted".	2014	Improving ecosystem and well-being.	(Wu, 2014, p. 213)
"*ecosystems which are ethical*, *effective* (*healthy and equitable*), *zero-waste*, *self-regulating*, *resilient*, *self-renewing*, *flexible*, *psychologically-fulfilling and cooperative*."	2008	Improving ecosystem and well-being.	(P. Newman & Jennings, 2008, p. 108)

Table 2 (cont'd)

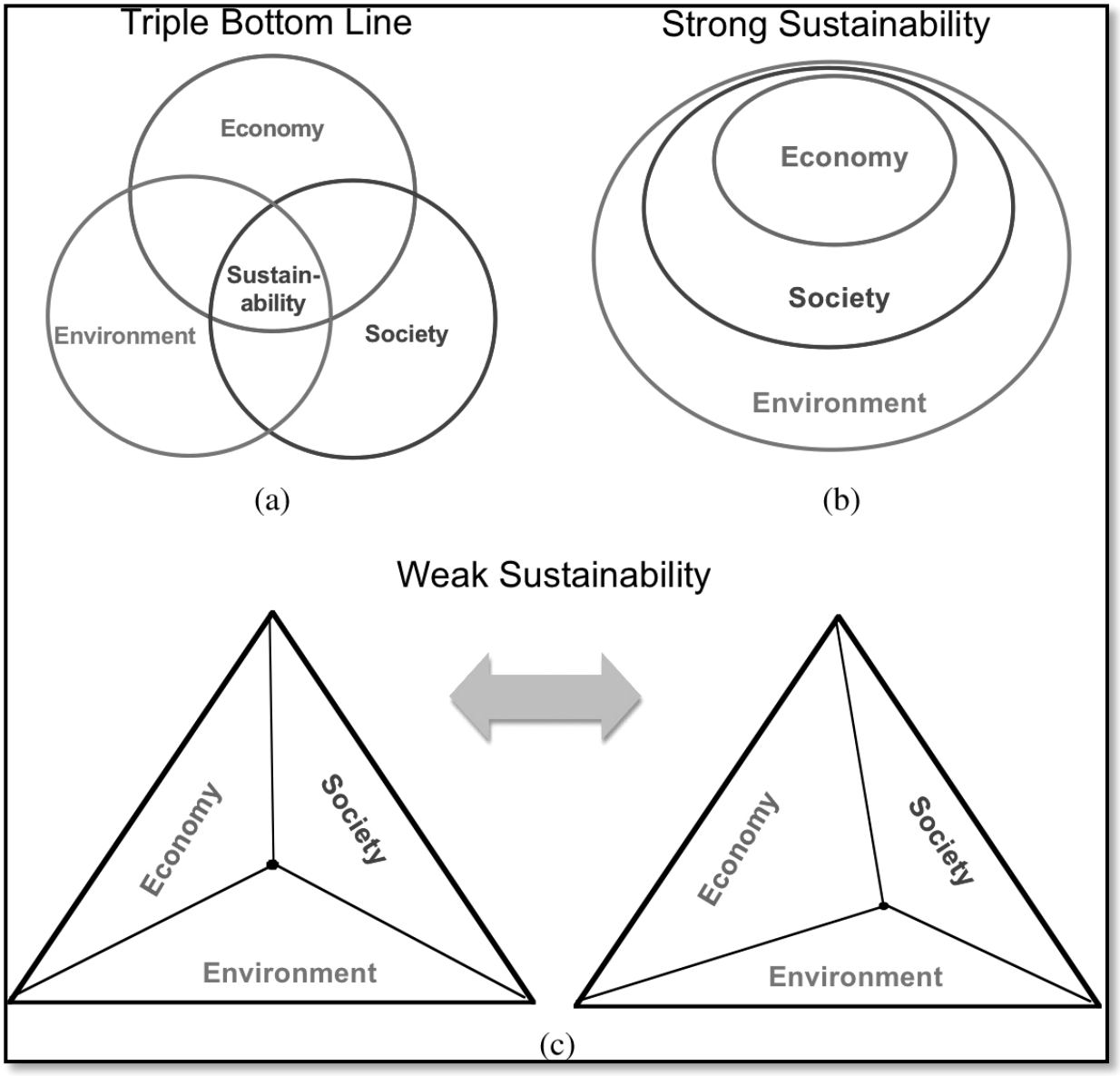
Definition	Year	Goals	Source
"Urban sustainability is the process by which measurable improvement of near- and long-term human well-being can be achieved through actions across environmental (resource consumption with environmental impact), economic (resource use efficiency and economic return), and social (social well-being and health) dimensions."	2016	Improving ecosystem and well-being.	(National Academies of Sciences and Medicine, 2016, p. 2)
"A city is enabled to achieve sustainability by using two important methods, which the Urban Sustainability Framework calls enabling dimensions: (1) good governance and integrated urban planning processes; and (2) sound management of city finances to ensure financial sustainability."	2018	Improving ecosystem and well-being.	(Wang, Salat, & Painter, 2018, p. 11)

In short, SD and urban sustainability are different concepts. Urban studies adopt SD concepts that have been interpreted through analyzing and explaining the values associated with the concept of city dynamics. Urban sustainability refers to achieving social equity, economic growth, self-efficient, and environmental protection (Kotharkar, Pallapu, & Bahadure, 2019). Urban sustainability literature has enriched action plans, policies, and implementation to seek more advanced urban sustainability. Yet, investigating the relationship between ecosystem services, society, and well-being is desirable in order to achieve a better understanding of the new version of cities and their people.

2.3 Urban Sustainability Perspective: Strong vs. Weak

The notion of weak and strong sustainability as the two main distinctive approaches and perspectives to sustainable development comes from the Brundtland Report (Heal, 2012). Specifically, when the term sustainability was coined in the early 1970s, the conflict between development (the exploitation of natural resources) and conservation (the protection of natural resources) appeared (Wu & Wu, 2012) (see Figure 3a and 3b). Although the three dimensions of sustainability (TBL) are widely recognized in sustainability research, their relationships remain controversial. On the one hand, weak sustainability (see Figure 3c) deals with maintaining a combined substitutable stock of all capitals: natural, human, and social capitals. This means natural capital has the same importance as other capitals (Nourry, 2008). As a result, this approach is perfectly substitutable for natural capital and human and social capital (Ayres, van den Berrgh, & Gowdy, 2001). This means that a high level of economic development can be substituted for a low environmental quality level.

Figure 3: Key Components of Sustainability and Their Relationship



***Source**: Adopted from (Wu & Wu, 2012, p. 68)*

Nasrollahi et al. 2020 showed that, based on the weak sustainability concept, "the capital stock as a whole should be maintained on aggregate; the more the natural capitals plunge, the more the economic dimension rises" (Nasrollahi et al., 2020, p. 1108). This means the interaction among the sustainability dimensions (TBL) should be treated in a holistic manner,

which in turn assumes that they are interdependent, equally significant, and share equal importance (Cato, 2009; Nasrollahi et al., 2020). A good example of weak sustainability indices can be found in the City Development Index (UNCHS, 2001), the Human Development Index (UNDP, 2005), and Prescott and Allen's well-being Index (Prescott-Allen, 2001).

As seen above, strong sustainability (see Figure 3b) does not allow substitution among capitals. It gives an important position to natural capital, which is non-substitutable as any conversion of natural capital to other forms is unacceptable (Mori & Christodoulou, 2012; Nourry, 2008; Wilson & Wu, 2017). This will lead us to rely on the notion that a high economic development level cannot be replaced by a low level of environmental quality. As Nasrollahi et al. (2020) mentioned in their paper, strong sustainability is profoundly connected to the idea that natural capital cannot be replicated. For example, natural habitat, the ozone layer, or coral reefs cannot be replaced by GDP growth (Nasrollahi et al., 2020).

It can be seen that if overall capital does not decline as a result of conserving natural and ecosystem stocks, strong sustainability is achieved (Ayres et al., 2001; Pearce, Atkinson, & Dubourg, 1994). However, sustainability and well-being increase as the system's total capital (such as a city) increases (Pearce et al., 1994). In other words, "economy operates within the society which itself is embedded inside the environment" (Nasrollahi et al., 2020, p. 1110). As a result, it can be said that cities, as a product of economic operations with society, negatively impact environmental capital (Mori & Christodoulou, 2012). Examples of indices by which strong sustainability has been assessed and monitored can be found in Ecological Footprint (Wackernagel & Rees, 1997), Green City Index (Shields et al., 2009), and Environmental Performance Index (Esty et al., 2008).

The bottom line here is that in order to analyze a system (which in this dissertation is a distressed city), we have to explicitly determine what aspect of sustainability we want to measure, which leads us to acknowledge which dimensions we aim to develop or conserve over time. As for weak sustainability, its purpose is to increase the stock of total capital and in that setting ecological systems are non-substitutable (Mori & Christodoulou, 2012; Wilson & Wu, 2017). Therefore, as a result, it can be said that measuring strong sustainability in an urban context can be complicated because of the actual lack of specific natural capital forms within an urban area's boundaries. Nonetheless, it is still crucial to consider natural capital in measuring sustainability (Wilson & Wu, 2017).

2.4 Sustainability Assessment and Indicators: Concepts and Types

Sustainability assessment tools have been mushrooming through the development of research on sustainability. They are being absorbed into the necessary policies that respond to urgent conditions and bridge past and present plans for future development goals (Hardi & Canada, 1997; Yigitcanlar et al., 2015). Waas et al. (2014) make it clear that sustainability assessment is any process that aims to:

1) Contribute to a better understanding of the meaning of sustainability and its contextual interpretation (interpretation challenge);
2) Integrate sustainability issues into decision-making by identifying and assessing (past and/or future) sustainability impacts (information-structuring challenge);
3) Foster sustainability objectives (influence challenge).

Based on this researcher's literature review, fourteen SD assessment systems widely used in the policy debate were identified. Table 3 provides the system, purpose, and type of sustainability each measures. These sustainability assessments were reviewed from many various sources from the litretaure review.

Table 3: Summary of Sustainability Indices

System	Indicator Type	Sustainability Perspective/TBL	Developer & Publication year	Reference
Ecological Footprint	Composite Indicator	Strong/ Environmental and social	Wackernagel and Rees 1992	(Wackernagel & Rees, 1997)
Living Planet Index	Composite Indicator	Strong / Environment	World Wildlife Fund 1998	(World Wildlife Fund, 1998)
Green City Index	Composite Indicator	Strong/ 3 TBL	Economic Intelligence Unit and Siemens 2009	(Unit, 2009)
Environmental Sustainability Index	Composite Indicator	Strong/ Environmental and social	Yale University and Columbia University 2005	(Esty, Levy, Srebotnjak, & De Sherbinin, 2005)
Environmental Performance Index	Composite Indicator	Strong/ Environment	Yale University and Columbia University 2006	(Esty et al., 2008)
City Development Index	Composite Indicator	Weak/ 3 TBL	UN-Habitat 1997	(UNCHS, 2001)
Genuine Progress Indicator	Composite Indicator	Weak/ Economic	World Bank 1994	(Lawn, 2003)
Genuine Savings Index	Composite Indicator	Weak/ Economic	World Bank 1999	(Atkinson, Hamilton, & Pearce, 1997)

Table 3 (cont'd)

System	Indicator Type	Sustainability Perspective/TBL	Developer & Publication year	Reference
Human Development Index	Composite Indicator	Weak/ Economic and social	UNDP 1990	(UNDP, 2005)
Happy Planet Index	Composite Indicator	Weak/ Environmental and Economic	New Economics Foundation 2006	("Happy Planet Index," n.d.)
Well-being Index	Composite Indicator	Weak/ 3 TBL	IUCN and International Development Research Centre 2001	(Prescott-Allen, 2001)
Sustainable Society Index	Composite Indicator	Either Strong or weak/ 3 TBL	Sustainable Society Foundation 2006	("Sustainable Society Index," n.d.)
Pressure-State-Response framework	Indicator Sets	Either weak or strong/ 3 TBL	Organization for Economic Cooperation and Development	(OECD, 1993)
Theme Framework	Indicator Sets	Weak/ 3 TBL	United Nations Commission on Sustainable Development	(United, 2007)

This literature review showed that each system developed for heterogeneous missions and conceptual frameworks. In addition, there is no global agreement on which system is better or which one is favorable.

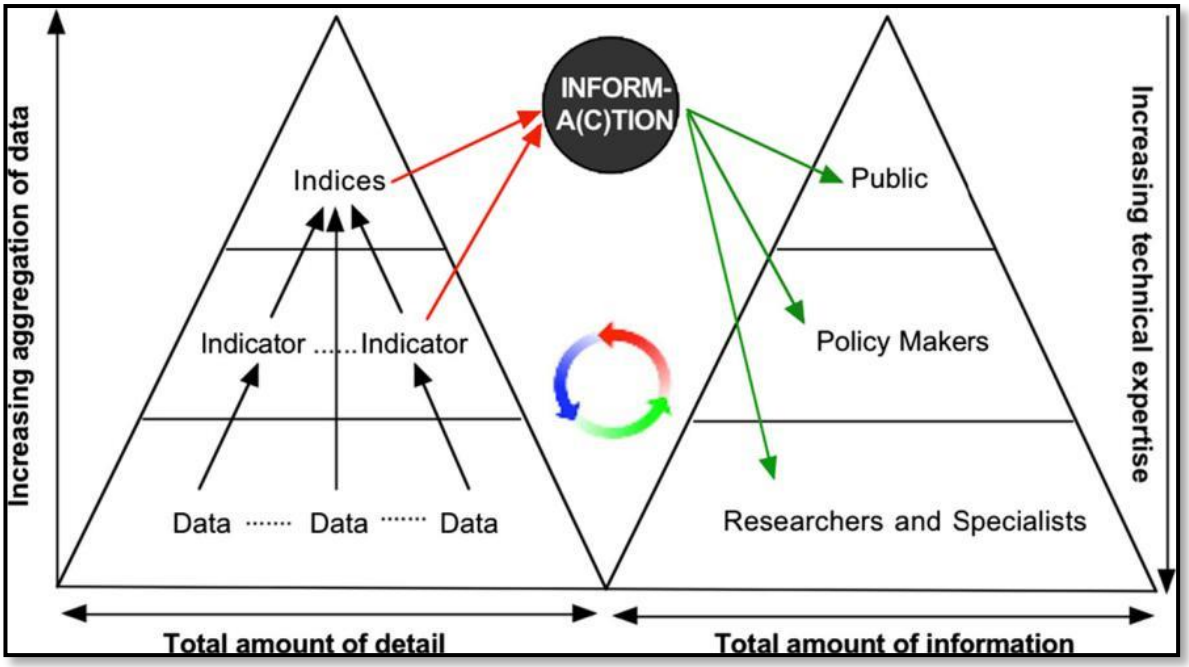
Cities are the product of their public and their institutions; thus, the public seek more efficiency for the ecosystem products, economic activators, and social well-being. One increasingly desired way to gauge the public interest is using urban sustainability indices (USIs). USIs are a mathematical way to implement public goals through TBL dimensions. Since urban systems are structured from complex components, there are multiple USIs to use among the world's cities. However, the literature on urban sustainability has successfully proposed specific USIs according to the targeted system's nature. Sustainability Indicators are a fundamental apparatus of sustainability assessment that helps to acknowledge the cutting-edge development situation and measure whether sustainability objectives are being met (Yigitcanlar et al., 2015; Yigitcanlar & Teriman, 2015).

As Gómez-Álvarez, López-Moreno, Bilsky, Ochoa, & Osorio (2018) mentioned in their paper, the SDGs emerging from the 2030 Development Agenda mark an urgent need to develop a greater amount of meaningful SIs for broader application within diverse urban settings. In this regard and for a local scale, Rodrigues & Franco (2020), in their research, mentioned that some theoretical and empirical evidence reveals the need to develop a multidimensional index that includes a mix of indicators by which a significant amount of information could be captured.

As such, SIs are crucial and increasingly needed for making decisions about the best policies and to track urban progress toward making "cities and human settlements inclusive, safe,

resilient and sustainable." (U. N. Habitat, 2015; Muhammad, 2001). To better understand the importance of SIs and their role in shaping urban policy decision, Figure 4 illustrates the reliability of sustainable urban actions on indicators and indices.

Figure 4: Relationship Between Sustainability Actions and SIs



***Source**: Adopted from (L. Huang et al., 2015, p. 1179; Wu & Wu, 2012, p. 71); the original figure was based on (Braat, 1991).*

Thus, measurable sustainability indicators are desired since city planners, managers, and policymakers employ them in the decision-making process to gauge the socio-economic and environmental impact of urban development (European Commission, 2015; Hernández-Moreno & de Hoyos-Martínez, 2010; Shen et al., 2011).

In light of the above, it becomes increasingly crucial to properly understand what is meant by the term "sustainability indicator." Fiksel et al. (2013) define a SI as "a measurable aspect of environmental, economic, or social systems that are useful for monitoring changes in system characteristics relevant to the continuation of human and environmental well-being" (Fiksel et

al., 2013, p. 6). It can measure socio-economic sustainability attributes such as equity, health, education, housing, and population, or environmental attributes such as land, biodiversity, atmosphere, and freshwater, as well as sustainability frameworks such as the Driving-force–Pressure–State–Impact–Response (DPSIR) indicator framework (Singh, Murty, Gupta, & Dikshit, 2012; Waas et al., 2014).

In the literature review done by Hiremath et al. (2013) to show the development of building sustainability indicators and indices, they stress that the purpose of SIs is "to show how well a system is working. If there is a problem, an indicator can help to determine what direction should be taken to address the issue" (Hiremath et al., 2013, p. 556). Moreover, Wu & Wu (2012), in their overview of a selection of commonly used SIs, defined SIs as "indicators that provide information on the state, dynamics, and underlying drivers of human-environmental systems." (Wu & Wu, 2012, p. 70).

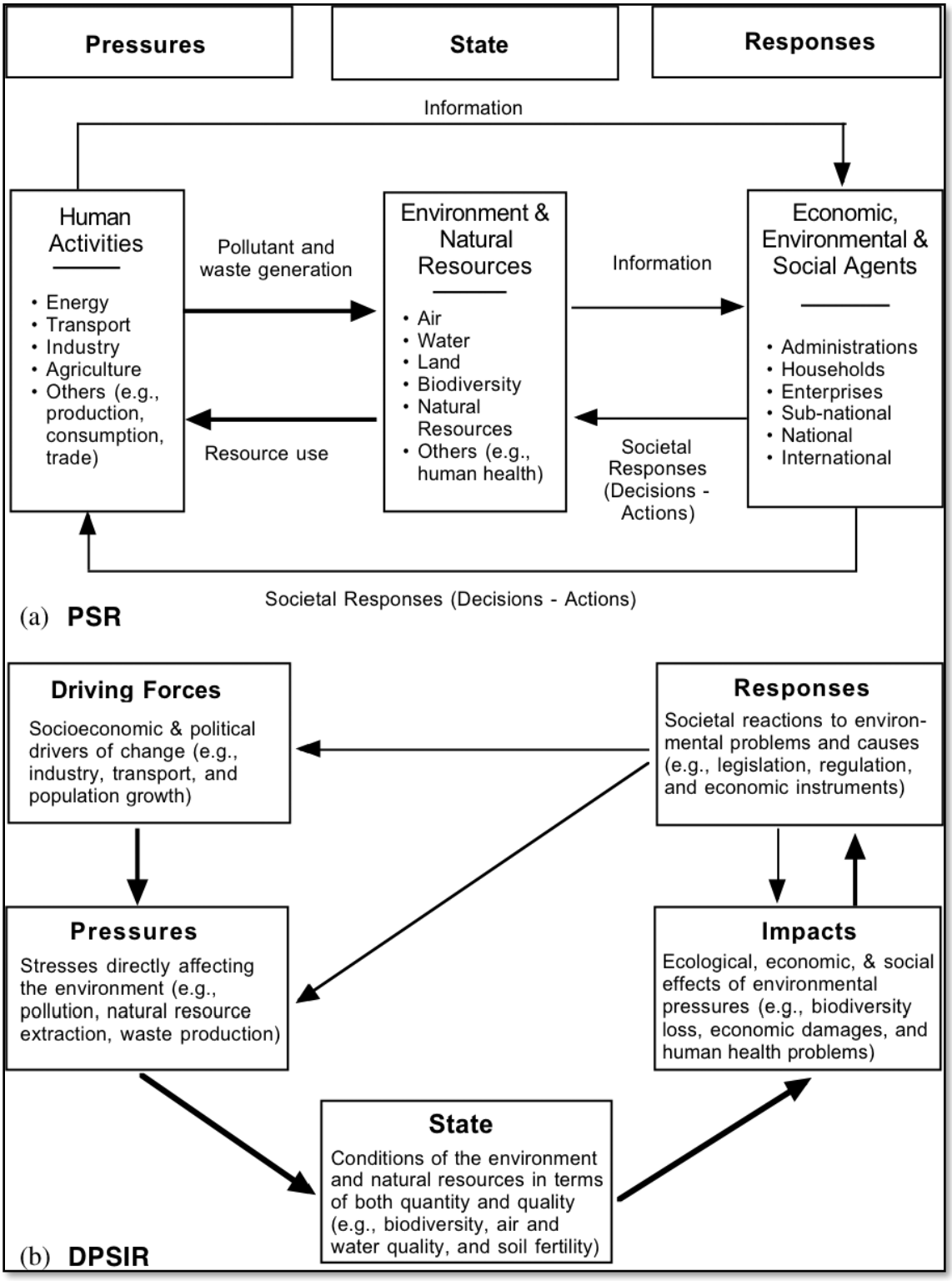
Indicators' importance is inevitable as they help policymakers and the public achieve sustainability targets and inform stakeholders about priority areas' current state (Pupphachai & Zuidema, 2017). Policymakers use SIs to differentiate what is sustainable and unsustainable as well as which results should be of top priority for them (Y.-J. Lee & Huang, 2007). While L. Huang et al. (2015) distinctly distinguished between indicators and indices, Wu et al. (2012) mentioned that " the indicators and indices are indispensable for creating scientific understanding and shaping policy" (Wu et al., 2012, p. 65). Taking things a step further, L. Huang et al. (2015) divided indicators sets into two essential types: First, indicator sets based on the Pressure-State-Response framework (PSR) and second, those sets based on the theme-oriented framework.

The usefulness of urban sustainability implementation can be judged according to the framework that sustainability goals employ. Each approach has a different level of transparency, consistency, and participation in identifying “problem situations” (Reed, Fraser, & Dougill, 2006; Riley, 2001). The PSR and the DPSIR were the most common, widely, and earliest used sustainability indicators framework (Dizdaroglu, 2017).

Figure 5 illustrates the components of each framework. Both frameworks have been designed and improved by OECD (Yigitcanlar et al., 2015). In the words of (Bradley Guy and Kibert 1998, p.41)*:*

> The pressure state response model illustrates the linkage between human activities and the environment. It describes the connections between pressures brought by human activities on the environment, the environmental states that occur, and the responses of society to those states. Continuous feedback results between both the environment and humans and the effects of the human elements on the decision-making processes. This is a valuable model to apply to social and economic states and, consequently, sustainability.

Figure 5: PSR & DPSIR Framework



***Source**: Adopted from (Wu and Wu 2012, p.75)*

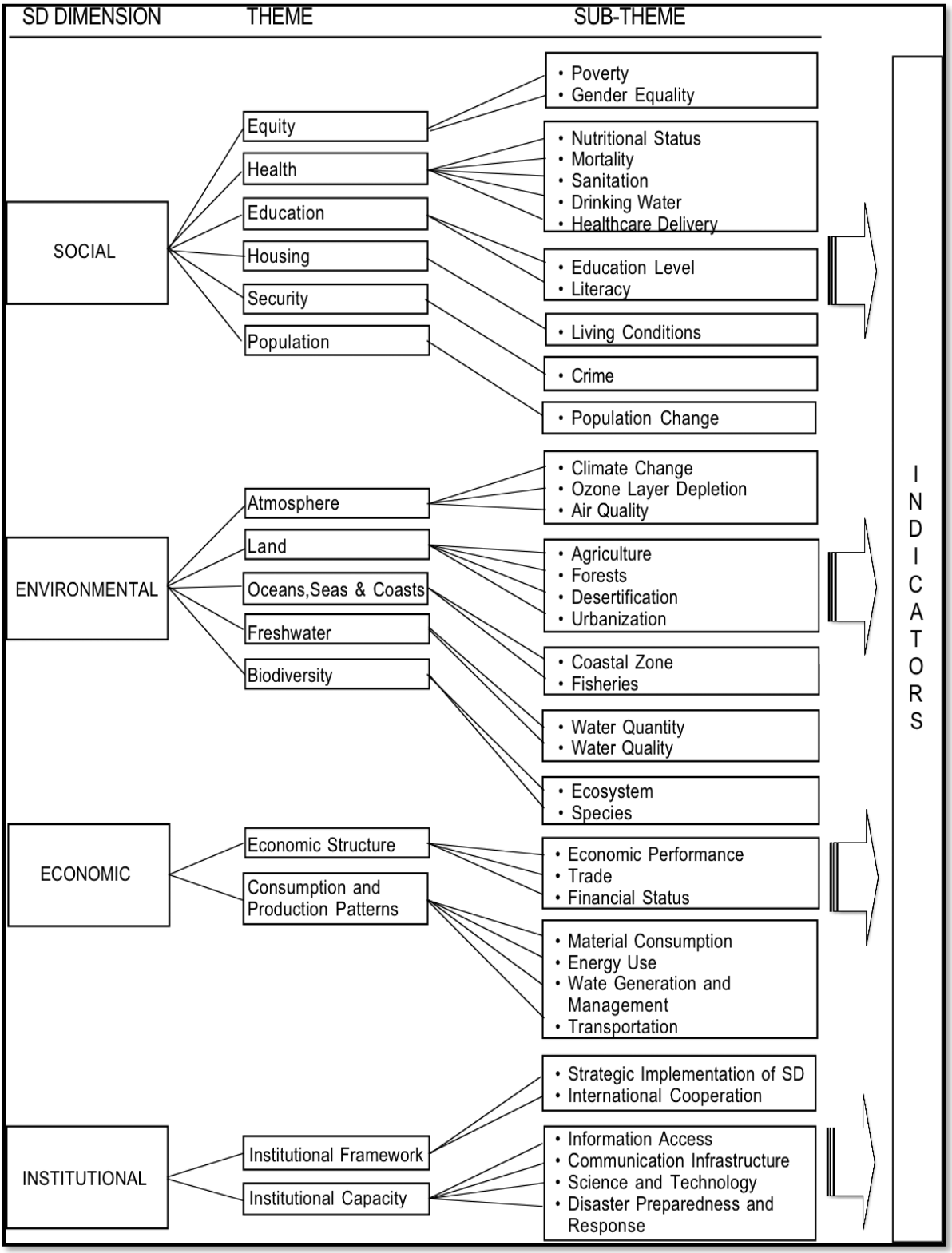
The European Environment Agency expands the notion of PSR and its more elaborated version of the DPSIR indicator framework based on the OECD's sustainability indicator framework (L. Huang et al., 2015). It is considered the most widely adopted framework to provide a holistic socio-economic and environmental analysis (Yigitcanlar et al., 2015). The PSR model is based on the cause-effect relationships between economic activities, environmental, and selected social conditions.

This framework assumes that human activities exert "pressures" on the environment and affect its quality and the quantity of natural resources ("state"); societies respond to these changes through environmental, economic, and social policies and through changes in awareness and behavior ("societal response") (DiSano, 2002). For more details about DPSIR and PSR see (Niemeijer & de Groot, 2008; Segnestam et al., 2003).

In short, "The PSR indicates the causality among factors within the human-nature system, accurately reflecting the correlation between ecological security and nature-economy-society, which laid the logical basis for the eco-security indicator system" (C. Zhao, Zhou, & Su, 2014, p. 2284). A good example of the PSR/DPSIR – based urban indicator sets can be seen in (Olewiler, 2006), and in particular systems such as Taiwan (S.-L. Huang & Chen, 2002), and the Chinese city of Mianyang (C. Zhao et al., 2014).

Although the PSR/DPSIR framework is well-respected, the theme-oriented framework is a more flexible conceptual structure that organizes indicators around critical themes (issues) according to policy relevance (L. Huang et al., 2015; Wu & Wu, 2012). As shown in Figure 6, the theme-oriented framework, unlike the PSR/DPSR framework, organized SIs around four

Figure 6: Theme-based Indicator Framework



***Source**: Adopted from (Wu and Wu 2012, p.76)*

sustainability dimensions: social, environmental, economic, and institutional. An informative example of using this framework is the United Nations Human Settlements Programme (UN-Habitat). It has established the Global Urban Indicators Database, including indicators of shelter, social development, environmental management, economic development, and governance (Un-Habitat, 2012). However, the United Nations Commission on Sustainable Development (UNCSD) has 50 core SIs incorporated within 14 themes and 44 sub-themes (Wu & Wu, 2012).

In order to develop indicator sets for assessing the sustainability of individual cities, several cities in developed and developing countries have adopted this framework (S.-L. Huang et al., 1998; Y. J. Lee & Huang, 2007; Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010). Even though indicators play an essential role in shaping urban policy and sustainability to assure the well-being of the current and future generations, too many indicators can also be misleading and confusing. To overcome this potential problem, Wu & Wu (2012) showed that combining indicators is one way to avoid confusion. They also showed that such a reduction could be accomplished by simply combining two or more indicators through mathematical manipulations. A considerable number of urban sustainability indices exist, but this dissertation focus on the most commonly used.

In sum, cities are increasingly concerned with developing sustainability assessment tools for gauging performance and progress toward urban sustainability. SIs are essential tools to pursue the trend of sustainability in cities. Developing an Indicator-Based Sustainability Assessment provides accurate information about the performance toward sustainability in an urban context. Specialists in urban sustainability are continuously collaborating with various stakeholders to

elaborate more efficient SIs in order to inform urban policymakers on implementing more sustainable plans.

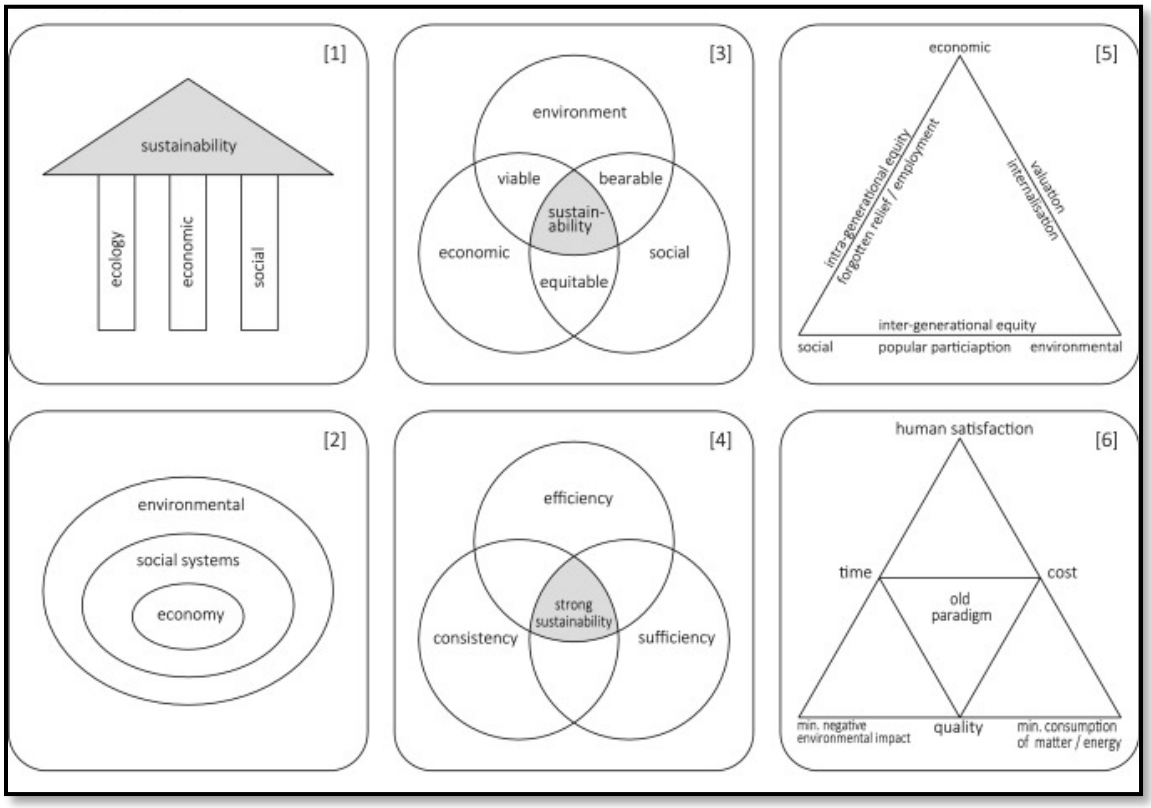
As a result, measuring urban sustainability is still the most significant challenge in implementing SD in cities where interchangeable information among social, economic, and environmental capitals is desirable (Y. J. Lee & Huang, 2007; Verma & Raghubanshi, 2018).

2.5 Exiting Sustainability Assessment Systems: Challenges and Opportunities

Through the use of sustainability frameworks, many urban sustainability scholars have been investigating to what extent cities are approaching sustainability (Hasan & Adnan, 2002; Hernández-Moreno & de Hoyos-Martínez, 2010; L. Huang et al., 2015; Karlenzig, Marquardt, White, Yaseen, & Young, 2007; Lombardi & Brandon, 2007; Parris & Kates, 2003; Riposa, 2004; Seattle, 1993; Shen et al., 2011). In terms of sustainability, this researcher has counted six schematic sustainability models from the literature in general. Figure 7 summarizes these models. Each of these has different views on how the TBL is related and interpreted.

As Ali-Toudert & Ji (2017) explored in their research, in model (1) and (5), ecology, economic, and social elements are relatively considered independently to reach others. Model (2), however, depicts a hierarchical organization where social activities are embedded in economic. The most widespread is represented in model (3) where the elements' interaction leads the sustainability goals. Model (4) relies on efficiency, sufficiency, and consistency. However, model (6) is shifted from the other models where the view focuses on human satisfaction, reduced consumption and environmental impact.

Figure 7: Review of Existing Sustainability Models from the Literature



***Source**: Adopted from (Ali-Toudert & Ji, 2017, p. 598) based on (Costanza, 1992; Neumayer, 1999)*

These sustainability models depict the complexity and diversity of how TBL is relatively related and, in turn, understood and interpreted. As such, urban sustainability is a challenge given the complexity of its TBL and involving the city as another interaction element. Consequently, several urban sustainability implementations have been applied to different global, national, regional, and local scales and levels. The scale of adopting urban sustainability implementation relies on two essential aspects:

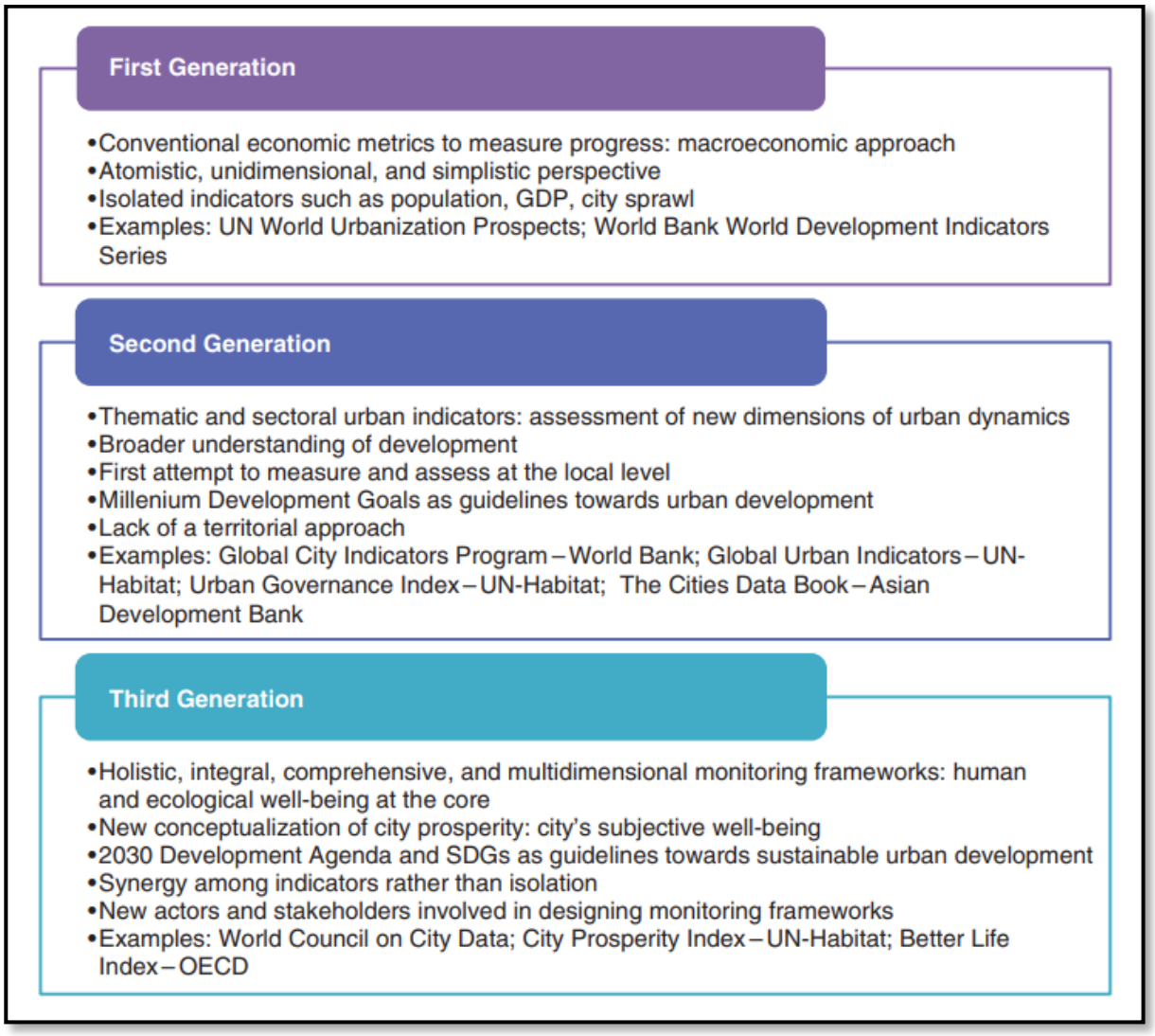
1) Stakeholders' interpretation of urban sustainability based on content; and
2) Ways to measure sustainability through implementing sustainability goals.

Global-scale usually focuses on the central theme of urban sustainability (TBL) and targets urgent common concerns and issues. Conversely, local and regional scales essentially focus on the interrelationship between the TBL and well-being and seek advanced sustainability through community-based projects.

The local and regional scale might be relevant to a multiscale project (L. Huang et al., 2015). Nevertheless, the local-level project may fail to implement what is vital to the local urban community if their policies and plans are fed by national-level interpretations of TBL (Riley, 2001). For example, the widely quoted environmental sustainability index (local scale project) has been thoroughly critiqued for ignoring local contextual issues (Reed et al., 2006). L. Huang et al. (2015) emphasizes the influence of scale and the level of urban sustainability on how TBL and well-being are related. The study mentioned that urban sustainability projects had been used mostly for cities and their community from small municipalities to large metropolises. Moreover, using a local scale provides more in-depth insights and critical information for the stakeholders in the sustainability system.

It is important to note, however, that the literature review showed that these efforts and implementations have not significantly emerged in distressed urban areas and lacked the measure in cases under such phenomena. To explore the wide range of implemented urban sustainability projects and their use of indices, a preliminary review of the literature on urban sustainability has been done. Consequently, two significant lists have been constructed. Figure 8 summarizes the evolution of urban indicators.

Figure 8: Review of Urban Indicators Evolution



***Source**: adopted from (Gómez-Álvarez et al., 2018, p. 167)*

The first list is for global projects. Those initiatives were carried out by supranational organizations such as the United Nations, UN-Habitat, the World Bank, the European Foundation, the European Commission on Science, Research and Development, the European Commission on Energy Environment and Sustainable Development (DiSano, 2002; W. B. Group, 2014; SAULE JÚNIOR & CARDOSO, 2004). Gómez-Álvarez et al. (2018) recognized these USIs as the first and second generation of urban indicators to generally address the three main

dimensions of sustainable development (TBL). Such global projects can be seen in Vision 2020 Sustainability for Canada, Proposal of sustainability System for Spanish context, and Case Study for Malaysia, China, Taiwan, and Malaysia (Braulio-Gonzalo et al., 2015; Michael, Noor, & Figueroa, 2014; Yanarella, 1999). All these sustainability assessments targeted the global and national levels and concerns in an urban setting.

The second list is a local urban sustainability implementation. These local urban sustainability projects were found in Mexico City's Green Plan, Melbourne's City Plan 2010, The Hong Kong 2030 Study, Green Plan for Mexico City, Singapore Green Plan, City Development Plan of Chandigarh and Pune, Taipei's Urban Sustainability, Sustainable Seattle Indicators Project, and Central Texas Sustainability Indicators Project, and the case of Portugal an example of using a composite Index (M. Holden, 2006; S. L. Huang, Wong, & Chen, 1998; Miller, 2005; Rodrigues & Franco, 2020; Shen et al., 2011).

These types of USIs were a turning point for communities focused on a more people-centered approach to meet their local needs rather than national needs. They were identified by Gómez-Álvarez et al. (2018) as the third generation of urban indicators emphasizing the "emergence and immersion of new actors and stakeholders in the difficult task of designing and developing innovative, holistic, and integral sets of indicators to measure and assess urban dynamics." (Gómez-Álvarez et al., 2018, p. 171).

A preliminary analysis of the literature review showed that the level of political influence had a tangible impact on the interpretation of urban sustainability goals and objectives. In fact there is a distinct contrast between local level goals and the global/country ones. To put it

differently, the Sustainable Seattle Project, for example, has interpreted environmental conservation through seven goals: wild salmon, ecological health, soil erosion, air quality, pedestrial and friendly street, open space near urban villages, and impervious surfaces. Seattle's stakeholders consider "wild salmon" not only as a link to the earth and a source of food, but also as an essential economic resource to Northwesterners of many different origins (M. Holden, 2006).

Yet, the Human Development Index (global scale) has not implemented the goal of environmental impact or eco-efficiency (Reed et al., 2006). With attention to what has been said, urban sustainability projects have played a vital role in revealing what a city or a metropolitan area is doing differently from others according to goals and objectives. More profound sustainability implementations are desirable to make the urban setting more harmonious and worth living in. For all the reasons mentioned above, there has been a call for a fourth generation of USIs through which a broader, people-centered and localized approach is adopted (Gómez-Álvarez et al., 2018). These indicators aim to enhance the accuracy in estimating urban needs, challenges, and opportunities for cities and communities.

To broadly identify the challenges and opportunities in the development and implementation of SIs, this dissertation adopted the literature review by Verma & Raghubanshi (2018) who reviewed over 341 pre-reviewed published articles in the field of urban sustainability indicators from 2006 to 2017 that resulted in identification of external and internal challenges in developing SIs.

The internal challenges to SIs are due to their development methodology and are caused by the following issues identified by Verma & Raghubanshi (2018, p. 286):

1) Methodology used in developing SIs
2) Weighting methods
3) Complexity in measurement
4) Lack of theoretical base

The external challenges are the issues that prevent the implementation of SIs framework. These challenges are due to the following (Verma & Raghubanshi, 2018, p. 287):

1) Lack of data
2) Policy unwillingness on the part of the government to implement SIs
3) Lack of constitutes standard indicators
4) Lack of comparative analysis across disciplines and cities

In addition to Verma and Raghubanshi, and for local initiatives, Merino-Saum, Halla, Superti, Boesch, & Binder (2020) analyzed 67 indicator sets for a total of 2,847 SIs from academics and practice. Their holistic review aimed at selecting the most suitable SIs, identifying the gaps in the ways urban sustainability is currently translated, and holistically understanding what ultimately applies best to urban sustainability. The study highlighted the most frequent SIs used in measurement and assessment. The research finding demonstrated the prominence of social issues in urban dynamics such as employment, consumer behavior, access to services, and quality of life. In addition, it should be noted that USIs generally pay marginal attention to political concerns such as citizens' participation, policies, and institutional settings.

All in all, the meaning of urban sustainability is most clearly seen in the SDG11 goal to "make cities and human settlements inclusive, safe, resilient and sustainable" through the satisfaction of current needs, social aspects, and the status of capital stocks (Merino-Saum et al., 2020; Secretariat, 2017, p. 107). As such, each project has been designed according to how stakeholders acknowledge the definition of urban sustainability and what goals can be sustained. On the one hand, global implementation has been adopted according to the worldwide agreement such as Agenda 21, Agenda 2030, and 17 Goals to Transform Our World. However, local projects have been implemented based on local standards, community-based concerns, and local interest in reducing the environmental burden. For instance, Mexico City's Green Plan, Plan Verde, was adopted after intense dialogue between the city's stakeholders and external experts about the city's total collapse by 2010. However, almost all stakeholders agree on the notion that urban sustainability consists of "enhancing the city's resilience, which reduces the vulnerability to natural and human hazards" (Ali-Toudert & Ji, 2017, p. 599). This notion is also supported by Collier et al., (2013).

Consequently, the development of USIs has moved beyond economic growth toward a comprehensive and fundamental understanding of human and societal well-being (Gómez-Álvarez et al., 2018). This inevitably leads to a change in the USI landscape to include a more localized people-centered approach (Wong, 2015). Given the challenges inherent in past USIs, there has been enormous progress in this regard. However, a concrete call for building a fourth generation of USIs that will provide better-informed policies and development plans for the future has been identified (Bell & Morse, 2018; Gómez-Álvarez et al., 2018; Mischen et al., 2019).

2.6 Summary

The birth of the Sustainable Development term relies on the foundation of the Brundtland Report, which was published in 1987. Since then, many disciplines, such as urban sustainability, have shaped their understanding of such fundamental concepts. Mainly, cities have emerged and developed various definitions to understand the phenomena of sustainability within their cities. For example, in the 1990s, the goal for sustainable cities was to "maintains lasting security from environmental hazards that may threaten development achievements by allowing only for acceptable risk" (UN, 2013, p. 61). However, the beginning of the 21st Century shaped a new goal of urban sustainability that lowers the human well-being impact on the environment by promoting democracy and affordability. Recently, scholars in urban sustainability reveal that sustainable cities' ultimate goal is to improve ecosystems and well-being. Thus, the definition and understanding of urban sustainability have been changing as society's, the engine of cities, adjustable needs.

Investigating the relationship between ecosystem services, society, and well-being helps urban sustainability scholars to understand the new version of cities and their people. One way to achieve that is using a mathematical framework of sustainability indicators to monitor the progress towards sustainability goals. To achieve that, places and communities have either maintained the people's well-being through economic, sociocultural, and ecological actions or converting natural capital is not a possible option. While the first option is more flexible and usually names as weak sustainability., the second option, which is called strong sustainability, is much complicated. Either option is controversial and has been hugely debated in the literature

review. Understanding the relationship between ecosystem services, society, and well-being frames the process of urban sustainability assessment.

Sustainability assessment helps stakeholders better to understand the contextual interpretation of the meaning of sustainability. In addition, it integrates sustainability challenges into the decision-making process. One increasingly desired way to gauge public interest is using urban sustainability indices (USIs). USIs are a mathematical way to implement public goals through TBL dimensions. Since urban systems are structured from complex components, multiple USIs are used among the world's cities. However, the literature on urban sustainability has successfully proposed specific USIs according to the targeted system's nature.

Moreover, some recent research showed an urgent need to develop more meaningful SIs for broader application within diverse urban settings. In this regard and for a local scale, some theoretical and empirical evidence reveals the need to develop a multidimensional index that includes a mix of indicators by which a significant amount of information could be captured. As such, identifying the best urban policies and trach progress toward making places and human well-being resilient and sustainable fundamentally relies on the correct use of indicators and indies.

Chapter 3: The Notion of Distressed Places and Communities in Urbanized World

In this research, the words "urban stress", "crisis", and "distressed urban areas" are used interchangeably, but the common theme that unites their use is recognition of the range of forces that limits well-being, safety, and personal choice. This chapter explores the concept of distressed urban areas in a very urbanized world. As such, the researcher in this chapter investigated and addressed three essential research questions of this dissertation. These research questions are as follows:

1) *What is the definition of a distressed place?*
2) *What are the characteristics of distressed places?*
3) *To what extent can a taxonomy be created of distressed places?*

Hence Chapter Four explores the methodology used to invistigate these questions. Addressing these research questions will bridge the gap between the understanding of distressed urban areas' phenomena and their distinctive characteristics. This chapter explicitly defines the phenomena of distressed places according to a systematic literature review analysis. The full details of this phenomenon are then discussed in detail, specifically, how a distressed place appears as an unhealthy place to live in. In this regard, the researcher mentioned some approaches and urban policies to confront the dilemma of distressed areas recommended by scholars who study this phenomenon and its consequences. The researcher also classified the distressed areas into three foundational themes based on the Triple Bottom Line of Sustainability notion. Each theme was thoroughly described and defined based on the knowledge of the literature review provided.

3.1 Urbanization and its Consequences: General Background

The change of land in our world had begun a long time ago with the advent of agriculture 8000 years ago (M. G. Wolman, 1993). The 18th century's Industrial Revolution exponentially intensified this change, and ever since that time, industrialization has been the driving force of pressure on our environment (Senge, Carstedt, & Porter, 2001). As a result, the earth's population has been dramatically increasing as agriculture and economic activities increase. The tremendous and steady increase in the world's population leads to the prediction that by 2030 more than half of the world's population will be living in urban areas (Chamie, 2004). Urbanization refers to transitioning when a rural area and society transform into an urban one (Weckström, 2012). Gotham & King (2019) state that the term also implies cities' physical, demographic, and economic growth.

The World Urbanization Prospects report pointed out that this increase in the world's population significantly impacts the interactions between populations and the urban environment (Chamie, 2004). For example, Tsai et al. (2018) pointed out that among urbanization consequences in urban areas is the increase in the risk for depression and other mental disorders. In this regard, urbanization increases the risk of mental health of urban dwellers, and a growing body of research indicates the natural environment, one of the TBL, confers numerous benefits on the social aspect of people, such as the alleviation of mental health issues (Tsai et al., 2018).

Rapid urbanization changes people's environment through their consumption of land, water, energy, and food system (Parikh & Radhakrishna, 1991). Weckström (2012) shows that urbanization usually brings a sign of progress as it occurs due to economic growth and

improvements in education, agriculture, and social health and care. However, it causes a burden on existing social services and infrastructure (Reba, Reitsma, & Seto, 2016). For example, the Arab Gulf States have the highest per capita water and energy consumption rates and generated waste in the world (Ramadan, 2015). The growth of urban activities dominates the increase of urban activities. Urban consumption of energy, for example, causes the heat island phenomena which stimulates the change of local weather patterns (Kolsrud & Torrey, 1992). Bolay (2020) identifies the adverse effects of current urbanization trends in the contemporary urbanized world, noting especially the development of slums and the deterioration of natural resources. According to Bolay, over one billion individuals live in precarious urban conditions, and 94 percent of slum dwellers live in developing countries (Bolay, 2020).

Consequently, some urban areas are the unhealthiest places for individuals to live (Rice, 2021). Keyfitz (1989) states that death rates in urban areas are significantly higher than in rural areas due to the rapid spread of infections in high-density settings. Not only life expectancy but also social equity becomes an issue in urbanized places. Urbanization can provide better opportunities to receive healthcare, education, and better jobs than found in less urbanized regions. Nevertheless, these potential advantages diminish dramatically in poor urban areas (Chamie, 2004).

There is no denying that urbanization makes our world more modern and dynamic. Nevertheless, this phenomenon has inevitable consequences on cities and their communities. People's demand for food, energy, water, education, more job opportunities, healthcare, infrastructure, and others exert ecological pressure, which in turn leads to environmental

catastrophe captured by climate change, pollution, and loss of biodiversity (Ahmed, Zafar, & Ali, 2020).

3.2 Definitions and Characteristics of Distressed Places and Communities

What does stress mean? Stress, as Cambridge dictionary defines it, is "worry caused by a difficult situation, or something that causes this condition" ("MICROBUSINESS | meaning in the Cambridge English Dictionary," n.d.). Yet, Dictionary.com defines a distressed area as

> A region so severely damaged by a flood, hurricane, or other natural catastrophes that its inhabitants need food, clothing, shelter, and economic aid from national charities or the federal government ("Distressed area | Definition of Distressed area at Dictionary.com," n.d.).

Hans Selye, the father of contemporary stress research, defined stress as "the non-specific response of the body to any demand made." (Ellison & Maynard, 1992, p. 2; Selye, 1974). Another definition provided by Baum, Fleming, & Singer (1985) defines stress as a process involving individuals' behavior that responds to a psychologically threaten phenomena on human well-being. The stress definition defines the cumulative number of both external and negative health influences. (Burton, 1990; Selye, 1974). As helpful as these definitions are, in an urban setting stress can be seen in adverse impacts on how cities, countries, and communities may respond to sustainability challenges.

Urban stress is inevitable, and some places experience a variety of types and levels of it. Unexpectedly, numerous distressed areas emerged in OECD countries in the 1990s. However, in some other countries, such as the United States and the United Kingdom, the phenomena of

distressed urban areas were evident in the 1960s and 1970s, respectively (OECD, 1998). Conway and Konvitz (2000) showed that up to 20 percent of people who live in the OECD might live in distressed urban areas where roughly 80 percent of the population lives in cities. The study mentioned that the presence of distressed urban areas phenomena has severe consequences; It weakens cities and creates socio-economic burden such as loss of human capital and potential growth and increase in social justice needs. The term itself has multiple dimensions. For one, it refers to areas within communities that suffer from various deprivations. This is more than just a question of low-income levels or areas of physical degradation (Conway & Konvitz, 2000, p. 750). As a result of the phenomena,, large distressed urban areas emerged in many OECD cities where economic, social, and environmental decline occurs at a significant scale (Kazmierczak, Curwell, & Turner, 2007). Kazmierczak, Curwell, & Turner (2007) study's findings showed that distressed urban areas are among the most problematic issues faced by developed countries during the 1980s and 1990s.

The definition of distressed urban areas has been framed based on the trajectory of places. In general, OECD (1998) (p.15) defines distressed urban areas as "portions of cities or their suburbs, usually at the scale of residential neighborhoods, in which social, economic and environmental problems are concentrated." The report showed that problems caused by distressing areas affect local communities and enterprises to differing degrees in terms of limited access to opportunities, resources, and services considered normal or standard in other parts of the city. Özgen (2009, p. 65) defined large urban distressed areas as:

> A considerable part of a city, suffering from multiple deprivations such as degraded housing; inadequate or sub-standard facilities; rundown or derelict

industrial estates, environmental risks, and problems; unattractive and disconnected urban structures; high unemployment and week social cohesion, which is detrimental to the sustainable development of the city as a whole.

At a neighborhood level, however, although the exact definition of a "distressed" neighborhood is ambiguous, it is usually defined by researchers as "a neighborhood with low income and occupational levels as well as poor health" (Ekstam, 2015, p. 434). Distressed neighborhoods are defined by a significant rate of unemployment and crime, physical decay, insufficient social networks and safety, and low socioeconomic conditions in urban areas (Baum, Singer, & Baum, 1981; Jencks & Mayer, 1990; Milgram, 1970; Suchday, Kapur, Ewart, & Friedberg, 2006). Dekker (2007) mentioned that a few issues make urban neighborhoods particularly susceptible to poor quality of life and distress. For example, pollution, neglect of maintenance, vandalism, crime, drug abuse, and social isolation are some of these issues. The study even showed that many European Union governments concentrate their urban policies on urban areas where those listed issues exist. Both Ross, Mirowsky, and Pribesh (2001) and Subramanian, Lochner, and Kawachi (2003) found that the level of participation, which relates to social capital, in distressed urban areas is lower than it supposed to be. The study's findings showed that people's trust is lower in distressed than in average neighborhoods.

According to Conway & Konvitz (2000), an OECD report compiled a demographic profile for distressed urban areas. In this profile, the rule of thumb is that each indicator has a significant differentiation from the national or state level. The indicators to be used in characterizing a distressed urban area are as follow (Conway & Konvitz, 2000, p. 750):

1) High level of poverty

2) Low educational achievement
3) Low rate of labor force participation
4) High number of single-parent families
5) High rate of health problems
6) Inadequate access to shops and other services
7) Low participation in the democratic process and community involvement
8) Isolation from the broader society
9) Insecurity and the incidence of crime and vandalism are often high.

Some studies, such as Davies & Vergriete (1998), characterized distressed urban areas as places with a concentration of social distress, environmental degradation, crime, and economic decline. To solve the issues in distressed areas, the authors concluded that a comprehensive approach must be integrated within the city's social, economic, and physical fabric. These particular approaches involve the following (Davies & Vergriete, 1998, p. 3)

1) Affordable access to basic services, especially housing, education and training, health, energy, transport and communications, effective policing, and justice.
2) Pathways to integration, for the hardcore of the long-term unemployed, young dropouts, lone-parent families and ethnic minorities, and others who are socially excluded.
3) Economic development strategies which support local businesses, especially start-ups and community enterprises through the provision of suitable infrastructures, advice, and support services.

4) Improvement of the physical environment including renovation of the housing stock, measures to reduce pollution and vandalism, and the protection and improvement of buildings and open spaces in rundown areas as well as the preservation of historic and cultural heritage.
5) Community development which encourages social mix and improved security for persons including maintenance of local commercial and leisure centers in distressed areas.

Hall (1997), Kazmierczak et al. (2007), and Morrison (1999) classified four broad categories of distressed urban areas: environmental, economic, social, and those related to urban structure. In the environmental category, environment and technology were selected. In the social category, however, crime, education was identified. For the economic category, access to employment and finance, extensive development, and formation of public-private partnerships were highlighted. The urban structure category had urban design quality, housing, transportation, and redevelopment of the cities. Earlier research done by Neal & Bunce (1994) , which investigated the socioeconomic changes in distressed American cities during the 1980s, emphasized that several indicators of stressful urban conditions must present when identifying distressed cities. Examples of these conditions include low income, job loss, unemployment, and crime (Neal & Bunce, 1994). The Department of Housing and Urban Development of the United States created a Housing and Community Act in 1997 through which substantial financial resources were granted to cities with great issues such as poverty, poor housing conditions, and low levels of education (Haque, 1998).

To investigate whether urban stress and sustainability have a significant positive relationship with pro-environmental behaviors in cities, Meloni, Fornara, & Carrus (2019) characterized urban stress based on seven factors:

1) Noise
2) Air pollution
3) Street traffic
4) Crowding
5) Pollution of sea and beaches
6) Visual pollution of landscape
7) Urban degradation

Another technique advanced by Nathan and Adams to assess urban hardship presented six key factors to comparatively analyze most metropolitan areas in the U.S. (Montiel, Nathan, & Wright, 2004). These six key factors and their definitions are as follows: (Montiel et al., 2004, p. 1)

1) Unemployment: the percent of the civilian population over the age of 16 who were unemployed.
2) Dependency: the percentage of the population that is under the age of 18 or over the age of 64
3) Education: percentage of the population over the age of 25 who have less than a high school education
4) Income Level: income per capita

5) Crowded housing: percentage of housing units with more than one person per room occupied; and
6) Poverty: percentage of people who remain below the federal level of poverty.

A study done by Haque (1998) proposed a method by which the most distressing parts of four major cities in the United States were identified. The method used seven standardized Intra-metropolitan and Intercity Hardship Index indicators (see Table 4) developed by the Brookings Institution (Haque, 1998).

Table 4: Definition of Intrametropolitan and Intercity Hardship Index Indicators

Distressed Urban City Indicator	Definitions
Percent of civilian labor force unemployed	• Percent of civilian labor force unemployed
Dependency	• Persons under eighteen or over sixty-five as percent of total population
Education	• Percent of persons twenty-five or older with less than twelfth-grade education
Crowded Housing	• Percentage of housing units occupied, with more than one person per room
Poverty	• Percent of families below the poverty level
Vacancy	• Percent of vacant housing units
Housing Built Before 1939	• Percent of housing units built before 1939

3.3 Themes of Distressed Places and Communities

Distressed urban areas are significantly dynamic; they are influenced by broad societal tendencies and local dynamics (Conway & Konvitz, 2000). The concept of distressed places and communities recognizes that some places and communities suffer significantly more economic and social problems than other cities (Neal & Bunce, 1994). To broadly distinguish the types of distressed places, the researcher divided them into two essential themes: The first is socioeconomically distressed areas, and the second theme is environmental, and climate change distressed urban areas.

3.3.1 Theme one: Socioeconomic Distressed Urban Areas

According to the American Psychological Association, "fundamental determinants of human functioning" rely on socioeconomic factors such as employment status, education level, and financial security (American Psychological Association, 2007, p. 1; Charles et al., 2019). Urban distressed areas have experienced inevitable socioeconomic costs.

On one hand, Conway & Konvitz (2000) expressed the economic costs of distressed areas in terms of human capital. Their study explained that distressed urban areas lead to low educational attainment, resulting in loss of human capital. Its findings proved that human capital loss compromises a nation's growth and community well-being as its citizens do not gain the necessary skills to make them productive. However, distressed urban areas accommodate people with low socioeconomic status (education, work, income) and non-native origin. Since it is assumed that these people lack the necessary participation tools (Purdue, 2001; Subramanian et al., 2003). Wolman et al. (2008) identified and characterized the dynamic of U.S. economically distressed cities as those whose economies and population well-being are

declining, and thus have a significant likelihood of being economically distressed. Wolman's study showed that economically distressed cities are those places that suffer from economic and population decline, stagnation, and lack of a standard of living for their residents.

On the other hand, In addition to their focus on human capital, Conway & Konvitz also emphasized that social exclusion is one of the essential keys to identifying distressed urban areas (Conway & Konvitz, 2000). The existence of social isolation causes less interaction among neighborhoods and their community members in distressed areas. Their research states that "when people of different socioeconomic groups no longer share the same neighborhoods, they interact with each other less, understand each other less well and fear each other more." (Conway & Konvitz, 2000, p. 750).

Several criteria can be used to quantify socioeconomically distressed communities, such as housing vacancy rate, adults not working, the poverty rate, median income ratio, change in employment, and change in business establishments (E. I. Group, 2016). Areas associated with a high concentration of poverty and unemployment are more likely to be recognized as distressed and disadvantaged (Zubairu & Adedayo, 2017). It is interesting to note that each country, city, and place has its own characteristics when attempting to quantify a distressed urban area's social dimension. Despite that fact, the Integrating Distressed Urban Areas report for the OECD cities was able to compile an aggregate list of socioeconomic characteristics for distressed areas. However, that list does not imply that all cities equally share these characteristics. Table 5 summarizes the benchmark indicators OECD countries consider to inclusively describe distressed urban areas (OECD, 1998, p. 34).

Table 5: OECD Countries Indicators to Describe Distressed Urban Areas

Indicator	Characteristics
Population profile	• High residential turnover and out-migration, particularly of young people • Atypical population profile
Education	• Low educational attainment • High rate of 16-17-year-olds not in education
Employment	• High male, youth, and long-term unemployment • Inadequate physical access to employment • Low economic activity rate
Income and needs	• Low average income • Large population receiving social assistance • Poor access to shops and services
Community life	• High crime rate and sense of insecurity • Low local election turnout
Communications	• High proportion of households with no car • High proportion of households without telephone
Health	• High premature mortality rate • High permanent disability/invalidity rate • High incidence of tuberculosis and other preventable diseases

Ten years after the OECD report, Wolman et al. (2008) used the City Economic well-being Index and the City Economic Condition Index to construct a broad perspective on cities' economic health. This set of indicators are as follows (H. Wolman et al., 2008, p. 152):

1) Per capita income
2) Median household income
3) Unemployment rate
4) Labor force participation rate
5) Growth in employment
6) Growth in annual payroll
7) Growth In the number of establishment

The urban crisis began in the 1960s and has become worse over the years (Gottdiener, 1985; Nelson, 1995; Teaford, 2016). Nelson, Schwirian, & Schwirian (1998) argued that large American cities had deteriorated dramatically between 1970 and 1990. The study even argued that socioeconomic distress continued to become worse. As Miethe (1995) reported, a high rate of crime and poverty, high unemployment, family compensation, excluded minority groups, and inadequate housing were the most heavily concerned in areas to be considered distressed.

There can be no denying that high crime rates produce more distressed places than cities with lower crime rates (Nelson et al., 1998). Additionally, low-quality housing is often associated with the residential crowding frequently found in socially distressed areas (Spain, 1990). Furthermore, Kasarda & Irwin (1991) showed that less educated people significantly compromise a city's ability to advance the emerging global economy's high-tech industries and jobs. Less skilled residents are usually doomed to the low-wage job positions expanding in many distressed places (Nelson et al., 1998). This aligns with the notion that the model of economic distress is embedded in the use of income, services, and resources in the city (Imbroscio, 1993). Low-income residents live near or below the poverty line, making them likely to experience distressed urban life (Nelson et al., 1998). They cannot afford an adequate residence in a safe neighborhood, medical care, schools, other public services (Nelson et al., 1998).

Low education rates lead a city to be socially fractured, which is often manifested in predominantly female-headed families. Communities dominated by single-parent families frequently experience relatively higher social distress levels due to health issues, poor school

performance, and issues with the criminal justice system (Moynihan, 1993). Nelson et al. (1998) identified seven variables that can be used to measure social and economic distress corresponding to the problems mentioned above. These variables follow (Nelson et al., 1998, p. 417)

1) Crime rate
2) Percentage of female-headed families
3) Percentage of crowded dwellings
4) Percentage of the population with less education than high school
5) Median family income
6) Percentage of families below the poverty line
7) Percentage of labor force unemployed.

The Economic Innovation Group developed another means of measuring socioeconomic distress. Their Distressed Communities Index (DCI) measures a community's distress at the ZIP code level (Hawkins et al., 2018). DCI scales distress from 0 (no distress) to 100 (severe distress) by incorporating the following seven indicators (Economic Innovation Group, 2018):

1) Unemployment
2) Education level
3) Poverty rate
4) Median income
5) Business establishments
6) Job growth, and,
7) Housing vacancies.

3.3.2 Theme two: Environmental and Climate Change Distressed Urban Areas

In most urbanized and population-dense areas, climate and environmental stress are inevitable. Rishi & Khuntia (2012) define urban environmental stress as "the situation that represents the level of anxiety of the urban inhabitants, facing the daily humdrum that is incompatible with their life." (Rishi & Khuntia, 2012, p. 2). Cities are on the front line of climate change, a constant threat to our cities and communities (Cohen, 2019). Aboulnaga, Elwan, & Elsharouny (2019) pointed out that climate change has severely impacted human settlement patterns in recent decades. Such impacts notably cause sea level rise, desertification, drought, extreme environmental events, food insecurity, increased health risk, and temperature-related morbidity in urban environments. The study even investigated the consequences of climate change on several dimensions of the built environment: agriculture, ecosystems, forests, health, coastal zones, tourism, energy, and economy.

For example, the Middle East is environmentally under severe stress because it has high levels of air pollutants and atmospheric dust (Pikridas, Barmpounis, Biskos, & Lelieveld, 2018). Moreover, the top air emitters in per capita terms worldwide are the Middle Eastern countries (Gholipour & Farzanegan, 2018). Petrović & Trajković (2010) note that air pollution is one of the leading causes of urban stress. It has become a concerning issue in many cities, such as in advanced industrialized societies and megacities (Calef & Goble, 2007; Goyal, Ghatge, Nema, & Tamhane, 2006). Alongside health consequences, urban environmental distress represented by air pollution has socioeconomic costs such as loss of productivity and also reduced educational performance (W Bank, 2016; Landrigan et al., 2018). It is telling to note that Zander & Mathew (2019) found that feeling increasingly heat-stressed compromises and reduces human

economic activity. For instance, the Australian economy lost around USD 6.2 billion over one year due to productivity losses due to the cost of heat and climate change (Zander, Mathew, & Garnett, 2018).

Climate change undeniably harms humans and production systems in developing countries, especially those heavily dependent on natural resources (Dhar & Khirfan, 2017; Teixeira, Fischer, Van Velthuizen, Walter, & Ewert, 2013). At a regional level, South Asia and Africa are particularly vulnerable due to the "urban heat island" phenomenon (Matthews, Wilby, & Murphy, 2017). Globally speaking, however, it is estimated that people in urban areas are twice as heat-affected as people in non-urban areas (Wouters et al., 2017). High heat stress is one sign of urbanization and has serious impacts on the environment, society, and public health. Specifically, Luo & Lau (2018) found that urbanization can greatly exacerbate thermal stress in cities, and its environmental consequences are much more rapid in the developed parts of the world than in less-developed areas.

In sum, despite significant advancements and improvements in the world's standard of living over the past two centuries, places and communities have largely failed to solve the problems such as intergenerational poverty among families living in distressed communities. Urbanization places heavy pressure on cities and generates various symptoms of urban stress. The impact of urban stress on socioeconomic conditions has become greater than ever (U Nations, 2014). Salmond, Sabel, & Vardoulakis (2018) emphasize that one of the most significant challenges of the 21st Century is promoting human well-being and a healthy lifestyle through designing and planning sustainable cities, resilient to environmental and population change. However, despite the progress achieved in pursuing more sustainable urban policies,

urban areas show increasing environmental stress signs, e.g., air pollution and air quality (European Environment Agency, 2008).

3.4 Summary

One objective of this research study is to advance the knowledge of distressed urban areas. Specifically, this dissertation focuses on advancing our understanding of all kinds of distressed urban areas in the urbanized world and identifying the factors to recognize distressed places from others. To this end, the researcher proposed three primary research questions that align with such an objective. First, w*hat is the definition of a distressed place?* Then, *what are the characteristics of distressed places?* Last, *to what extent can a taxonomy be created of distressed places?*

Addressing these research questions will bridge the gap between understanding distressed urban areas' phenomena and their distinctive characteristics. This chapter explicitly defines the phenomena of distressed places according to a systematic literature review analysis. The full details of this phenomenon are discussed in detail, specifically, how a distressed place appears as an unhealthy place to live in. In this regard, the researcher mentioned some approaches and urban policies to confront the dilemma of distressed areas recommended by scholars who study this phenomenon and its consequences. The researcher also classified the distressed areas into three foundational themes based on the Triple Bottom Line of Sustainability notion. Each theme was thoroughly described and defined based on the knowledge of the literature review provided.

The definition of distressed urban areas has been framed based on the trajectory of places. In general, the concentration of social, economic, and environmental problems are the major symptoms of distressed places. In addition, local communities in areas under concern usually have limited access to opportunities, resources, and services considered normal or standard in other parts. Therefore, the researcher divided them into two distinct themes to broadly distinguish the types of distressed places: Socioeconomically distressed areas and environmental and climate change distressed urban areas. Several criteria were identified to quantify these two distinct themes of distressed urban areas. However, it is interesting to note that each country, city, and place has its characteristics.

Chapter 4: Research Design and Methodology

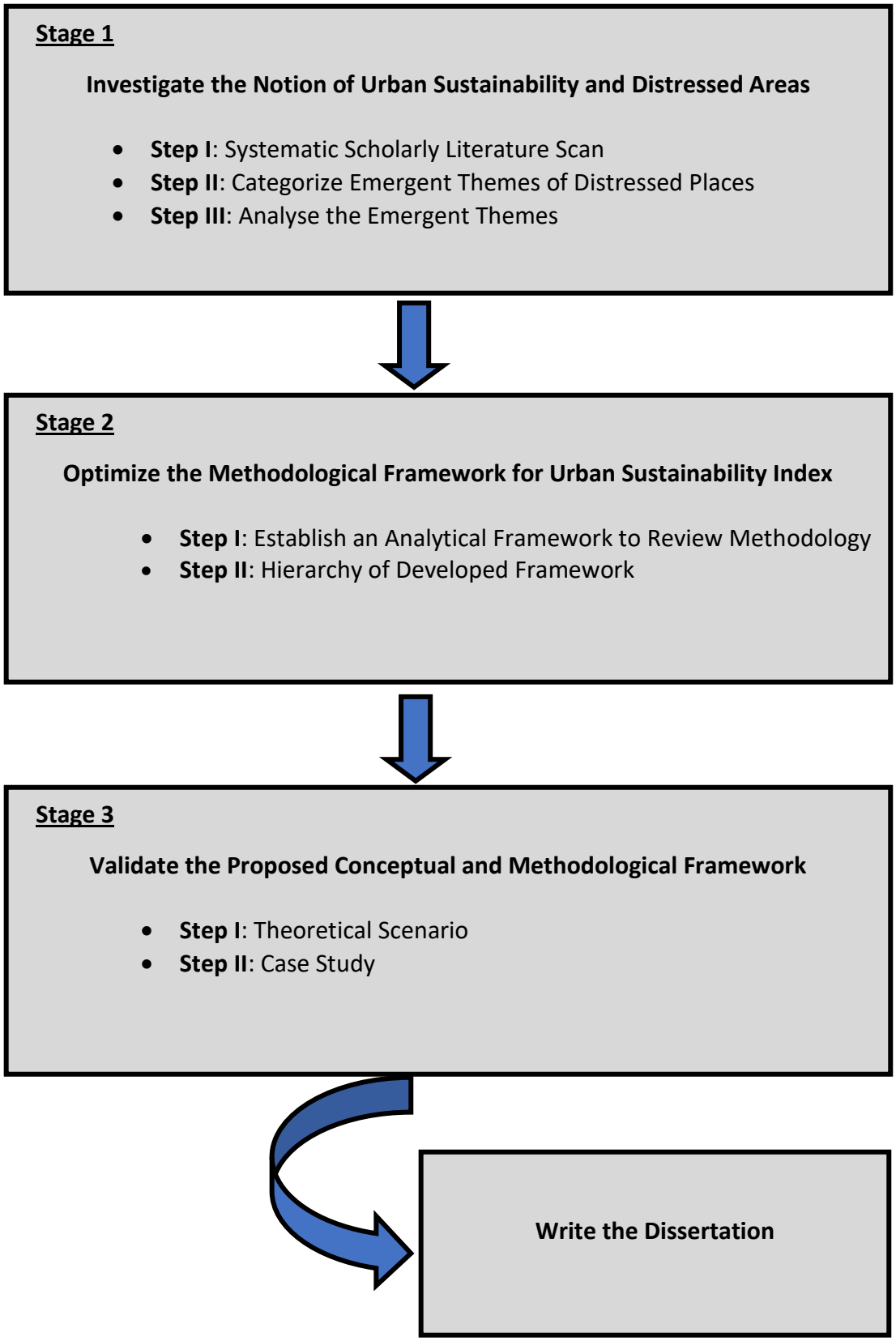
In this chapter, the research methods and the methodology behind this dissertation will be discussed. To achieve the dissertation objectives and address its questions, the researcher has adopted a mixed methodology**.** Specifically, the study is based on a systematic, holistic, multi-criteria analysis and an integrated approach.

The researcher followed an approach to integrating qualitative and quantitative data by which theoretical frameworks may yield further information beyond what this approach provides (Creswell & Creswell, 2017). Furthermore, the researcher used a case study as it could be "…. a community; a specific policy; and so on." (Merriam 1998, p.27). Thus, the case study in this research is used as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin 1993, p.13).

As mentioned above, the study methods are preliminarily mixed methods and consist of a systematic, holistic, multi-criteria, and integrated approach. A two-stage exploratory design, a theoretical scenario, and a Case Study have been employed to address the study questions and their objectives.

The theoretical scenario is for a generic distressed place called “X”. However, the researcher validates the developed conceptual and methodological framework using Duhok City as an empirical case study. In this chapter, intensive details are being provided for each stage and its steps. Figure 9 summarizes the stages and steps used for the methodology.

Figure 9: The Framework of Research Design and Methodology



4.1 Stage One: Contemporary Concepts of Urban Sustainability and Distressed Areas

As mentioned previously, the ultimate goal for this stage is to help the researcher answer the following three research questions:

1) *What is the definition of a distressed place?*
2) *What are the characteristics of distressed places?*
3) *To what extent can a taxonomy be created of distressed places?*

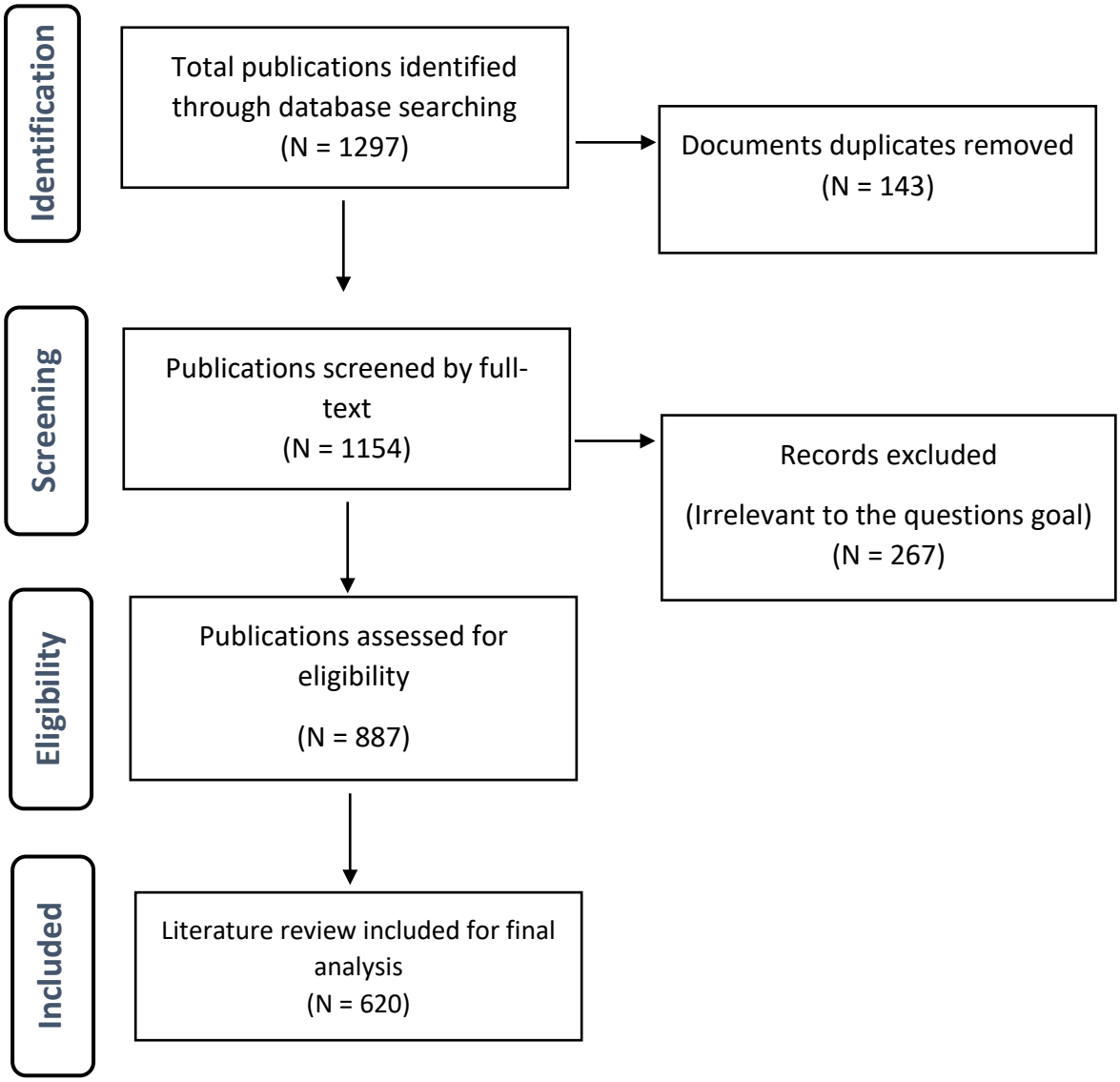
The researcher followed the PRISMA flowchart, shown in Figure 10, to review the literature relevant to these research questions, run an intensive literature review analysis, and select the relevant papers for this stage. As a result, stage one has been divided into three steps as follows.

4.1.1 Step One: Systematic Scholarly Literature Scan

To select research in the literature review associated with the notion of urban sustainability and distressed places, the researcher used six common academic databases.

1) Google Scholar
2) ProQuest
3) Scopus
4) ScienceDirect
5) Web of Science, and
6) ResearchGate

Figure 10: Literature Selection Procedures for Stage One



***Source**: PRISMA flowchart adopted by (Liberati et al., 2009)*

The scholarly literature scan was launched according to keywords and terminology relevant to the notion of urban sustainability *and* distressed places. To determine what these essential contemporary keywords are, the researcher consulted preliminary work presented in related conferences as well as a wide range of professionals in academia whose work is related to the subject in question. Consequently, nineteen contemporary keywords and phrases were identified and used for this step. They are as follows:

1) Distressed Cities
2) Urban Stress
3) Urban Vulnerability
4) Urban Crisis
5) Distressed Urban Areas
6) Distressed Urban Communities
7) Conflicts in Urban Areas
8) Disasters in Urban Areas
9) Sustainability Indicators
10) Measuring Urban Sustainability
11) Urban Sustainability Indicators
12) Sustainability Assessment
13) Sustainable Cities
14) Indicator Framework
15) Sustainable Development Assessment
16) Sustainability Measurements

17) Urban Indicators

18) Sustainability Evaluation

19) Sustainability Indices

A combination of these nineteen keywords was used through the web-database mentioned above. For example, sustainability indicators "AND" distressed urban areas were used as well as urban sustainability indicators "AND" urban crisis "AND" distressed cities as a combination to find relevant literature review to these topics. The inclusion criteria identified included being peer-reviewed, available online in full text, and published in English scholarly articles between 1990 - 2020. Among the emerging search methods, Research Gate and Google Scholar provided the most significant and valuable journals. However, Scopus, ProQuest, ScienceDirect, and Web of Science databases were used as alternative sources in order to provide comprehensive coverage. In every instance, the keywords mentioned above were directed to the searched articles' titles, keywords, and abstracts.

Initially, this step revealed a total of 1297 publications. All of them were screened and read for accuracy and consistency with the keyword and terminology search. That review reduced the researcher’s findings to 1154 after removing 143 duplicated documents. The researcher then adopted an eye-balling qualitative technique (Yigitcanlar et al., 2019; Yin, 2015) to evaluate the abstracts against the research questions' goals. As a result, 267 publications were excluded because of being irrelevant to the research questions.

The 887 intermediate publications were then reduced to 620 after excluding any publication that did not explicitly investigate the phenomena of measuring urban sustainability and

distressed places. The final 620 publications were then fully read, reviewed, categorized, and analyzed. Out of these 620 documents, 9 were books, 11 were chapter books, and the rest were peer-reviewed journals.

4.1.2 Step Two: Categorize Emergent Themes of Distressed Places

The first part of the researcher's investigation relies on a descriptive rather than a statistical analysis of results. As mentioned earlier, this part has three research questions as follows:

1) *What is the definition of a distressed place?*
2) *What are the characteristics of distressed places?*
3) *To what extent can a taxonomy be created of distressed places?*

With those questions in mind, the researcher chose a methodology of qualitative content analysis. Bengtsson (2016) states that "The purpose of content analysis is to organize and elicit meaning from the data collected and to draw realistic conclusions from it." (Bengtsson, 2016, p. 8).

With content analysis as the foundation, the researcher developed coding for emerging thematic areas, categorizing the 620 publications discovered in the literature scan by leaning on the "Triple Bottom Line of Sustainability" (TBL). During this analytical process, keywords were derived and identified from this researcher's investigative perspective. The text then was approached as single keywords (one of the keywords mentioned in stage one of the methodology) in association to distressed places content. To ensure credibility through this step, the researcher adopted the overview of the content analysis process from planning to presentation as recommended by Bengtsson (2016).

As mentioned in chapter one, this researcher's ultimate goal is to bridge the gap in acknowledging the notion of urban sustainability in distressed places. To accomplish this goal, three central themes were used in order to separately investigate the characteristics of distressed places through the lens of TBL. These themes are as follows:

1) Theme one: Environmental and Climate Change Stress, which aligns with Environmental sustainability.
2) Theme two: Economic Stress, which aligns with Economic sustainability.
3) Theme three: Social Stress, which aligns with Social sustainability.

The coding scheme was framed according to the selected publications in which the concepts of Environmental and Climate Change Stress, Economic Stress, and Social Stress were highlighted.

4.1.3 Step Three: Analyse the Emergent Themes

In this step, the three thematic categories of the reviewed literature were analyzed in three ways. First and foremost, the significant challenges of being under stress in urban settings was highlighted and tabulated. Next came defining the theme in order to categorize each piece of reviewed literature best. Finally, these themes were cross-checked with each other to identify standard criteria and characteristics. As a result of this thematic analysis, the number of articles from the literature review was reduced again to the 177 items that proved most relevant to this stage of the researcher's investigation parameters. Table 6 illustrates the three coding themes and their characteristics.

Table 6: Coding Emergent Themes of Distressed Places

Theme	Codes	Characteristics
Environmental & Climate Change Stress	EN1 CC1	Reference to the definition and/or characteristics of Environmental distressed urban areas (i.e., sea-level rise, desertification, drought, extreme environmental events, food insecurity, increased health risk, and temperature-related morbidity in urban environments).
Economic Stress	ES1	Reference to the definition and/or characteristics of economically distressed areas (i.e., economic costs of distressed areas in terms of human capital).
Social Stress	SS1	Reference to the definition and/or characteristics of socially distressed areas (i.e., social costs of distressed areas in terms of well-being).

4.2 Stage Two: Conceptual and Methodological Framework for a Holistic Index

As mentioned earlier, the second part of the research questions aims to develop a conceptual and methodological framework to construct a nimble, flexible, and efficiently-optimized urban sustainability index for the distressed urban areas. As a result, this stage has consisted of three systematic steps to investigate the research question, which states:

What is the conceptual and methodological framework to be employed to construct an urban sustainability index for a distressed place?

4.2.1 Step One: Establish an Analytical Framework

In this primary step, an analytical framework was established to ensure that our understanding of the fundamental concept and principles of constructing an urban sustainability index was as representative and comprehensive as possible. This step strives to acknowledge and emphasize the inclusive areas of consideration to build such an index. The analytical framework also guides this study to acknowledge the state-of-the-art in methods and recommendations to overcome major misleading issues and challenges in building SIs and USIs. As such, the analytical framework was divided into five schematic areas backed up by the reviewed literature from the previous primary step, as follows:

1) Type of sustainability indicator sets.
2) The sustainability perspective.
3) The weighting methods.
4) The aggregation methods.
5) The applied scale and spatialize USIs.

Out of the 620 publications, 461 documents were considered relevant to this step. The above five schematic areas were used as criteria to exclude any publication that does not explore one of the five mentioned aspects. For example, a publication is excluded and considered irrelevant within this step if it did NOT.

1) Investigate what type of sustainability indicator sets were used;
2) Define and consider any sustainability perspective;
3) Mention what weighting and aggregation methods were used to construct a SIs; and,
4) Apply the notion of spatializing and scaling of the system being examined.

The 461 publications considered relevant to this step were re-read entirely and qualitatively analyzed. This reviewed literature disclosed a substantial amount of what has been achieved in constructing sustainability indices since the 1990s. The 461 publications provided the researcher with the following to be reviewed:

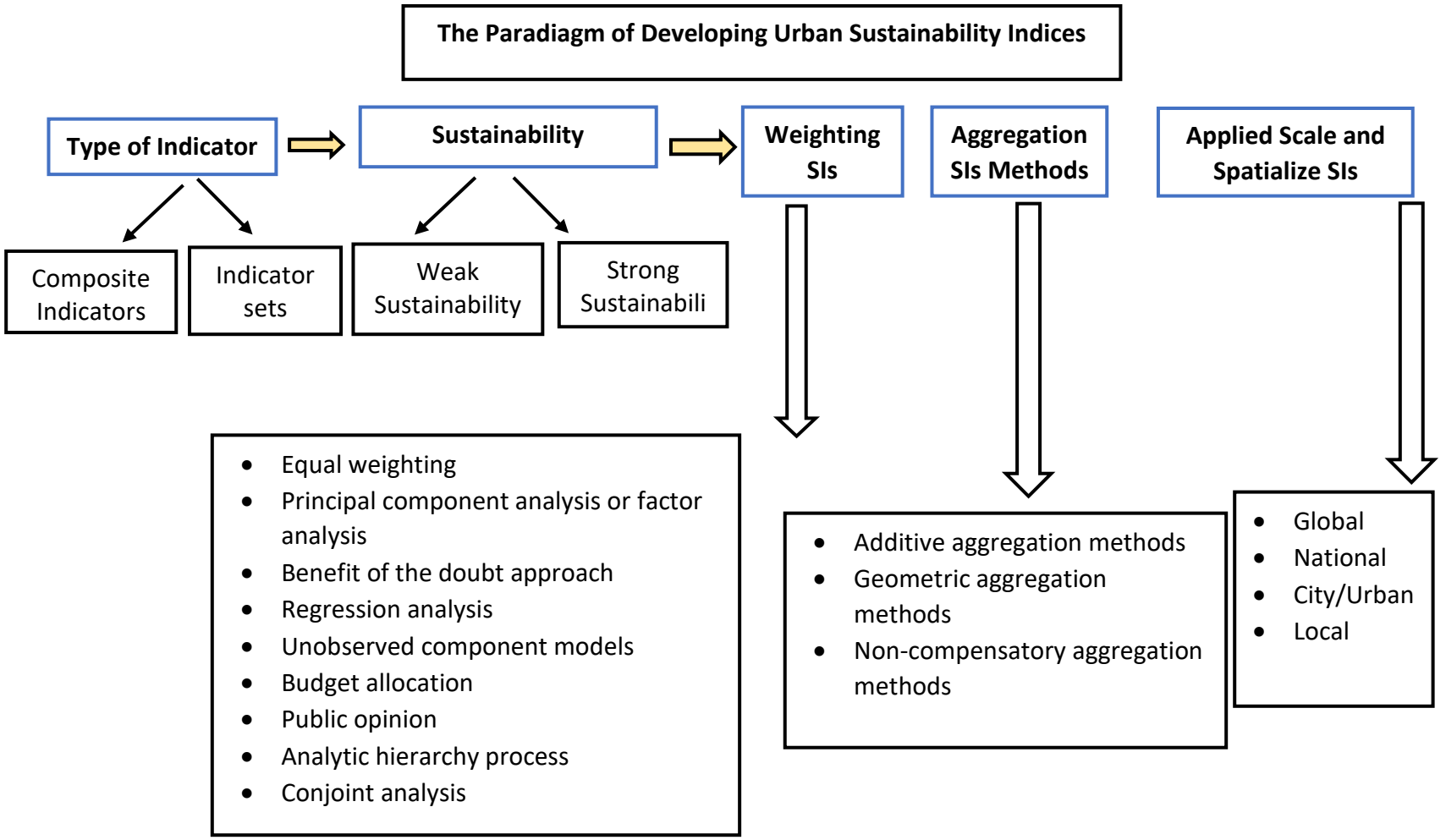
1) Case studies
2) Conceptual development, arguments, and fundamental debates
3) Issues and concerns to be addressed within any new index
4) Commonly utilized indices and recommendations to close the knowledge gap regarding developing potential indices.

At this point, the study provides fundamental qualitative findings from analyzing the 461 reviewed literature in order to absorb the conceptual analysis for further steps. These

qualitative findings will serve as references and establish fundamental approaches this researcher will adopt in building the index.

As mentioned earlier, five contractual schemes determine the form of an urban sustainability index. Figure 11 summarizes these five areas and their quantitative details. First of all, two types of sustainability indicators highlighted through the analyzed conceptual schemes will be used in constructing urban sustainability indices – indicator sets and composite indicators.

Figure 11: Conceptual Scheme for Analyzing Urban Sustainability Indices



It should be noted that while indicator sets (indicator frameworks) tend to come in a group of non-aggregated indicators, composite indicators are much like mathematical or computational models (Commission, 2008; L. Huang et al., 2015). Indicator sets are a conceptual structure based on sustainability principles and are mainly used through an indicator framework (Wu & Wu, 2012). Both types are heavily used to monitor progress toward sustainability's objectives (Gómez-Álvarez et al., 2018). The reviewed literature in this step showed there are three types of indicator sets based on the framework as follows:

1. Indicator sets based on the PSR/DPSR framework;
2. Indicator sets based on the theme-oriented framework;
3. Indicator sets based on the material and energy flow framework.

Among the 461 reviewed publications in this step, 65% adopted the PSR/DPSR framework to build their sustainability system, and 33% adopted the theme-oriented framework. Chapter two provided comprehensive details about these types of frameworks.

The third type of Indicator set is based on the material and energy flow framework (also known as a life cycle assessment). Among the 461 reviewed articles, roughly 2% adopted such a framework. The material and energy flow is a framework through which sustainability can be assessed to keep track of the input, output, and internal dynamics of energy and material within a system (Rizzo, 2017). However, this type of assessment fails to integrate different domains in a single index (Kotharkar et al., 2019) and therefore is excluded from this step as it does not align with the dissertation's ultimate goal.

Table 7 shows the researcher summarizes the normalization, weighting, and aggregation methods for the composite indicators and Indicators sets the researcher identified. This table was backed up by the literature review this step utilized. It shows that each measurement method gauges different systems on a divergent scale for various goals. The table also shows the sustainability perspective they gauge and the aggregation and weighting methods used in selecting SIs.

It is important to note that this step's reviewed literature stresses the importance of being vividly clear about what type of system SIs are measuring: weak or strong sustainability. This is especially significant in regard to the methods used to collect and weight SIs. The notion of sustainability perspective, weak vs. strong, has already been explained in chapter two. In short, as pointed by Heal (2012), the notion of weak and strong sustainability, which considers the fundamental two main types of SD, comes from the Brundtland Report. The field of environmental economics assumes that various types of capital (environment-natural, economic-human, and social) are substitutable (Wilson & Wu, 2017). However, strong sustainability focuses on natural capital and environmental functions (Mori & Christodoulou, 2012), which rejects the assumption of substitutability among the three capitals (Wilson & Wu, 2017). This notion has a relative correlation with methods of weighting and aggregating SIs.

This step's analytical framework analysis leads to informative reviews related to choosing appropriate weighting and aggregating methods for constructing SIs. In this regard, this research adopts Gan et al. (2017) statistical and quantitative findings to shed light on the most commonly used methods and to discuss their benefits and drawbacks depending on research objectives.

Table 7: The Methods of Measuring Urban Sustainability Systems

System	Normalization Methods	Weighting Methods	Aggregation Methods	Scale
PSR/DPSIR-based indicator sets	Standardized score	Equal or experts' opinions	Summation or Average or weighted average	Any
Theme-based indicator sets	Standardized score	Equal or experts' opinions	Summation or Average or weighted average	Any
Ecological Footprint	Global or hectares	Equal	Summation	Any
Green City Index	(1, 10)	Equal	Average	Urban
Environmental Performance Index	(0, 100)	PCA[3] or experts' opinions	Weighted average	Global or National
City Development Index	Distance from mean	PCA or expert's opinion	Weighted average	Urban
Genuine Progress Indicator	Monetized	Equal	Summation	Global or National
Genuine Savings	Monetized	Equal	Summation	Global or National
Human Development Index	(0, 1)	Equal	Average	Global or National
Happy Planet Index	(0, 100)	N/A	N/A	Global or National

[3] PCA: Principal Component Analysis

Table 7 (cont'd)

System	Normalization Methods	Weighting Methods	Aggregation Methods	Scale
Well-being Index	(0, 100)	Unequal or categorical	Weighted average	Global or National
Sustainable Society Index	(0, 10)	Unequal	Weighted average	Global or National

***Source**: Researcher based on the literature review*

The researcher adopts the particular study reviewed in this step because it is based on a synthesis of peer-reviewed journal articles, books, and reports from international organizations, governmental agencies, and research institutions. The researcher systematically analyzed 96 SIs by screening 1,417 research documents.

As a result of that synthesis, the researcher noted that Gan et al. (2017) concluded that aggregation methods could be categorized into additive, geometric, and non-compensatory methods. Additionally, different weighting methods symbolize different substitutability for different dimensions of SIs. The study showed that among the 96 SIs reviewed in the paper, 86.46% used an additive method, 46.88% adopted equal weighting methods, 21.88% adopted statistical-based methods, and 23. 95% adopted participatory-based methods. See Appendix A1 and A2 (adopted from Gan et al. (2017)) which provide an overview of a simple definition, a practical example, mathematical formulas, advantages, and disadvantages for each weighting and aggregation method.

Among the reviewed literature backed by the conceptual framework used in this step, practical issues and recommended remedies are pointed out to maximize the usefulness of SIs and move forward to advancing potential indices. First of all, Meadows (1998) pointed out that "sustainability indicators must be more than environmental indicators; they must be about time and/or thresholds; Development indicators should be more than growth indicators; they should be about efficiency, sufficiency, equity, and quality of life." (Meadows 1998, p.12). In light of these insights, and to evolve the SIs and indices, it is fundamental to increase participation levels from stakeholders of all kinds as Wu & Wu (2012) pointed out. To accomplish that goal,

Waas et al. (2014) endorse the need for "multiple perspectives - "top-down/expert-driven" and bottom-up/stakeholders-driven" integration.

Secondly, a study done by Böhringer & Jochem (2007) reviewed eleven sustainability indices and showed that composite sustainability indices (mentioned earlier in Table 3.1) fail to fulfill fundamental scientific requirements making them rather useless if not actually misleading concerning policy advice. The study focuses on further requirements for any meaningful SIs and indices, such as adequate normalization, aggregation, and weighting methods. For example, Böhringer & Jochem assert that it is possible to achieve a meaningful index if an arithmetic mean is employed, aggregation-based, and indicators scale considered. More importantly, the index, in general, should be "at least sufficient transparent in composition" (Böhringer and Jochem 2007, p.3).

Finally, Wilson & Wu (2017) provided concise mathematical forms for the types of SIs and what they represent. They focused on equal-weighted, additive SIs, and their connection to substitutability when the objective is to gauge weak sustainability. Moreover, Huang et al. (2015) concluded that urban sustainability indicators have technical issues of normalization, weighting, aggregation, and conceptual issues of indicator selection, boundary delineation, heterogeneity, scale, and strong versus weak sustainability. To overcome these problems, and advance the performance of the urban sustainability index, Huang et al. (2015) recommended the following:

1) The PSR and theme-based framework to be followed to compromise the inherent subjectivity and cognitive bias in the process of selecting SIs.

2) Cover the three sustainability pillars
3) Project objectives, scale, and strong versus weak need to be considered.
4) Include at least one strong sustainability indicator to avoid misleading interpretations by combining indicator sets and composite indices.
5) Follow rigorous methods for normalization, weighting, and aggregations

In addition to the insights gained from Wilson & Wu (2017), Gan et al. (2017) proposed a four-step process for working through the SIs issues identified above, but they also systematically discussed nine weighting methods and three aggregation methods for SIs. Their four-step process is as follows (Gan et al. 2017, p.500):

1) Clearly describe the purpose of developing or using SIs;
2) Determine the particular spatial and temporal scales at which the SIs are to be applied;
3) Be explicit about the specific type of sustainability that SIs are used to assessing; and
4) Conduct a comprehensive evaluation of the built SIs based on the previous three factors.

All in all, the analytical framework used in this step sheds light on crucial issues in selecting SIs and developing sustainability indices. The issues are concentrated around three fulcrums: level of participation and decision-making process, type of sustainability system under concern, and weighting and aggregation methods to select SIs. After analyzing the reviewed literature in this step, the researcher has concluded several methods, processes, and methodologies to be considered for further steps; all of which aim to enhance and maximize the efficiency of the urban sustainability index under investigation.

4.2.2 Step Two: Hierarchy of the Developed Methodological Framework

This step aims to explore how a collection of SIs, processes, approaches, and methodologies could be combined to develop a comprehensive and coherent picture of a conceptual urban sustainability framework. Instead of making the index in question more complex and compromise its usefulness, this step simplifies the many segregated approaches and presents them in one place. In other words, to select a simplified SIs system, the significant challenges to application and development shown in the previous step have been resolved throughout this step. To this end, this researcher proposes three rigorous, multi-criteria, and participatory processes to build the urban sustainability index for distressed places.

In chapter two and through the analytical analysis explained in the previous steps, constructal issues and misconceptions with SIs and indices, recommendations and methodologies to remedy these issues have been pointed out by a diversity of prominent scholars such as in (Bell & Morse, 2012, 2018; Gan et al., 2017; Gómez-Álvarez et al., 2018; Hák, Janoušková, & Moldan, 2016; Huang et al., 2015; Janoušková, Hák, & Moldan, 2018; Mischen et al., 2019; Mori & Christodoulou, 2012; Mori & Yamashita, 2015; Shang, Wu, Huang, & Wu, 2019; Verma & Raghubanshi, 2018; Waas et al., 2014; Wilson & Wu, 2017; Wu & Wu, 2012). To overcome these issues and misconceptions and optimize the developed conceptual and methodological framework's efficiency, the researcher conducted this step backed by step one's analytical framework.

In general, to fulfill the call that asserts the needs for intense conceptual and methodological work rather than merely the statistical production of the TBL (Tomáš Hák et al., 2016), this researcher adopts the Bellagio STAMP methodology ("Sustainability Assessment and

Measurement Principles" (Pintér, Hardi, Martinuzzi, & Hall, 2012), as a general guideline for this step. According to Waas et al. (2014), an ideal system of sustainability assessment should have a "starting point" and to be guided by four categories as follows:

1) Fostering sustainability objectives;
2) Adopting a holistic perspective;
3) Incorporating sustainability in the assessment process;
4) Supporting decisions.

Table 8 illustrates the generic characteristics of Bellagio's STAMP. For concrete guidelines and a useful Bellagio STAMP framework to assess progress toward SD, see Pintér et al., (2012). Incorporating the qualitative findings from the previous step with the four Bellagio STAMP categories leads the researcher to propose three rigorous, multi-criteria, and participatory processes to accomplish the ultimate goal of establishing a conceptual and methodological framework to build an urban sustainability index for distressed places. The following sections explain these three rigorous and multi-criteria procedures.

Table 8: The Characteristics of an Ideal Sustainability Assessment

Bellagio STAMP Categories	Ideal and Typical Characteristics
1. Fostering sustainability objectives	a) Inter/Intragenerational equity b) Geographical equity c) Interspecies equity d) Procedural equity
2. Adopting a holistic perspective	a) Assess the system as a whole, including it parts and their interactions b) Assess the system considering the different sustainability objectives together (*integration*) c) Assess dynamics and interactions between trends and drivers of change d) Adopt appropriate time horizon (*short, medium, and long term*) and (*geographica*l) scope
3. Incorporating sustainability in the assessment process	a) Consider the normative nature of sustainability b) Broad participation of stakeholders, including experts, while providing active leadership to the process c) Transparency regarding data (*sources, methods*), indicators, results, choices, assumptions, uncertainties, funding bodies and potential conflicts of interest d) Avoid irreversible risks and favors a precautionary approach e) Be responsive to change, including uncertainties and risks (dynamism)
4. Supporting decisions	a) Assessment of sustainability impacts and alternatives for decision-making, including synergies and trade-offs b) Establish formal and transparent synergy/trade-off rules c) Assessment is based on a conceptual sustainability framework and its indicators d) Ensure effective communications (*clear language, fair and objective, visualization tools and graphics, make data appropriately available*) e) Adapted to and integrated into the institutional context f) The iterative assessment process, starting at the onset of the decision-making process g) Develop and maintain adequate capacity h) Continuous learning and improvement

***Source**: Adapted from Waas et al. 2014, p.5518*

A) Foster an Inclusive Notion of Urban Sustainability

As stated by Wilson and Wu, "before sustainability can be measured, it must be concretely defined" (Wilson and Wu 2017, p.44). In other words, distressed place stakeholders of all levels must first clearly understand the notion of urban sustainability and determine its objectives.

Other scholars support building sustainability on a clear definition. For example, Huang, Wu, and Yan (2015) state that "how urban sustainability is defined certainly affects how its indicators are derived" (p. 1177). As a result of these academics' work, it is clear that the ultimate urban sustainability index must begin with a concrete definition. That concrete definition might be built upon a wide range of sustainability definitions used for various systems and case studies (as mentioned in chapter two) but should be supported by decision-making and a participatory process that reflects the local community. Stakeholders of all kinds and from all backgrounds should come together to share their knowledge about local conditions and needs. In other words, a multiple perspectives (integration) approach is highly recommended; one that utilizes community-based methods to determine the urban sustainability definition of the system (Waas et al., 2014).

The above-identified multiple perspective approach makes the foundation of the framework to construct an urban sustainability index as transparent as possible and interprets stakeholders' aspirations toward sustainability of the system in question. Those local aspirations should become the sustainability objectives to be achieved over a specific period. Whether single or multiple SIs measures are employed, each objective interpreted should reflect the stakeholders' vision and perception for the system’s further well-being. In other

words, stakeholders establish a human and environmental context for the system in question, and their needs and perceptions should be considered fundamental to success.

B) *Select Sustainability Projects and Initiatives as References*

This section explores the most relevant sustainability projects and initiatives provided by the body of work done on urban sustainability. Also, it serves as a "starting point" for selecting SIs and their themes for the researcher's proposed index.

First, among the 461 reviewed publications that laid the foundation for stage two, hundreds of studies, projects, and initiatives were based on measuring urban sustainability at various geographical scales but only 14 of them were conducted for cities, places, and communities. Some of which had already analyzed dozens of case studies. The criteria used to select these 14 urban sustainability initiatives was a local place-based system and each of these projects was initially intended for an urban, local, and community base-scale. Table 9 summarizes the number of SIs used in each study and its specific features to identify the selected references. To review the list of indicators for each reference, see Appendix A3.

Table 9: Summary of Sustainability Initiatives as References for the Study

Project/Initiative	Reference	Specific Features of Study	No. of Indicators
Ecological Footprint	(Rees, 1992)	Focuses on the environmental dimension of sustainability	3 sub-indices
Sustainable Seattle Indicators Project	(Seattle, 1993)	• Volunteer citizen's network and civic forum • Grassroots effort with the aim of improving economic, environmental, and social vitality	40
San Francisco Sustainability Plan	(City, 1996)	Achieving sustainability within a comprehensive plan	54
Measuring Taipei's Urban Sustainability	(S.-L. Huang et al., 1998)	• Conceptual Framework of SIs • Relies on the natural process and evolves urban development. • Selection of SIs based on participation (Bottom – up approach)	80
City Development Index	(UNCHS, 2001)	• Measures urban development • Evaluates urban poverty and governance	5 sub-indices
Sustainable Development Indicator Initiatives in Malaysia	(Nordin & Hezri, 2001)	Conceptual and theoretical basis for SIs. Indicators	48

Table 9 (cont'd)

Project/Initiative	Reference	Specific Features of Study	No. of Indicators
Central Texas Sustainability Indicators Project	(Parris & Kates, 2003)	• A community-based effort • Provides information about the progress toward sustainability	42
Santa Monica Sustainable City Plan	(Bertone, Parry, Kubani, & Wolch, 2006)	• Guides urban policy in the city	56
Green City Index	(Unit, 2009)	• Has assessed more than 120 cities worldwide • Assessing the environmental performance	30
United Nations Commissions on Human Settlements	(Michael et al., 2014; UN-Habitat, 2009)	Considers the feasibility and stability of data collection, the significance of correlation with public policy	40
Measuring the Sustainability in Cities: An Analysis of Use of Local Indicators	(Tanguay et al., 2010)	Analyses 17 local case studies that consist of 188 sustainability themes	188
Urban Sustainability Indicators in Mexico	(Hernández-Moreno & de Hoyos-Martínez, 2010)	Depends on Agenda 21 to identify the study indicators.	168
China's set of indicators	(Urban China Initiative, 2012)	Comprehensive five-part definition of sustainable development encompassing 21 individual indicators based on 21components	21

Table 9 (cont'd)

Project/Initiative	Reference	Specific Features of Study	No. of Indicators
Malaysia's Set of Indicators	(Michael et al., 2014; Shamsuddin & Rashid, 2013)	Categorized set of indicators under six dimensions and 21 themes that reflect the level of sustainability of towns in Malaysia	37
Taiwan's set of indicators	(Michael et al., 2014, p. 497)	Collection of indicators for sustainable development that were categorized into 12 themes	87
Measuring Urban Sustainability in Europe	(Meijering et al., 2018)	Identifies the most relevant definition of urban sustainability in a European context	28

C) *Construct the Overall Structure of the Framework*

In this section, the researcher will clarify the hierarchical structure for the proposed framework and the way it will be constructed. It proposes an integration of the Theme-based indicator framework and the PSR framework to safeguard the principle of an ideal urban sustainability index that interchangeably covers all three sustainability dimensions as recommended by L. Huang et al. (2015). Two components and one characteristic are identified to configure the organizational forms of the final conceptual framework. These framework components are as follows:

1) Triple Bottom Line of sustainability and Themes
2) SIs and Mathematical Calculations and Sustainability's goal.

As one structural framework, these components produce an ideal design; one that reflects the SMART characteristics. These characteristics will be explained throughout this part as subsections C.I and C.II. In addition, Table 10 clarifies the hierarchical structure of each component and its contexts.

C.I. Triple Bottom Line of Sustainability and Themes

The proposed framework organizes the entire structure according to the three pillars of sustainability (environment, economy, and society). The three pillars are strongly correlated with multiple-themes incorporated to expand each dimension around issues of policy relevance. The policy-driven themes clarify the system's sustainability objectives, mentioned in the previous step, and reflect the notion of urban sustainability within its context.

Table 10: The Hierarchical Structure of the Final Framework

TBL Sustainability	Theme (Category)	Indicator	SIs Calculation	Target
Economical Sustainability	Financial performance, Industry sector performance, etc	PSR/DPSIR	• Top-Down & Bottom-Up • Data Availability	Increase or Decrease
		Strong Economical sustainability Index	Mathematical Formula	
Social Sustainability	Health, Education, Housing, etc.	PSR/DPSIR	• Top-Down & Bottom-Up • Data Availability	Increase or Decrease
		Strong Social sustainability Index	Mathematical Formula	
Environmental Sustainability	Biodervisity, Land, Atmosphere, etc.	PSR/DPSIR	• Top-Down & Bottom-Up • Data Availability	Increase or Decrease
		Strong Environmental sustainability Index	Mathematical Formula	

Sustainability themes organize what needed to be measured to gauge the system's progress toward sustainability (UNECE, Eurostat, & Force, 2013). As mentioned in section A, the study adopts a participatory process among the system's stakeholders to fulfill the call of constructing a comprehensive, transparent and efficient index (Pintér et al., 2012; Waas et al., 2014). This process will guarantee that more influential stakeholders are involved. Consequently, the following questions need to be investigated by stakeholders to determine what the significant TBLs are to be considered in the system being examined:

- What components shape the system's three TBL (Social sustainability, Environmental sustainability, and Economic sustainability)?
- What are the areas of concern through which the system's sustainability progress is to be gauged? List as broadly as possible.

C.II. SIs, Mathematical Calculations, and Sustainability Target

This subsection's purpose is to select, normalize, aggregate, weigh, and collect data for SIs. The indicators measure the type of sustainability best suited within a relevant theme(s). The list of SIs derived from the sustainability projects and initiatives mentioned in subsection B (see appendix A3) can help substantiate what SI goes to what theme. However, the mechanism of SIs selection is not indiscriminate. Assigning an SI that corresponds with a theme is governed by the integration approach between Indicator Sets and Composite Indicators. The researcher has already mentioned the differences between these two kinds of SIs and their conceptual dynamics in step two.

This integration elevates the coverage of all three dimensions of sustainability (environment, economy, and society) and assures the consideration of at least one strong sustainability indicator (L. Huang et al., 2015). As mentioned in step two, the composite indicators are rigid and have fixed mathematical combinations for a set of indicators. It is obvious what composite indicators should be placed on the social sustainability theme as an example. Step two already explained what composite indicators cover what kind of sustainability dimension. However, the Indicator Sets framework has a more complicated approach.

Hereinafter, the researcher adopts a PSR/DPSIR framework related to questions based on Wu and Wu (Wu & Wu, 2012, p. 74) and Guy and Kibert (Bradley Guy & Kibert, 1998) to select what SI of the reference list mentioned earlier could be a candidate for this initial list. The set of the corresponding PSR/DPSIR frameworks questions are:

- Why is the state of our environmental and socio-economic system changing? In other words, what are the indicators that define the needs of the stakeholders of the system of concern (Driving Force SIs)?
- What is happening to the state of our environmental system? In other words, what is happening to our environmental and socioeconomic system? What indicators highlight the consequences of fulfilling the stakeholder's needs of the system of concern (Pressure SIs)?
- What are we doing about the changes in our environmental system and the underlying causes? In other words, what are the indicators that shed light on the stakeholder's actions to remedy the pressure on the system under consideration (Response SIs)?
- Do the indicators measure something related to the state of the system?

- Are the indicators' policy and objectives relevant to the sustainability of the system mentioned in subsection A?
- Are the indicators simple enough to be understood by ordinary people?
- Do the indicators respond quickly and measurably to changes?
- Do the indicators link environmental, economic, and social issues?

As mentioned before, the conceptual and methodological framework to build the ultimate sustainability index wholly relies on a participatory process. To this end, and for effectively investigating all the above questions, stakeholders should collaboratively participate. More specifically, a "Top-Down and Bottom-up" approach should be integrated (Mischen et al., 2019). This approach avoids the problem of external influence issues in the decision-making process for selecting SIs (Waas et al., 2014). Expert opinion is essential; yet, the point of the role of SI in stimulating vision, interpreting, and drawing constructive criticism based on the system's context is also critical. The system's background has a unique character and dynamics and although the notion of sustainability focuses on socioeconomic and environmental well-being, the relevant issues that will determine the system's future are varied. For example, daily income equal to or less than 1 USD will be meaningful, which is not the case for most developed places (Mori & Yamashita, 2015).

Given that this research investigates urban sustainability progress for distressed places over a single period, the final framework adopts a weak urban sustainability index for which an additive aggregation and a normalized equal weighting approach are employed.

To start with, the selection of SIs based on the previous task has to be standardized. This is achieved mathematically by using the mean and standard deviation of SIs values (Bell & Morse, 2012). Either of the following equations gives the standardized value:

Standardized SI = SI value – Mean / Standard deviation …….. (1)

Standardized SI = Mean – SI value / Standard deviation …… (2)

The criteria for selecting which equation to use in order to standardize SIs values is the sustainability target. In other words, if high SIs values are deemed to be "good" for sustainability (e.g., civic engagement), then increasing the SIs capital is desired and equation (1) should be applied (Bell & Morse, 2012). Otherwise, when high SIs values are deemed to be "bad" for sustainability (e.g., reduction in human health, air pollution), then decreasing the SIs capital is desired, and equation (2) should be applied (Bell & Morse, 2012).

Given the consequences of urban stress phenomena in general, this researcher leans toward the notion of weak sustainability. This means that substitution among TBL sustainability components is accessible (Wilson & Wu, 2017). Consequently, this study adopts an equal weighting approach to the system's TBL sustainability components. In other words, socioeconomic well-being is equally essential to the ecosystem and ecological services. This notion is backed by Munda & Nardo (2005), as they clarified that when all SIs are considered equally essential or when no statistical evidence supports a different scheme, equal weighting is always used. It should also be mentioned that this is recognized as the most straightforward strategy and can be quickly adopted by others (Land, 2006). This researcher has already mentioned what sustainability indices use equal weighting backed by the literature review.

The urban sustainability index in question is recognized as an additive index as it has employed an additive aggregation approach. The additive index is defined as "any index that is formed by the addition of any sub-indicators or indices." (Wilson and Wu 2017, p.45), or that employs " functions that sum up the normalized values of sub-indicators" (Gan et al. 2017, p.497). In this case, the economic index, for example, is initially the arithmetic mean of several corresponding normalized SIs. The same standard is applied to social and environmental indices. Practically speaking, the sum of several sub-indicators or the arithmetic mean of the standardized SIs is then found for each theme. To accomplish that, the average standardized SIs for each of them may take the following form:

$$Theme_i = (Stand\ SI_1 + Stand\ SI_2 + . . . + Stand\ SI_n)/ N \qquad (3)$$

Where i is the theme number, N is the total number of corresponding indicators. Equation (3) reiterates what Munda and Nardo asserted, namely that the contribution of all SIs can be added together to yield a total value (Munda & Nardo, 2005). Accordingly, the index in question is fundamentally the arithmetic mean of several sub-indices. It may take the following form:

$$USI = (Economic\_index + Social\_index + Enviromental\_index) / 3 \qquad (4)$$

Where USI is the ultimate yield of the index under question, each sub-index explicitly represents one TBL component's perspective.

4.3 Stage Three: Validation of the Developed Methodological Framework

The last stage of the methodology by which this study is conducted aims to validate the proposed conceptual and methodological framework to develop an urban sustainability index for distressed places through a case study. The researcher used a theoretical scenario to provide a hands-on guide to developing an urban sustainability index. The researcher then provided a case study to investigate whether the conceptual and methodological framework is reliable and successful.

4.3.1 Step One: Theoretical Scenario

This theoretical scenario provides a substantial hands-on guide to implementing the conceptual and methodological framework developed in the previous stages. The researcher visualizes a theoretical scenario for a generic local-based distressed place called "X" in which an urban sustainability index would be constructed to assess a weak urban sustainability system for a specific period.

As mentioned earlier, the researcher proposed three rigorous, multi-criteria, and participatory processes to accomplish the ultimate goal of establishing a conceptual and methodological framework to build an urban sustainability index for distressed places. In this part, the researcher explicitly explains these three procedures for the generic and hypothetical place called "X."

A) Foster an Inclusive Notion of Urban Sustainability

In terms of the local-based distressed place called "X" the recent and ongoing trend of the mainstream of urban sustainability focuses on the interchangeable relationship between well-being and total capital of the TBL; sustainability and well-being increase as the total capital of the system increase (Wilson & Wu, 2017). Therefore, for the place X, the UN-Habitat's definition might be adopted due to its emphasis on the essential role that cities play in environmental, social, and economic well-being (Hassan & Kotval-K, 2019).

As stated by the UN, "sustainable development of human settlements combines economic development, social development, and environmental protection, with full respect for all human rights and fundamental freedoms, including the right to development, and offers a means of achieving a world of greater stability and peace, built on an ethical and spiritual vision. Democracy, respect for human rights, transparent, representative and accountable government and administration in all sectors of society, as well as effective participation by civil society, are indispensable foundations for the realization of sustainable development" (HABITAT II 1996, p.12).

In light of the UN's insights, stakeholders of all kinds should follow a participatory approach to determine what vision and objectives need to be fulfilled. This task could be accomplished by conducting focus groups among stakeholders from diverse backgrounds such as local decision-makers, legislators, planners, data analysts, students, teachers, workers, farmers, transportation authorities, environmentalists, social workers, engineers, economists, public policy advocates, etc. To maintain the level of informed participation, the focus group can be

divided into several subgroups. Each subgroup would represent stakeholders who have knowledge in a particular area such as the economy, health, the environment, community participation, education, resource consumption, population, politics, etc. After being formed, each focus group should be asked to rank factors they consider to be essential for the place's sustainability. More specifically, the following questions need to be addressed in order to launch this step:

- What is the system the stakeholders are aiming to sustain?
- Do stakeholders agree with the adopted sustainability definition? If no, what is the stakeholders' definition?
- If stakeholders agree with the adopted sustainability definition, do they have any modifications they would make to the system's context in question?
- What objectives will be achieved within a specified period that makes the system more dynamic in terms of facing urgent, emergent, and potential challenges?
- Do these objectives align with the sustainability systems' definition mentioned earlier?

This step stimulates the stakeholders to visualize their place after a certain period. It starts with a concrete definition of the systems' sustainability and its objectives. The process follows a participatory approach among all stakeholders to help overcome any undue influence on the decision-making process. Specific questions guide the participatory process to come up with a vision of and objectives for a sustainable future for the place in question.

B) Select Sustainability Projects and Initiatives as References

The place "X" stakeholders should first review the foundation list of sustainability projects provided in Appendix A3. This list could be expanded based on the place's interest in broadening sustainability objectives and goals. At that point, the stakeholders need to answer these three questions.

- Over what space is sustainability to be achieved? (Bell and Morse 2012, p.14)
- Over what time is sustainability to be achieved? (Bell and Morse 2012, p.14)
- How many sustainability themes can the stakeholders identify from the list of reference projects?

C) Construct the Overall Structure of the Framework

I. Triple Bottom Line of Sustainability and Themes

For the place "X", the stakeholders incorporate the PSR framework with the significant and efficient list of SIs provided in subsection B. In short, each theme of the framework assigns a specific indicator that interprets particular issues within the urban system in question. For example, not meeting the stakeholder's needs, such as creating more jobs to combat poverty and unemployment, causes pressure on the system. As a result, combating poverty will be designated as a theme measured by the unemployment indicator rate. To take things further, let us assume that air pollution is a concern for the system being examined. Where air quality is a problem, stakeholders will seek candidate SIs from the subsection B list. Specifically, they need to find what SIs measure results of the air pollution issue. For example, as an option, an indicator in this situation could be the increasing cases of lung cancer for people who live near

polluted resources and a response indicator could be government policy toward minimizing air pollution sources. In general, the stakeholders need to ask these questions after selecting SIs by using the integration method:

- Are the selected SIs compiled using systematic and rigorous methods?
- Why is the state of our environmental and socioeconomic system changing? In other words, what are the indicators that define the needs of the stakeholders in the system being examined (Driving Force SIs)?
- How is the state of our environmental system changing? What is happening to our environmental and socioeconomic system? What indicators highlight the consequences of fulfilling the stakeholder's needs of the system in question (Pressure SIs)?
- What are we doing about the system's changes and underlying causes? In other words, what are the indicators that shed light on the stakeholder's actions to remedy the pressure on the system (Response SIs)?
- Do the indicators measure something related to the state of the system?
- Are the indicators' policy and objective relevant to the sustainability of the system mentioned in subsection A?
- Are the indicators simple enough to be understood by ordinary people?
- Do the indicators respond quickly and measurably to change?
- Do the indicators link environmental, economic, and social issues?

In order to explain and acknowledge the above "checklist" questions, Table 11 shows an example of how to integrate PSR and theme-based indicator sets with a composite indicator for the place "X".

Table 11: A Theoretical Example of Integrating PSR Framework and Composite Indicator

TBL	**Theme**	**PSR**	**Composite Indicator**
Economic Sustainability	• Economic • Housing	***Pressure***: Population Growth in the city under question ***State***: Combat Poverty ***Response*****:** Increase local government welfare programs ***Pressure***: Population Growth in the city under question ***State***: Promote internal and external investment in the housing sector ***Response***: a Tax break for Housing Development Corporations	City Development Index Green City Index
Social Sustainability	Civic Engagement	***Pressure***: Corruption and lack of governance ***State***: Encourage grass-root movement within the society ***Response***: Increase the number of NGO	
Environmental Sustainability	Air quality	***Pressure*****:** Population Growth ***State***: Combat traffic congestion as a cause of air pollution ***Response***: decrease the number of parking lots and adopt public transportation models for commuting.	

In light of the above and in order to complete building the index under investigation, efficient data resources to quantify the selected SIs are needed. Unfortunately, given the circumstances in any distressed place where resources to collect valuable data may be lacking, data limitation might be a continuing issue. Thus, a refinement process may be needed in most cases. As a broad example, in order to measure the air quality indicator, air pollution is usually used. However, suppose place "X" does not provide sufficient data about these measurements. In that case, stakeholders can use alternative measurements such as the amount of rain during the period or the number of dusty days since these alternative measures have a significant relationship to the Indicator at issue.

In order to clarify the process, stakeholders need to ask these data-driven questions to determine what resources are to be used for SIs data collection:

- Can the data be collected on a regular basis locally?
    - If yes, are they available, valid, and reliable?
    - If no, are there any external data resources?
- If there are external data resources, are they available, valid, and reliable?

In Table 12, a few examples were given to clarify the refinement process. For the sake of clarity, the themes, goals, target, and typical indicators/measurements were adopted from (Sirgy, Phillips, & Rahtz, 2009). The given tweaking indicators measures have been provided according to the above clarification. These alternative measures play an exemplary role and do not necessarily mean that they are the only options.

Table 12: Examples of Tweaking Process

Sustainability Theme	Goal	Target	Regular Indicator/ Measures	Tweaking Measures
Community Education and Civic Participation	Community members participate actively and effectively in civic affairs and community improvement efforts.	Upward trend	*Community involvement* = Percentage of residents who have attended a community event in the last year	*Community involvement* = Percentage of residents who have visited the public library in the city/year
Housing	Provide a mix of affordable, livable, and green housing types for people of all socioeconomic, cultural, and household groups.	Upward trend	*Availability of affordable housing* = Percentage of new and existing homes in the city affordable to very low, low, moderate, and upper-income families	*Availability of affordable housing* = Percentage of new housing projects in the city that designed for the upper-income families and under
Economic Development	Nurture a diverse, stable local economy that meets the basic needs of all segments of the community.	Upward trend	*Economic Diversity* = Percentage of total economic activity/output by business sector (expressed as a percentage of total wages)	*Economic Diversity* = • Percentage of total indirect investment per 10,000 residents in the city. • Percentage of green startups per 10,000 residents in the city. [4]

[4] This indicator has a multidimensional aspect (economic and environmental)

Table 12 (cont'd)

Sustainability Theme	Goal	Target	Regular Indicator/ Measures	Tweaking Measures
Environmental and Public Health	Minimize/eliminate the use of hazardous and toxic materials and the levels of pollutants entering the air, soil, and water.	Downward trend Reduce wastewater flows	*Wastewater* = Total citywide generation (also report per capita and by sector)	*Wastewater* = Number of leaking outdoor faucet in the city[5]
Transportation	Reduce traffic and pollution associated with transportation and ensure safe, efficient mobility and access for all.	Upward trend in the use of sustainable modes of transportation	*Modal Split* = Number of trips by type citywide	Green Transportation = Number hybrid public bus per 10,000 residents[6]
Resource Conservation	Decrease consumption of non-local, non-renewable, and non-recyclable energy, water, materials, and fuels. Reduce waste going to landfills and promote renewable resource use and sustainable purchasing.	Generation: do not exceed year 2000 levels by 201 Diversion: increase amount diverted to 70% of total by 2010	Solid-waste generation = ● Total citywide generation (also report per capita and by sector) Amount landfilled ● Amount diverted (recycled, composted, etc.) from landfill	Solid-waste generation = ● Average solid-waste generation per 10,000 residents ● Number of days landfilled do not get burned[7]

[5] This indicator has a multidimensional aspect (economic and environmental)
[6] This indicator has a multidimensional aspect (economic and environmental)
[7] This indicator has a multidimensional aspect (socio-economic and environmental)

The above questions emphasize that if the indicators are essential to use even if the data are not accessible or available, considering the possibility the data may be available in the future, these indicators must be considered for the last index. Appendix A3 has a good foundation of sustainability themes that can be used as references for this rigorous step. At this point, the ultimate urban sustainability index is semi-finalized and ready for the next task of determining the normalization, aggregation, and weighting approach.

II. SIs, Mathematical Calculations, and Sustainability Target

The place "X" adopts a weak urban sustainability index for which an additive aggregation and a normalized equal weighting approach is employed. Since place "X" adopts weak sustainability, the importance of each TBL sustainability component is equal. In other words, socioeconomic well-being is equally vital to environmental protection, ecosystem services, and ecological service. The following equations need to be applied to successfully compile the urban sustainability index for the place "X":

Standardized SI = SI value – Mean / Standard deviation …….. (1)

Standardized SI = Mean – SI value / Standard deviation ……..……(2)

$Theme_i$ = (Stand SI_1 + Stand SI_2 + . . . + Stand SI_n)/ N …….. (3)

USI = (Economic_index + Social_index + Enviromental_index) / 3……..(4)

4.3.2 Step Two: Implementing the Conceptual and Methodological Framework

In this final step, the researcher validates the developed conceptual and methodological framework using a case study. Chapter Five elaborates on the reasons why the researcher used this particular city. The case study will show how flexible and well-grounded the developed framework is when dealing with socioeconomic and environmental urban distress.

4.4 Summary

This chapter discussed the research methods and the methodology behind this dissertation. The researcher has adopted a mixed methodology**.** The mixed-methods consist of a systematic, holistic, multi-criteria, and integrated approach. Specifically, a two-stage exploratory design, a theoretical scenario, and a Case Study employed to address the following research question and its objective.

What is the conceptual and methodological framework to be employed to construct an urban sustainability index for a distressed place?

The two-stage exploratory design was used to investigate the contemporary concepts of Urban Sustainability and Distressed Areas. Then, the theoretical scenario applied for a generic distressed place called “X”. The researcher validates the developed conceptual and methodological framework using Duhok City as an empirical case study.

The theoretical scenario provided a substantial hands-on guide to implementing the conceptual and methodological framework developed in this chapter. The researcher visualized a theoretical scenario for a generic local-based distressed place called "X" in which an urban sustainability index was constructed to assess a weak urban sustainability system for a specific

period. The methodology's fundamental contribution to building urban sustainability indices for distressed places is captured by the three rigorous, multi-criteria, and participatory processes the researcher developed in this chapter.

The three rigorous processes consist of fostering an inclusive notion of urban sustainability, selecting sustainability indicators and projects as references, and constructing the overall structure of the framework. All of which were deliberately explained and provided step-by-step guidance. Particularly, understanding the methods of selecting urban sustainability indicators to monitor and observe urban sustainability progress for distressed places has been accomplished.

Chapter 5: Assessing Urban Sustainability for Distressed Urban Areas[8]

To validate the developed conceptual and methodological framework elaborated in chapter four and unpack the complex imagination about measuring urban sustainability in general, Duhok City as a case study used as empirical evidence. This case study provides a practical implementation of how to gauge urban sustainability progress in a distressed place through an urban index.

5.1 Abstract

In Iraq, the City of Duhok, as one of the Kurdistan Region's (KR) main cities, is concerned about sustainability but lacks the measures to guide urban policies. This study bridges this gap and offers an example of the use of urban sustainability indicators in an emerging region that experiences rapid urbanization and growth. This study's substantial objective was to develop a functional framework of indicators to assess and measure urban sustainability for the city after KR's declaration of autonomy in 1991 until 2010. That is, we limited our investigation to examining previous research, which decisively contains the approach to "measuring urban sustainability". The study followed a three-step approach to examine urban sustainability as an integration of a few other relevant studies. The study concluded with two facts: First, the lack of progress on urban sustainability in the first decades resulted from the destabilized era that left the city administratively fragmented. Second, the political and economic watershed led to steady progress towards urban sustainability post-2005. The study highlights nine urban sustainability indicators, from a total of 39 indicators, that played an essential role in navigating

[8] The following chapter contains material reproduced from an article published in the journal of *Sustainability* with the citation: Hassan, A.; Kotval-K, Z. A Framework for Measuring Urban Sustainability in an Emerging Region: The City of Duhok as a Case Study. *Sustainability* **2019**, *11*, 5402.

the general trend of urban sustainability in the city and how they can be used to promote future sustainable practices.

Keywords: measuring urban sustainability; sustainability indicators; emerging cities; Duhok; Kurdistan Region

5.2 Introduction

Urbanization and urban growth are the contemporary phenomena in urban settings. Cities and their environment, as Power noted, are constantly changing due to the dramatic increase in urban populations (Power, 2006). While 30% of the world's population was living in urban areas in the 1950s, recently around 54% live in urban areas, and that is projected to increase to 66% in 2050 (L. Huang et al., 2015; U Nations, 2014). More specifically, the developing world cities are expected to absorb 95% of urban growth by 2030 (Waas et al., 2014). Consequently, cities worldwide are increasingly recognizing the need to pursue a sustainability agenda to address the effects of urbanization and urban growth (Hodson & Marvin, 2010). However, sustainability goals cannot be achieved without local communities, governments, and citizens cooperating to meet sustainability's major challenges (Basiago, 1998).

One way to incorporate sustainability concerns into local planning programs is to develop and use urban sustainability indicators (USI) (Science for Environment Policy, 2015; Waas et al., 2014; Yigitcanlar et al., 2015). As noted in the literature, sustainability assessment frameworks such as USI are needed to monitor progress toward achieving sustainability goals and provide a basis for assessing whether policies, plans, and programs have the desired effects (Yigitcanlar et al., 2015; Yigitcanlar & Teriman, 2015). Consequently, the performance of urban dynamics in

cities could be gauged by using USIs that characterize cities' environmental, economic, and social performance.

In developing countries that experience rapid growth and change, in particular, there is an increasing need for an investigation that traces the impact of urban change on sustainability through time to provide valuable information needed for sustainable urban progress (Barredo & Demicheli, 2003; Drakakis-Smith, 1996). Many cities, regions, and countries adapt and use USIs to monitor progress toward achieving sustainability goals, but these cases tend to be in the developed world, with few measures explicitly designed for developing countries (see (Hasan & Adnan, 2002; Hernández-Moreno & de Hoyos-Martínez, 2010; L. Huang et al., 2015; Karlenzig et al., 2007; Lombardi & Brandon, 2007; Parris & Kates, 2003; Riposa, 2004; Seattle, 1993; Shen et al., 2011)).

The Kurdistan Region (KR) of northern Iraq, for example, is concerned about sustainability but lacks the measures to guide such policies. One of its main cities, Duhok, offers an example of the use of USI in an emerging region that experiences rapid urbanization and growth. Duhok is primarily a Kurdish city of over 400,000 people located in northern Iraq, and in some ways shows its resilience to past challenges, yet it faces political, economic, and environmental threats to its growth and quality of life (Natali, 2013; Omer, 2016; Raswol, 2017).

5.3 Objectives and Research Questions

This case study's objective was to develop a functional framework of indicators to assess and measure urban sustainability for Duhok City after KR's declaration of autonomy in 1991. Furthermore, the study addressed several fundamental issues for sustainability measures in the city. As such, this paper addresses the following research questions:

3) What kind of urban sustainability progress has the city achieved?
4) How is urban growth affecting the sustainability in Duhok City? In other words, what are the key factors that influence the pattern of urban sustainability, and how can they be used to promote future sustainable practices?

The approach adopted was to assess previous urban plans and policies that were drawn by the city's local government and decision-makers. As such, this paper underlines the appropriate urban policies which the city's authorities, urban planners, and decision-makers could use to make Duhok City more sustainable. Embracing the proposed policies would conserve and enhance local resources, safeguard human health and the environment, maintain a healthy and diverse economy, and improve the livability and quality of life for all of the city's residents.

5.4 Materials and Methods

To develop an urban sustainability indicators framework for Duhok City, existing systems were reviewed, but, as they were created for developed countries, it was necessary to refine the USIs for use in a development context and make an initial distinction between the desired goals for sustainability.

5.4.1 Review of Literature

The concept of sustainable development grew rapidly after 1987, when the World Commission on Environment and Development (WCED) published *Our Common Future* or the *Brundtland Report*. The report defines sustainable development (SD) as, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, p. 43). According to this definition, SD has three essential components (triple bottom line): the environment, including protection of ecosystems and natural resources; the economic, including economic vitality and growth; and equity, including issues of equity and social wellbeing (OECD, 2001; Waas et al., 2014; Yigitcanlar et al., 2015). In the urban context, however, the definition tends to be more explicit. The United Nations Human Settlements Programme (UN-Habitat) defines urban sustainable development (USD) as:

> Sustainable development of human settlements combines economic development, social development, and environmental protection, with full respect for all human rights and fundamental freedoms, including the right to development, and offers a means of achieving a world of greater stability and peace, built on an ethical and spiritual vision. Democracy, respect for human rights, transparent, representative and accountable government and administration in all sectors of society, as well as effective participation by civil society, are indispensable foundations for the realization of sustainable development (L. Huang et al., 2015, p. 1178).

The above definition of urban sustainability emphasizes the indispensable role that cities play in environmental, social, and economic wellbeing. Thus, this paper argues that cities play a

crucial role as well in responding to urban sustainability challenges. That is, cities are expected to respond to the urbanization and urban growth phenomena, and climate change thresholds.

5.4.2 The Objectives of Urban Sustainability

As some researchers point out, after a decade of announcing Brundtland's definition, over eighty different definitions of sustainability were already in the sustainability literature, reflecting the variation of sustainability objectives in general (Hardoy & Satterthwaite, 1991; Vojnovic, 2014). Four principles of sustainable development were derived from the Brundtland Report, which was the fundamental approach to advance global sustainability (P. W. G. Newman, 1999). The principles are as follows.

1) The elimination of poverty, especially in the Third Word, is necessary not just on humanitarian grounds but as an environmental issue.
2) The First World must reduce its consumption of resources and production of wastes.
3) Global cooperation on environmental issues is no longer a soft option.
4) Change toward sustainability can occur only with community-based approaches that take local cultures seriously.

In 1995, the European Environment Agency adopted five urban sustainability goals to pursue (Stanners & Bourdeau, 1995). These goals are:

1) Minimize the consumption of space and natural resources;
2) Rationalize and efficiently manage urban flows.
3) Protect the health of the urban population.
4) Ensure equal access to resources and services.

5) Maintain cultural and social diversity.

The primary notion of urban sustainability for the 21st century was “think global, act local” (Vojnovic, 2012). Local community-based efforts tend to put more emphasis on the participation of urban citizens (Munier, 2007). The recent reports of urban sustainability progress from different scales showed links between local actions and global interest in pursuing more advanced urban sustainability (Vojnovic, 2014). As such, the recent objectives of urban sustainability at the local-level have shifted to maintaining the mechanism of human well-being and ecosystem services (Elmqvist et al., 2013; L. Huang et al., 2015; Nassauer et al., 2014; Wu, 2010, 2014).

The recent trend of the mainstream of urban sustainability research focuses on the interchangeable relationship between well-being and total capital; sustainability and well-being increase as the system's total capital increases (Wilson & Wu, 2017). The relationship between ecosystem services and society are an essential component of urban sustainability (Nassauer et al., 2014). That is, conceptualization of urban sustainability based on cities culture, values, and unique urban ecosystem services are the recent trend that urban sustainability studies seem to focus on (L. Huang et al., 2015; Vojnovic, 2014; Wu, 2010, 2014).

Overall, the overall objectives focus on the enhancement of deep-rooted human well-being by ensuring the existence of a coherent triple bottom line of sustainability (Elmqvist et al., 2013; L. Huang et al., 2015). These objectives are:

1) Sufficiently reduce the consumption of natural resources and environmental damages.
2) Ensure democracy and equity between intra/inter generation.

3) Maximize resource use efficiency.

5.4.3 The Significance of Indicator-Based Sustainability Assessment

Sustainability assessment tools have been mushrooming through the development of research on sustainability. They help to assimilate into the necessary policies that respond to urgent conditions and bridge the past and present plans for future development goals (Hardi & Canada, 1997; Yigitcanlar et al., 2015). Waas et al. (2014) elucidated that a sustainability assessment is any process that aims to:

a) Contribute to a better understanding of the meaning of sustainability and its contextual interpretation (interpretation challenge).
b) Integrate sustainability issues into decision-making by identifying and assessing (past and or future) sustainability impacts (information-structuring challenge).
c) Foster sustainability objectives (influence challenge).

Sustainability indicators are one of the fundamental apparatuses of sustainability assessment that help acknowledge the up-to-date development situation and concede whether sustainability objectives are being met (Yigitcanlar et al., 2015; Yigitcanlar & Teriman, 2015). Fiksel et al. (2013) defined a sustainability indicator as "a measurable aspect of environmental, economic, or social systems that is useful for monitoring changes in system characteristics relevant to the continuation of human and environmental well-being" (p. 6). As such, measurable sustainability indicators are desired since city planners, managers, and policymakers employ them in the decision-making process to help them gauge the socio-

economic and environmental impact of urban development (Hernández-Moreno & de Hoyos-Martínez, 2010; Science for Environment Policy, 2015; Shen et al., 2011).

Sustainability indicators can measure two dimensions, namely sustainability attributes such as socio-economic (equity, health, education, housing, and population) or environmental attributes (land, biodiversity, atmosphere, and freshwater), and include frameworks such as the Driving force–Pressure–State–Impact–Response (DPSIR) indicators (Singh et al., 2012; Waas et al., 2014). The DPSIR indicator framework, which is expanded by the European Environment Agency based on the OECD's sustainability indicator framework, is considered the most widely adopted framework to provide a holistic socio-economic and environmental analysis (Yigitcanlar et al., 2015) (see (Niemeijer & de Groot, 2008; Segnestam et al., 2003) for more details about DPSIR). Through the use of sustainability frameworks, many researchers have been investigating to what extent cities are approaching sustainability (Hasan & Adnan, 2002; Hernández-Moreno & de Hoyos-Martínez, 2010; L. Huang et al., 2015; Karlenzig et al., 2007; Lombardi & Brandon, 2007; Parris & Kates, 2003; Riposa, 2004; Seattle, 1993; Shen et al., 2011).

In sum, cities are increasingly concerned with developing sustainability assessment tools for gauging performance and progress towards urban sustainability. Sustainability indicators are essential tools to pursue the trend of sustainability in cities. Developing an indicator-based sustainability assessment provides accurate information about the performance towards sustainability in an urban context.

5.4.4 Weak and Strong Sustainability

The notion of weak and strong sustainability as the two main approaches to sustainable development comes from the Brundtland Report (Heal, 2012). On the one hand, weak sustainability deals with maintaining a combined substitutable stock of all capitals: natural, human, and social capitals. This means natural capital has the same importance as other capitals (Nourry, 2008). As such, this approach is perfectly substitutable for natural capital and human and social capitals(Ayres et al., 2001).

On the other hand, strong sustainability does not allow substitution among capitals. It gives an essential position to natural capital, which is non-substitutable as any conversion of natural capital to other forms is unacceptable (Mori & Christodoulou, 2012; Nourry, 2008; Wilson & Wu, 2017). That is, if the overall capital does not decline as a result of conserving natural and ecosystem stocks, strong sustainability is achieved (Ayres et al., 2001; Pearce et al., 1994).

In other words, sustainability and well-being increase as the total capital within the system (in this case, a city) increases (Pearce et al., 1994); however, cities have negative impacts on environmental capital (Mori & Christodoulou, 2012). The bottom line here is that the purpose of weak sustainability is to increase total capital stock; however, ecological systems are non-substitutable (Mori & Christodoulou, 2012; Wilson & Wu, 2017). Therefore, measuring strong sustainability in an urban context can be convoluted because of the actual lack of specific forms of natural capital in urban areas' boundaries, but it is still crucial to consider natural capital in measuring sustainability (Wilson & Wu, 2017).

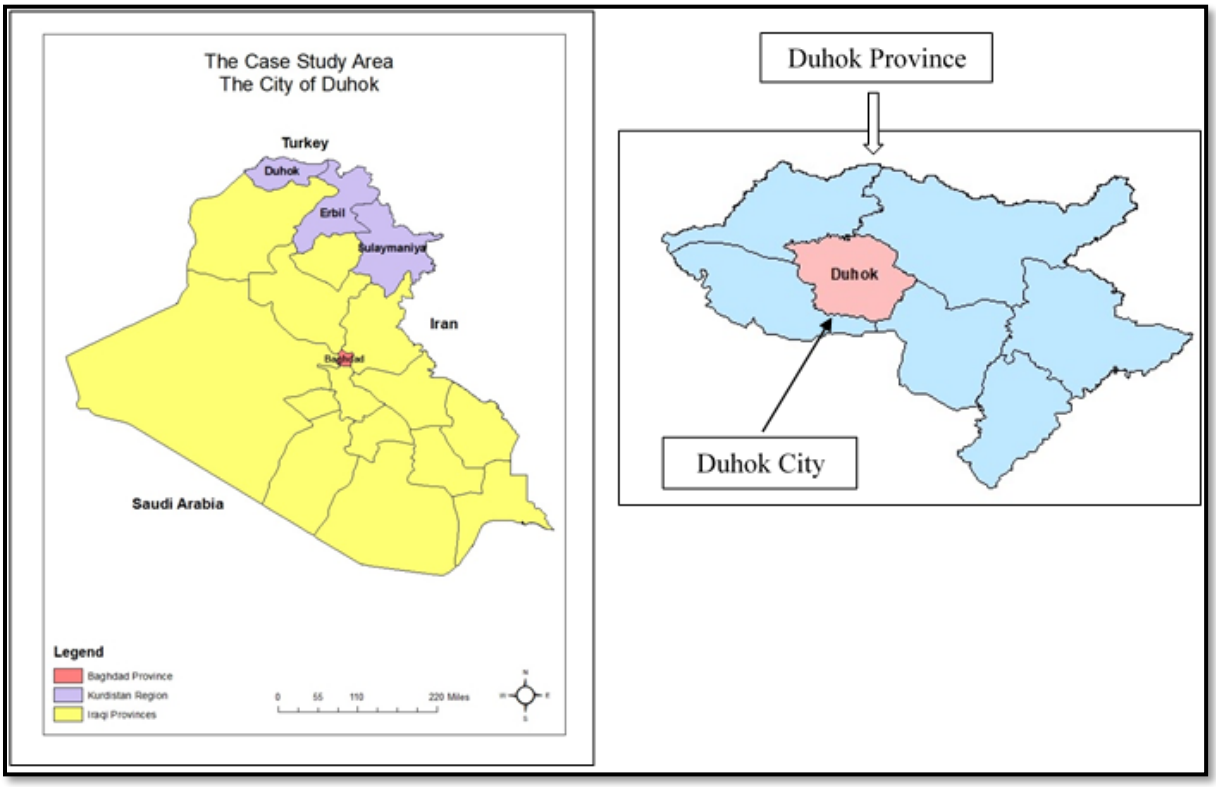
Although tremendous efforts to measure sustainability have been mushrooming, there is a lack of measures in emerging regions. This study bridges the gap in urban sustainability science literature and provides an example of a region that experiences new democracy, rapid urbanization, and growth.

5.4.5 The Case Study Area and Its Sustainability Objectives

Duhok City (Figure 12) is at the center of Duhok Province in the autonomous Kurdistan Region in Iraq and was built in 1887 during the Ottoman caliphate (Kurdistan Board of Investment, n.d.; Omer, 2016). The city spans over 36 square miles (A. O. Mohammed, 2013) and occupies the valley between the two mountains to the north and south, Bekhair and Zaiwa, respectively (Mustafa, Ali, & Saleh, 2012). It also is Iraq's northern gateway to trade with Turkey and Europe in general. As such, the city has a strategic location that provides an important economic role for the Iraqi Kurdistan Region (H. Mohammed & Ali, 2014; Mustafa et al., 2012; Omer, 2016; Othman, 2014; Taha, 2012). More importantly, it has a diverse cultural fabric, both ethnic and religious, and the majority of the population are Kurds, with minority groups of Assyrians, Chaldeans, Arabs, and Armenians (H. Mohammed & Ali, 2014; Othman, 2014; Taha, 2012).

Duhok City is a valuable case because it has been continuously experiencing dramatic urban growth resulting in serious environmental and economic challenges (A. O. Mohammed, 2013; Omer, 2016). The rapid urban growth is due mainly to migration from other parts of Iraq (conflict refugees) seeking a stable environment (Eklund, 2012; Natali, 2013).

Figure 12: The Case Study Site



The population increased from 5621 inhabitants in 1947 to more than 300,000 inhabitants in 2014 (see Table 13 and Table 14), with subsequent impacts on the environment and social wellbeing (Omer, 2016; Raswol, 2017). The city of Duhok is noted as a mid-sized town, but, due to the pressure of population growth, it should be classified as a highly-urbanized city (Mustafa et al., 2012; Omer, 2016; Raswol, 2017). The population growth has been increasing by 6.4-6.8% per year over the past few years (KRG, 2009). The demographic growth in the metropolitan area of the city has been projected to increase from 325,000 to 605,000 inhabitants between 2007 and 2032 (KRG, 2009).

Table 13: Urban Area Growth Rate of Duhok City During 1947–2014

Year	1947	1977	1990	2003	2008	2014
Urban Area (Hectare)	76.9	1058.7	853	2173.7	4096.5	10763.2
Urban Growth Rate %		90.99	19.43	51.3	46.94	61.94

***Source**: Adopted from (Raswol, 2017, p. 335)*[9]

Table 14: Population Growth Rate of Duhok City During 1947–2014

Year	1947–1957	1957–1967	1967–1977	1977–1987	1987–1997	1997–2007	2007–2014
Population Growth Rate Percent	3.17	6.37	15.27	23.57	34.57	52.07	55.47

***Source**: Adopted from (Omer, 2016; Raswol, 2017).*

As denoted by some researchers, the city has witnessed rapid expansion in the urban areas; nevertheless, such rapid expansions have occurred between what the city's authorities plan for and the status quo. The urban expansion proceeded largely in an east-west direction with most development occurring between 1973 and 1984 as well as between 1986 and 1994 and in particular after 2006 (A. O. Mohammed, 2013; H. Mohammed & Ali, 2014; Omer, 2016; Raswol, 2017). For example, the urban area of the city was dramatically increased from 10.25 ha in 1923 to 224.58 ha in 1977, and then from 535.83 ha in 1987 to 2794.6 ha in 2007 (KRG, 2009). According to Raswol (2017), the area of urban land increased by 79.8% between 2004 and 2014. Table 1 provides the urban growth changes from 1947 to 2014 periodically.

Such phenomena have dire consequences on many sectors in the city. For example, the city government has limited ability to address the economic and social needs of the people. In addition, it faces air and water pollution (U Nations, 2014; UNHCR, 2007). Worse, as climate

[9] The researcher converted the original table from km^2 to ha

change impacts the city, a very harsh drought-affected people's lives in the city and its surrounding area (U Nations, 2014; UNHCR, 2007). The supply of fundamental social needs such as drinking water, electricity, and affordable housing has been the base of intense social struggle in the city. For instance, Duhok has not had a stable power supply since 1990. It always has outages, and many households have diesel-operated generators, which leads to great atmospheric pollution in the city (KRG, 2009). According to Duhok's Environment Protection Department, Duhok City has been more toxic than ever due to the 2000 registered power generators (Shilani, 2019). In addition, Eklund (2012) showed that there is a significant decline in rainy season in the city due to the changes in climatic conditions. During the hydrological years 2006–2009, the accumulated rainfall dropped to almost 50% below the 2000–2010 total average of 368 mm Ibrahim, Rasul, Ali Hamid, Ali, & Dewana (2019).

Duhok's 2032 Master Plan has a set of goals, objectives, and strategies that together describe the path towards Duhok 2032 as a result of extensive participation among Duhok's residents and official public collaboration. Through this Master Plan, the City of Duhok has endorsed these principles of SD (KRG, 2009).

1) Urban development in the city intends to take a balanced approach based on economic vitality, social equity, environmental preservation, and respect for the needs of future generations.
2) Urban planning and development decisions will be made in a way that encourages citizen involvement and respects the results of public consultations.
3) Duhok must provide a pleasant environment and diverse urban experiences to its citizens and visitors.

4) Adopt principles of universal accessibility by which all residents have access to all of the City's public facilities and spaces, as well as buildings both public and private.
5) To improve the quality of life of the city's residents, the master plan supports an ensemble of measures linked to the quality of dwellings, public facilities, nature areas, and the environment.
6) Reinforce the linkage between the various areas of urban activity to avoid urban sprawl due to the dramatic projected demographic growth between 2007 and 2032.
7) Improve the cost-effectiveness of urban infrastructure and reduce the cost of the city's related maintenance and rehabilitation costs.
8) Improve the quality of architecture and urban landscape to orient the culture of the city toward better urban design.

5.5 Methodology to Develop the Urban Sustainability Framework for Duhok City

The approach and model to be considered for measuring urban sustainability have long been debated as there is no prominent index by which we may reach a state of consensus on the methodologies which should be adopted in this emerging region. Thus, we limited our investigation to examining previous research which decisively contains the approach to measuring urban sustainability, and follow a similar approach (Hasan & Adnan, 2002; Hernández-Moreno & de Hoyos-Martínez, 2010; L. Huang et al., 2015; Karlenzig et al., 2007; Lombardi & Brandon, 2007; Parris & Kates, 2003; Riposa, 2004; Seattle, 1993; Shen et al., 2011; Yigitcanlar & Teriman, 2015). This study consisted of three main steps of analysis by which the urban sustainability framework of the city of Duhok was created.

5.5.1 Step 1: Adopt DPSIR

Based on the triple bottom line of SD, the proposed framework that measures urban sustainability in Duhok City deals with a variety of aspects of cities such as environment, economic, and social. The present study considered the most common uses of the DPSIR to elevate the usefulness of USIs by comprehensively reviewing several leading international examples (e.g., (Hasan & Adnan, 2002; Hernández-Moreno & de Hoyos-Martínez, 2010; L. Huang et al., 2015; Karlenzig et al., 2007; Lombardi & Brandon, 2007; Parris & Kates, 2003; Riposa, 2004; Seattle, 1993; Shen et al., 2011; Yigitcanlar & Teriman, 2015)).

The study assimilated the main urban sustainability themes and indicators adopted by the reviewed studies and employed the DPSIR concept for Duhok City simultaneously. For the study system such as in Duhok City, “Driving force” indicators define the needs of Duhok City people such as creating more jobs and enhancing the city’s infrastructure. The “Pressure” indicators

highlight the consequences of meeting such needs. For instance, air pollution is one of the main concerns that Duhok people consider. The “State” indicators reveal a descriptive analysis of the pressure indicators such as the rapid urbanization rate in Duhok City. The “Impacts” indicators explain what would happen if the city’s authorities take no action to overcome the pressure indicators. For example, the city was expected to experience a shortage in housing supply if the city’s decision-makers proposed no further investment initiatives. The “Response” indicators identify the planning implementation, urban policies, and regulations the city’s authorities had taken or could take, such as the planning regulations the city adopted to fight urban sprawl.

As a foundation for an indicator that could be used for Duhok City’s urban sustainability framework, Table 15 presents a categorization of the pool of 140 USIs collected throughout the reviewed studies. The study implemented the DPSIR framework to determine which categories among those that shaped the 140 USIs should be kept, merged, or eliminated. For example, the Environment and Public Health category in Table 16 was derived from merging two categories in Table 15. However, the Natural Resources and Resources Conversation categories listed in Table 15 were dropped as they do not constitute the city’s 2032 vision. In other words, the City’s Master Plan does not mention or endorse principles of SD that have the notion of natural resources preservation.

To determine what indicators could be adopted from the case studies the study reviewed or must be derived (do not exist in the reviewed case studies), the study followed the rigorous criteria shown in Step 2.

Table 15: Initial Set of Indicators Reviewed by Category

Categories	No. of Indicators	Categories	No. of Indicators
Environment	10	**Housing**	6
Environment and Public health	9	**Housing and Education**	7
Transportation	15	**Natural Resources**	5
Changing our mode of transportation	1	**Resources Conservation**	6
Economy	15	**Youth and Education**	2
Economic Development	11	**Children and Education**	3
Land Use	4		
Land Use/Mobility	5	**Community education and Civic participation**	7
Open Space and Land Use	5	**Education and Community**	7
Land Use in Urban Area	1	**Health and Community**	4
Population and household	4	**Safety and Health**	5
Demography	5	**Personal Health and well-being**	3

***Source**: Adopted from (Hasan & Adnan, 2002; Hernández-Moreno & de Hoyos-Martínez, 2010; L. Huang et al., 2015; Karlenzig et al., 2007; Lombardi & Brandon, 2007; Parris & Kates, 2003; Riposa, 2004; Seattle, 1993; Shen et al., 2011; Yigitcanlar & Teriman, 2015).*

5.5.2 Step 2: Finalize the List of Urban Sustainability Indicators

To finalize the USI framework to be used to measure and assess urban sustainability in the city of Duhok, three fundamental criteria were employed simultaneously:

a) City's vision to pursue sustainable development and community leaders' perspective;

b) SMART characteristics; and,

c) Data availability.

The final list consists of nine comprehensive urban sustainability categories that measure 39 indicators. Table 16 illustrates the proposed and implemented framework that measures urban sustainability in Duhok City. The first criterion to be applied to the proposed framework included the city's vision to pursue SD and experts' perspectives. The City's Master Plan 2032 vision to pursue SD was used as a benchmark to apply the DPSIR. It reveals seven fundamental long-term objectives that reflect the aspirations toward SD (Omer, 2016). These long-term sustainability objectives are mentioned in the case study and its sustainability objectives section.

Table 16: Urban Sustainability Framework of the City of Duhok

Category/Indicator	Calculation	Notes
Environment and Public Health		
General air quality	1. Annual Average Rainfall (mm)	More is better
	2. Yearly-Average dust fall (g/m^2/year)	Less is better
Volume of air pollution per 10,000 inhabitants	(Number of new cars registered in the city/Total population) × 10,000	Less is better
Waste generation per 10,000 inhabitants	(Amount of waste generation (kg per capita/year) × 10,000	Less is better
Energy consumption per household	Amount of electric power consumption (MW-h per year)/Total household	Less is better
Transportation		
Car ownership rate	(Total number of registered cars/Total population)	Less is better
Traffic system safety per 10,000 inhabitants	(Injuries in road traffic accidents/Total population) × 10,000	Less is better
Economic and Urban Development		
Employment rate	The number employed/Labor force	More is better
Unemployment rate	The number of unemployed/Labor force	Less is better
Rate of capital investment projects	(Number of capital investment projects in the city/Total capital investment projects in the province)	More is better
New buildings permit issued rate	Number of new building permits issued/Total permits	Has two tails
Rezoning permits issued rate	Number of rezoning building permits issued/Total permits	More is better
Building renovation permits issued rate	Number of renovation building permits issued/Total permits	More is better
Mixed-use property permits issued rate	Number of mixed-use property permits issued/Total permits	More is better
Manufacturers permit issued rate	Manufacturers permits issued/Total permits	Has two tails
Hotels and motels permit issued rate	Number of hotels and motels issued permits/Total permits	More is better

Table 16 (cont'd)

Category/Indicator	Calculation	Notes
Land Use and Open Space		
Percentage of residential areas	(Area of residential land/Total area) × 100	Less is better
Percentage of commercial areas	(Area of commercial/Total area) × 100	Less is better
Percentage of public services areas	(Area of public services/Total area) × 100	More is better
Percentage of industrial areas	(Area of industrial/Total area) × 100	Has two tails
Percentage of tourist facility areas	(Area of tourist facility areas/Total area) × 100	More is better
Percentage of transportation areas	(Area of transportation/Total area) × 100	More is better
Percentage of green open space	(Area of cemetery and green area/Total area) × 100	More is better
Population Demography and Household		
Population growth	Total population change per year during 1990–2000	Less is better
Population density	Total population/Total area (Hec)	Less is better
Average household size	Total population/Total households	More is better
Percentage of urban population	Total population in urban area/Total population	Has two tails
Housing		
Rate of new housing permits	(Number of new housing units permits issued/Total permits) × 100	More is better
Rate of permits issued for new construction of new apartments	(Number of apartment housing permits/Total permits) × 100	More is better
Housing investment projects per 100,000 inhabitants	(Number of housing investment projects/Total population) × 100,000	More is better
Education and Community		
Rate of new schools	(Number of new schools/total past schools) × 100	More is better
Quality in education	No. of students per teacher = (Number of Students/Number of teachers)	Less is better
Equity in education	No. of students per classroom = (Number of students/Number of classroom)	Less is better
Level of educational Attainment	Number of college completion adults/Total population	More is better

Table 16 (cont'd)

Category/Indicator	Calculation	Notes
Health and Community		
Number of hospitals per 100,000 inhabitants	(Number of hospitals/total population) × 100,000	More is better
General health status per 100,000 inhabitants	(Number of registered patients in the hospitals/total population) × 100,000	Less is better
Number of medical staffs per 100,000 inhabitants	(Number physicians/total population) × 100,000	More is better
Infant mortality rate per 100,000 live birth	(Number of infants' mortality less than one year/Total births) × 100,000	Less is better
Community and Civic Engagement		
Number of NGOs per 10,000 inhabitants	(Number of NGOs/total population) × 10,000	More is better
Annual library visits per capita	(Total annual library visits/Total Population)	More is better

The City's Master Plan 2032 was done through a collaboration between a foreign consultant company and the Directorate of urban planning in Duhok governorate, Ministry of Municipalities and Tourism, Kurdistan Regional Government, Iraq. Local consultants, specialist, and the city's residents participated in intensive focus groups, questionnaires, and surveys to represent the perspective of the City's people and reduce the influence of international perspectives. Four technical reports were presented to the focus groups, respectively, by which SWOT (Strengths, Weaknesses, Opportunities and Threats) and scenarios were provided to show the progress towards the final draft of the master plan.

Simultaneously, various experts, represented by the local authorities and decision-makers, were consulted to address the comprehensive dimensions of the selected indicators from their perspective. Thirty-seven professionals, local authorities, and decision-makers were interviewed by employing a snowball sampling technique. Below are the locations where the 37 participants were selected.

1) The Directorate of Electricity in Duhok Governorate;
2) The Directorate of Health in Duhok Governorate;
3) The Directorate of Education in Duhok Governorate;
4) The Directorate of Water and Sewage in Duhok Governorate;
5) The Directorate of Environment and Water in Duhok Governorate;
6) The Directorate of Municipalities in Duhok Governorate;
7) The Directorate of Urban Planning in Duhok Governorate;
8) Duhok Governorate Council;
9) Spatial planning Department at the University of Duhok;

10) The Directorate of NGO's in Duhok Governorate; and,

11) Duhok's Local Library.

Employing the sustainability objectives and pursuing the experts' perspective assisted this study to fulfill community-based bottom-up and top-down approaches, which are strongly recommended to develop any potential urban sustainability framework (Hernández-Moreno & de Hoyos-Martínez, 2010; L. Huang et al., 2015; Mori & Christodoulou, 2012; Waas et al., 2014).

The second criterion involved considering the comprehensive characteristics of USIs. Each indicator of the final 39 has SMART (Specific, Measurable, Achievable, Relevant, and Time-related) characteristics (Shen et al., 2011). The study selected only representative, reliable, feasible, and measurable indicators to reflect the dynamics of urban systems in the city of Duhok. For instance, as shown in Table 3, 10 indicators could be used to measure the capital of Environment. The study, however, used just four indicators, as shown in Table 16. Those four indicators have specific and measurable goals for the city of Duhok. In addition, they are relevant to the city's 2032 vision according to the local authorities' perspective.

Finally, data availability, validity, and reliability (Commission, 2008; OECD, 2001) were considered as a criterion for selecting the final pool of 39 indicators. A challenge in the development of the urban sustainability framework for Duhok City was the wide variation in the availability of data on all urban sustainability aspects, but specifically the public health and environment aspects.

5.5.3 Step 2: Data Collection, Measuring, and Statistical Analyses

This study used available data for the period 1990–2010. The proposed urban sustainability framework was operationalized using data from various local and national censuses of the Republic of Iraq as well as international censuses (see Appendix A4). The selected indicators were measured in different units such as hectare, persons, percentage, g/m^2/month, etc. that required normalization. The approach adopted was to construct a z-score for each indicator using the following formula (Commission, 2008):

$$Zx = \frac{Xi - \mu x}{\sigma x} \quad (1)$$

where Zx is the z-score for Xi value of the observation, μx is the mean value of each indicator, and σx is the standard deviation of the indicators. The z-score was calculated for the 39 indicators by using the IBM SPSS Statistics 24. Principle Component Analysis (PCA) was then used to do the following:

1) Test the significance of the USIs framework of the study area.
2) Explore the factors that influence the pattern of urban sustainability in Duhok City, and how they can be used to promote future sustainable practices.

As shown in Table 16, the final urban sustainability framework to measure and assess urban sustainability in Duhok City was determined by finding the average of the urban sustainability categories (see Equation (2)): Environmental and Public Health (EPH); Transportation (T); Economic and Urban Development (EUD); Land Use and Open Space (LUOS); Population Demography and Household (PDH); Housing (H); Education and Community (EC); Health and Community (HC); and Community and Civic Engagement (CCE).

The Urban sustainability in the City of Duhok was measured as follows:

$$USi = 1/9\ (EPHi + Ti + EUDi + LUOSi + PDHi + Hi + ECi + HCi + CCEi) \quad (2)$$

where (i) is the year when the data were collected for each category. Each category was measured by using a certain set of indicators. For example, as stated in Equation (3), the EPH was measured by four indicators: air quality, volume of air pollution per 10,000 inhabitants, waste generation per 10,000 inhabitants, and energy consumption per household.

Hence, the association among the indicators were determined by DPSIR, as mentioned above, thus Equation (3) shows that specific indicators are supposed to decline to achieve positive progress toward urban sustainability. For example, to achieve progress toward sustainability, the level of air pollution in the city must decrease. See Table 4 for more details about the remaining categories.

$$EPH = \text{Air quality} - \text{volume of air pollution per 10,000 inhabitants} - \text{waste generation per 10,000 inhabitants} - \text{energy consumption per household} \quad (3)$$

Chapter 6: Results and Discussion[10]

In this chapter, results, discussion, and recommendations are stated according to findings drawn from the case study of Duhok City. Furthermore, the researcher addresses the essential research questions presented in chapters one and four. The major results shed light on a comprehensive understanding of urban sustainability in distressed places and communities. Thus, this chapter has been subdivided to present notion of distressed places and urban sustainability in Duhok City.

6.1 Notion of Distressed Places

The first objective of this research study was *Advancing the Knowledge of Distressed Urban Areas.* In order to investigate all kinds of distressed urban areas in the urbanized world and identify factors that distinguish distressed places from others, this study proposes three primary research questions:

1) *What is the definition of a distressed place?*
2) *What are the characteristics of distressed places?*
3) *To what extent can a taxonomy be created of distressed places?*

Even though the phenomena of distressed urban areas was evident in the literature review starting in the 1960s, analysis shows an absence of a concise definition that comprehensively understands its characteristics. In fact, most of the studies have leaned towards exploring its consequences rather than conceptualization. In general, three broad definitions which are

[10] The following chapter contains material reproduced from an article published in the journal *Sustainability* with the citation: Hassan, A.; Kotval-K, Z. A Framework for Measuring Urban Sustainability in an Emerging Region: The City of Duhok as a Case Study. *Sustainability* **2019**, *11*, 5402

framed on the trajectory of places, have been identified to expand our understanding of distressed urban areas. The first definition, provided in 1998 by OECD (1998, p. 15), defines distressed urban areas as "portions of cities or their suburbs, usually at the scale of residential neighborhoods, in which social, economic and environmental problems are concentrated." In 2009, Özgen (2009, p. 65) defined large distressed urban areas as:

> A considerable part of a city, suffering from multiple deprivations such as degraded housing; inadequate or sub-standard facilities; rundown or derelict industrial estates, environmental risks, and problems; unattractive and disconnected urban structures; high unemployment and week social cohesion, which is detrimental to the sustainable development of the city as a whole.

However, at a neighborhood level, a distressed neighborhood is usually defined by researchers as "low income and occupational levels as well as poor health" (Ekstam, 2015, p. 434). Distressed neighborhoods are distinctively characterized by a significant unemployment rate and crime, physical decay, insufficient social networks and safety, and low socioeconomic conditions in urban areas (Baum et al., 1981; Jencks & Mayer, 1990; Milgram, 1970; Suchday et al., 2006).

The presence of distressed urban areas weakens cities and creates socio-economic and environmental burdens. Notably, the quality of life in such places is jeopardized. The systematic literature review showed that distressed places are particularly susceptible to loss of socioeconomic and environmental capital. Some studies, such as Davies & Vergriete (1998), characterized distressed urban areas as places with a concentration of social distress, environmental degradation, crime, and economic decline. As a whole, such places have a

concentration of pollution and environmental degradation, low civic engagement and educational achievement, poor housing conditions, and a higher prevalence of vandalism, crime, poverty, and drug abuse.

Based on the above statements, distressed urban areas have three components in common with sustainable development. As explained in chapter two, SD has three essential components called the Triple Bottom Line (TBL) composed of the environment, including the conservation of ecosystems and natural resources, economic vitality and growth, and social equity, including issues of equality and social well-being (OECD, 2001; Waas et al., 2014; Yigitcanlar et al., 2015). However, each city's unique setting, place, and community must be taken into consideration when characterizing distressed places. For example, Conway & Konvitz (2000) mentioned nine socioeconomic indicators to be used in compiling a demographic profile for distressed urban areas. It is interesting to note, however, that the study does not mention environmental conditions even though distressed neighborhoods are often the most polluted.

Aboulnaga, Elwan, & Elsharouny (2019) pointed out that climate change also has severely impacted human settlement patterns in recent decades. Such impacts notably cause sea level rise, desertification, drought, extreme environmental events, food insecurity, increased health risk, and temperature-related morbidity in urban environments. In light of these insights, it is clear that scholars cannot apply existing principles and tools to every city in the same way because each city has a unique history as well as distinctive social, political, and economic dimensions.

In general, this dissertation presents distressed places as the contradiction of a healthy city, where the healthy city is defined as

> one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and developing to their maximum potential (Nutbeam, 1998, p. 359).

This dissertation also argues that the works of literature on distressed urban areas have missed essential components that may broaden the discourse on stress in places. Expanding our understanding in this context increases our acknowledgment of the dynamics and genealogy of distressed communities' problems. Specifically, it helps us understand the complexities of societies and the genealogy of their issues, and informs our activities and planning to avoid, reduce, or reverse distress by broadening the discourse on distress in cities. The following section is where this study expands its arguments to cover the missing themes that may broaden the discourse on distressed places.

Geopolitical Distressed Places

One essential form of urban stress that seems to have been overlooked is distressed geopolitical areas. The word 'geopolitics' encompasses multiple and diverse sets of definitions. Caldara & Iacoviello (2018) pointed out that the term covers a set of events with a wide range of causes and consequences. However, they defined geopolitical risk as being "associated with wars, terrorist acts, and tensions between states that affect the normal and peaceful course of international relations" (p.2).

Political tension can dramatically reshape a city's post-conflict population, compromise trust, and undermine communities (Fabre, 2017). For instance, the Middle East witnessed

intensive geopolitical shifts after the Iraq war in 2003 and the Arab Spring in late 2010. Ehteshami, Huber, and Paciello (2017) explain the changing of the Mediterranean region's geopolitics. According to them, although Qatar and Saudi Arabia have been overlapping priorities with the developed world in areas such as business development, the two countries are more interested in securing their geopolitical interests and safeguarding their security than their Western counterparts. Qatar has been under grievous geopolitical stress as surrounding countries have imposed a blockade and closed land, sea, and air borders (Sailer & Roll, 2017). In their research, Alkaabi and Soliman (2017) provided profound evidence that the recent crises among the Arab Gulf States and Qatar have imposed critical socio-economic stress on Qatari citizens. Their investigation supports the notion that geopolitical stress harms residents in terms of mental health, work, education, and community fabric.

The impact of geopolitical stress on places and communities goes beyond that mentioned above. Internal conflicts and wars also affect social and environmental conditions. In 2015, about two-thirds of the world population suffered from water stress that caused subsequent water conflicts and that may lead to water wars in the future in places such as Israel, Jordan, Syria, Turkey, Iraq, Egypt, and Ethiopia (Halász, 2019). Cities are often the center of violence and social disturbance and according to Fabre (2017), a city's ecosystem in conflict areas can be disrupted as infrastructure is destroyed or damaged, or local authorities cannot deliver services to the population. Mass displacement can occur at the macro and micro levels that cause severe stress on the city's structure and sociology, impacting current dynamics and economic trends.

A prime example of the above is Iraq, where war has been the primary cause of environmental stress resulting in tremendous numbers of congenital disabilities and cancers (Savabieasfahani, Ali, Bacho, Savabi, & Alsabbak, 2016). Munoz & Shanks (2019a, 2019b) showed that displacement, due to geopolitical stress, has negatively affected social cohesion in Iraq's Kurdistan Region. They also stressed that regional stability and protection of minority rights would depend on the sustained political commitment to identifying and pursuing peaceful solutions.

For decades the city government of Duhok has witnessed several waves of forced migration. Munoz & Shanks (2019a) identified three occasions that caused this place to witness demographic shifts and displacement crises. Substantial numbers of Arabs and Christians fled violence after the 2006 Samarra bombings and the country's resulting sectarian conflict. Then, the civil war in Syria began in 2011, which caused refugees to seek escape from the violence. Periodically, internally displaced people have had to evacuate their towns in Iraq because the Islamic State invaded Mosul City and the surrounding regions in 2014. As a result, the KRI has become a sanctuary to almost one million internal refugees from heterogeneous ethnic backgrounds and cultures (Shanks, 2019).

Global Public Health Stress

The second essential form of urban stress that previous research seems to have overlooked is the global public health crisis. The recent wide-ranging and disruptive pandemic caused by the first coronavirus (COVID-19), a novel severe acute respiratory syndrome (SARS)-CoV-2 virus (Burkle, Bradt, & Ryan, 2021), has dramatically affected our world. This pandemic has been one

of the most devastating disruptions in recent memory (Remko, 2020). Karmaker et al. (2021) stated that COVID-19 is no longer simply a global health crisis but has become an economic and labor crisis as well. As such, the pandemic's impact could increase global inequalities and poverty (Asare & Barfi, 2021).

Advanced economies are predicted to experience an expected downturn of about six percent in 2020, while the developing economies and emerging markets are expected to fall by one percent (IMF, 2020). The Global Economic Prospects expects that the global economy, measured by the gross domestic product (GDP), would contract by 5.2 percent this year (World Bank, 2020). The effects of this disease on the economy are long-term unemployment for all people, reduced income, and reduced working hours (Karmaker et al., 2021). The virus has been a major setback in terms of production, and thus it was unavoidable that the economy would contract (Boettke & Powell, n.d.; Cachanosky, Cutsinger, Hogan, Luther, & Salter, 2020).

During the pandemic period, general workers were confronted with unemployment problems and difficulties in paying daily expenses (Marnn et al., 2021). This global health stress could obstruct progress made towards achieving the Sustainable Development Goals, requiring a great deal of additional attention and urgent response (United Nations Development Programme, 2021). In their report about the Global Economic Outlook During COVID-19, the World Bank (2020) confirms that the outbreak is likely to leave significant long-term harm on the global economy by reducing investment, erosion of human capital by the loss of work and education, and fragmentation of international trading and supply connections.

Due to the pandemic, people are losing their lives and livelihoods at this moment due to economic hardship from the slowdown in demand and supply (Asare & Barfi, 2021). Population-

based studies, such as the one done by Bemanian et al. (2021), have also reported high levels of psychological distress symptoms during the early stages of the coronavirus pandemic. The pandemic is, therefore, not only a global health problem but a socio-economic problem that suppresses the global sustainable development agenda (Nicola et al., 2020; Pirouz, Shaffiee Haghshenas, Shaffiee Haghshenas, & Piro, 2020).

6.2 Urban Sustainability in Duhok City

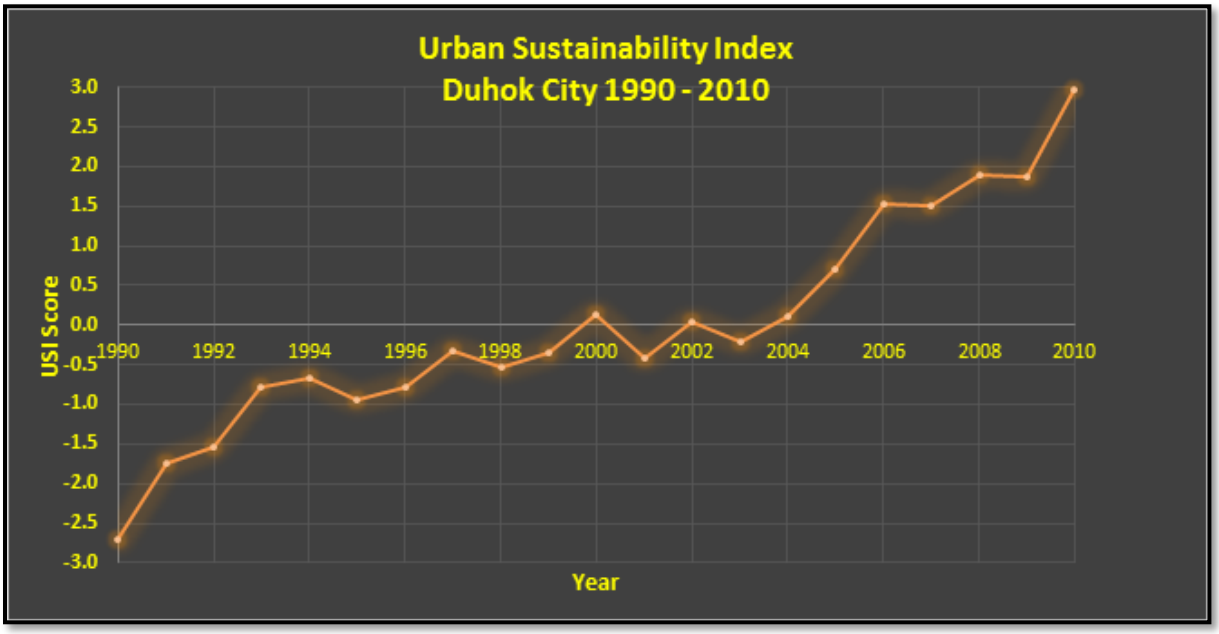
The second objective of this dissertation was to *Understand the Process of Constructing a USI for Distressed Urban Areas.* In order to advance our understanding of the methods of selecting urban sustainability indicators to monitor and observe urban sustainability progress for distressed places, this dissertation sought to address the following question:

What is the methodological framework to be employed to construct an urban sustainability index for a distressed place?

The case study of Duhok City offers a practical example of USI's use in a distressed region that experiences rapid urbanization and growth, geopolitical dilemmas, and socio-economic issues. The present case study adopted an urban sustainability framework to assess and measure sustainability in Duhok City after the declaration of autonomy of the Kurdistan Region in 1991. As such, an equal weighting of 39 USIs was used to measure and assess the progress on urban sustainability in the city from post-declaration of autonomy until 2010. After applying the 39 indicators to the city, an overall urban sustainability composite index (Figure 13) showed the trend of urban sustainability progress with two distinct outcomes.

No urban sustainability progress was demonstrated during the first decade of the autonomous declaration, yet, in the second decade, there was steady progress toward urban sustainability. On the one hand, the urban sustainability index score showed there was no urban sustainability progress (negative score) during the time between 1991 and 1999. Nevertheless, it was improving over those ten years to record the first positive score in 2000. However, the index then dropped to the negative path (non-sustainability) between 2001 and 2004. On the other hand, the progressive activities toward urban sustainability launched post-2005 demonstrate that people in the city of Duhok started to meet their fundamental needs, as measured by the indicators. Since then, the urban sustainability index of Duhok reached the positive benchmark stating that the city has begun a new trend towards sustainability.

Figure 13: Urban Sustainability Index of Duhok City, KRG 1991–2010



As mentioned above, sustainability and well-being are significantly related (Wilson & Wu, 2017). Consequently, a satisfaction of human needs and improving quality of life were achieved under the condition of an ecosystem with the capital growth indicating the system is achieving progress toward sustainability (Ayres et al., 2001; Pearce et al., 1994). These sustainability measures have shown progress toward improved urban conditions: transportation; economic development; land use and open space; housing; education and community; and community and civic engagement (see Figure 14). In contrast, three sustainability dimensions—environment and public health, population demography and household, health, and community—have shown negative progress towards urban sustainability over the two decades.

Table 17 offers a simplified understanding of Figure 14. For instance, when the stock of environment and public health increased over the two decades between 1990 and 2010, USI traced negative progress towards sustainability due to the fact that the averages of waste generation and energy consumption in the city had increased. In addition, air quality and pollution were getting worse in the city.

PCA was used to identify the factors that influenced the pattern of urban sustainability trend with the two distinct outcomes. The factor analysis of 39 USI extracted seven factors that account for about 90% of the dataset's total variance. Table 17 summarizes the influence, positive and negative trends, for each of the 39 indicators for the City of Duhok during the two decades of the study period. The first factor accounts for 48.1% of total variance (see Table 17).

Figure 14: Urban Sustainability Index by Categories of Duhok City, KRG 1990–2010

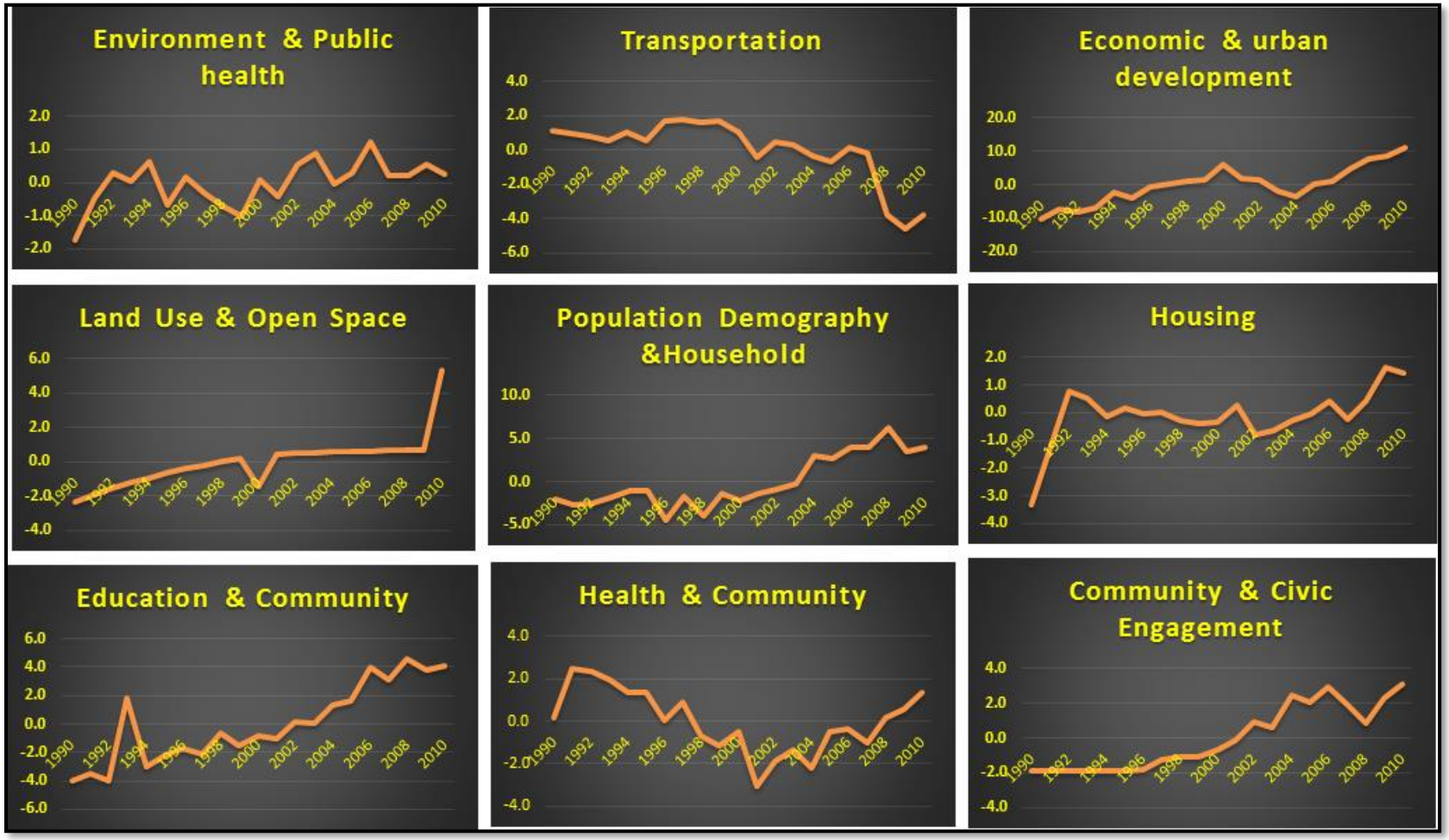


Table 17: Indicator Influenced on Urban Sustainability Trend, 1991–2010

Factor	Percentage of Variance	Positively Strong Indicator Influence	Factor Loadings	Negatively Strong Indicator Influence	Factor Loadings
1	48.1%	Energy consumption per household	0.947	Quality in school	−0.755
		Unemployment rate	0.937	Population density	−0.665
		Housing investment projects per 100,000 inhabitants	0.937		
		Level of educational Attainment	0.843		
		Employment rate	0.843		
		Waste generation per 10,000 inhabitants	0.826		
		Number of NGOs per 10,000 inhabitants	0.823		
		Number of medical staffs per 100,000 inhabitants	0.812		
		Percentage of urban population	0.797		
		Percentage of green open space	0.775		
		New buildings permit issues rate	0.794		
		Infant mortality rate per 100,000 live birth	0.734		
		Number of hospitals per 100,000 inhabitants	0.638		
2	14.5%	Number of NGOs per 10,000 inhabitants	0.534	Population density	−0.520
		Percentage of urban population	0.526	Equity in school	−0.853
		Percentage of green open space	0.560	Percentage of transportation areas	−0.846
		Car ownership rate	0.902	Number of hospitals per 100,000 inhabitants	−0.827
		Percentage of commercial areas	0.873	Rezoning permits issued rate	−0.542
		Annual library visits rate per capita	0.867		
		Percentage of industrial areas	0.691		
		Hotels and motels permit issues rate	0.640		
		Rate of capital investment projects	0.546		
		General air quality	0.531		

Table 17 (cont'd)

Factor	Percentage of Variance	Positively Strong Indicator Influence	Factor Loadings	Negatively Strong Indicator Influence	Factor Loadings
3	8.8%	Volume of air pollution per 10,000 inhabitants	0.854	Traffic system safety per 10,000 inhabitants	−0.813
		General health status per 100,000 inhabitants	0.659		
		Mixed-use property permits issued rate	0.623		
		Percentage of public services areas	0.620		
		Rate of new housing permits	0.593		
		Percentage of tourist facility areas	0.523		
4	5.9%	Building renovation permits issued rate	0.805	None	
		Population growth rate	0.729		
		Average household size	0.580		
5	4.5%	Manufacturers permits issued rate	0.787	None	
		Rezoning permits issued rate	0.761		
		Percentage of residential areas	0.627		
6	4.1%	Rate of new housing permits	0.719	None	
		General air quality	0.704		
7	2.8%	Rate of new school	0.877	None	

The factor loadings are positively strong (above 0.5) for thirteen indicators, while two indicators reflect a strong negative influence on urban sustainability (below −0.5). The second factor accounts for 14.5% of total variance, and the loadings are positively strong for ten indicators, while five negatively strong indicators are shown for this factor. The third factor accounts for 8.8% of total variance, and the loadings are positively strong for six indicators, while one indicator indicates a negative influence on urban sustainability. Finally, while there is no strong negative influence for the fourth, fifth, sixth, and seventh factors that account for 5.882%, 4.525%, 4.136%, and 2.748% of total variance respectively, nine indicators show strong positive influence.

The lack of progress on urban sustainability in the first decade resulted from the destabilized era that left Duhok City administratively fragmented, and the political trajectory defective (Leezenberg, 2015; Natali, 2013). In 1991, under United Nations Security Council Resolution 688, the Iraqi army forcefully evacuated the three primarily Kurdish governorates: Erbil, the current capital of Iraqi KR, Sulaymaniyah, and Duhok (Natali, 2013; Voller, 2014). After 1991, for the first time, the Kurds of Iraq have had full control over the three provinces. The coalition government (KRG) is the first democratic structure in the region, activated when the Kurdistan Democratic Party (KDP) and the Patriotic Union of Kurdistan (PUK) conducted elections, recognized by international monitors as relatively free and fair (Meadowcroft, 1992), for a regional parliament and presidency (Voller, 2014).

However, similar to the rest of Iraq, KR suffered hardship under UN sanctions imposed on Iraq after it invaded Kuwait in August 1990 (Noori, 2018). Hardship continued during the mid-1990s, when KR was torn by a civil war between the dominant political parties, KDP and PUK

(Voller, 2014). Consequently, political turmoil generated severe economic hardship in the city and KR in general. Duhok's economy was entirely destroyed and it lost its role as a catalyst for development (Leezenberg, 2015; UNHCR, 2007). Thus, the city was a victim of decades of internal and external conflicts that constrained its growth.

The years of 1998 and 2003, respectively, represent political and economic development watersheds in KR (Leezenberg, 2015) that led to steady progress towards urban sustainability in Duhok City post-2005. First, in 1998, both KDP and PUK made a peaceful agreement to end the conflict (Stansfield, 2003). Simultaneously, the UN and Iraqi government signed the Oil for Food (OFF) agreement, which KRG earmarked for 13% of the OFF budget (Leezenberg, 2015; Stansfield, 2003). Second, post-2003, KR has been increasing its fiscal income from the federal government, which increased during 2005–2013 from about $2.5 billion to $13 billion (Leezenberg, 2015; Natali, 2013). Thus, KRG had the resources for regional plans promoting multidimensional development (Natali, 2013; Noori, 2018). During this period, the region became "the new democratic experiment" after successfully conducting two regional campaigns in 2005 and 2009, respectively (Voller, 2014). Duhok, as one of KR's main cities, was promoting its ambitious agenda for economic and community development.

As mentioned above, this study addressed two research questions. These questions were quite relevant in terms of the kind of urban sustainability progress the city has achieved and how its urban growth affects the sustainability in the city. In other words: What are the key factors that influence the pattern of urban sustainability, and how can they be used to promote future sustainable practices?

Overall, the implemented urban sustainability framework in Duhok City focuses on measuring weak sustainability. This notion has been supported by this study since the employed framework assesses the environmental, economic, and social dimensions of sustainability without intentionally leaning on natural and ecological capital (Mori & Christodoulou, 2012; Wilson & Wu, 2017). Apparently, Duhok City dynamics were not successfully able to maintain and enhance its ecological and environmental capital during the period of rapid urban growth in the past two decades.

Figure 14 shows that the environmental capital dramatically increased in its consumption of relevant indicators, which in turn indicates negative progress on urban sustainability from 1990 to 2010. The study realized that, while rapid growth enhanced socio-economic capital, the city's authorities failed to maintain the quality of air, the amount of waste generation, and energy consumption. In the sense of capital stock, while many sustainability dimensions were simultaneously recovering from the consequences of internal and external conflicts, the steady growth on the city's stock of transportation, economic, land use, housing, education, and community engagement could not conserve the city's environmental conditions. As such, the city's rapid growth has led to strong sustainability issues (related to ecological and environment capital), which give rise to a deep concern regardless of the potential consequences and impacts of the steady urban growth on the environment and ecosystem of the city. Correspondingly, two decades of urban growth in Duhok City had come out very strongly in favor of weak sustainability.

In addition, the study investigated the main reasons that promote positive progress towards sustainability. In other words: Does the local government's planning and policy achieve

such progress, or it had occurred since post-2005 as a reaction to the organic growth of the city? After 2003, political and economic stability has enriched the city of Duhok by allowing it to pursue significant steps toward enhancing the process of economic development and growth. As such, the city has witnessed rapid urban and population growth, improving infrastructure, providing secured business and investment opportunities, and improving living conditions (J. Mohammed, 2013; Natali, 2013; Omer, 2016; Raswol, 2017).

Economic and political conditions attracted migrants from all over Iraq to KR, in general, and Duhok, in particular, to pursue business opportunities and investment in a region more secure than Iraq (Mustafa et al., 2012; Natali, 2013; Noori, 2018). The consequences of this multi-dimensional growth in the absence of urban planning and policies led to many problems. Before 2003, the city grew organically due to the absence of land-use management and policy (H. Mohammed & Ali, 2014). In 2009, however, the city finished the first comprehensive master plan that formulates a general outline of the city's vision and mission towards a more sustainable city by 2032 (Omer, 2016; Raswol, 2017). Neither this master plan nor the city authorities, however, explored the needed urban policies and planning to achieve sustainability goals (Omer, 2016). Therefore, this study highlights the factors that influence the pattern of urban sustainability and how they can be used to promote future sustainable practices in the next section.

In summary, the typology of distressed urban areas takes two fundamental forms that present context-specific conditions in cities and communities: socioeconomic and environmental. The large majority of research has concentrated on these challenges in urban settings without acknowledging that distressed urban areas' characteristics are heterogeneous

from place to place. This research, as a result, argues that conditions caused by geopolitical stress and the global health crises could threaten the very fabric, dynamics, and quality of life of urban areas. Urban policy and sustainability researchers need to provide concise definitions and explorr the impact of diverse characteristics of distressed urban places.

The city of Duhok's case study offers a practical example of USI's use in a distressed region that experiences rapid urbanization and growth, geopolitical dilemmas, and socio-economic issues. This case study's objective was fulfilled by developing a functional framework of indicators to assess and measure urban sustainability for Duhok City after KR’s declaration of autonomy in 1991.

Chapter 7: Recommendations and Conclusion[11]

Chapter seven concludes this research with recommendations for the next steps and potential research to enhance our understanding of urban sustainability in distressed places on ongoing basis. Furthermore, this chapter highlights the key factors affecting the pattern of urban sustainability in Duhok City and how to promote sustainable future practices. Finally, the researcher acknowledges and presents the limitations and challenges that affected this research.

This dissertation aimed to advance our understanding of urban sustainability in distressed urban areas. The study focused on identifying the factors to recognize distressed places in the urbanized world and designed a methodological and conceptual framework of an Urban Sustainability Index (USI) to determine the policy implications that will accelerate urban sustainability progress. This study, therefore, proposed fundamental primary research questions to achieve its objectives.

To begin with, in order to investigate all kinds of distressed urban areas in the urbanized world and identify factors that distinguish distressed places from others, this study proposes three primary research questions that align with such objective:

1) *What is the definition of a distressed place?*
2) *What are the characteristics of distressed places?*
3) *To what extent can a taxonomy be created of distressed places?*

[11] The following chapter contains material reproduced from an article published in the journal *Sustainability* with the citation: Hassan, A.; Kotval-K, Z. A Framework for Measuring Urban Sustainability in an Emerging Region: The City of Duhok as a Case Study. *Sustainability* **2019**, *11*, 5402

To address these questions that comprehensively explored the definitions, characteristics, and types of distressed places, this study used a content analysis methodology supported by the Systematic Reviews and Meta-Analyses (PRISMA) flowchart (Liberati et al., 2009). Then, in order to advance our understanding of the methods of selecting urban sustainability indicators to monitor and observe urban sustainability progress for distressed places, this dissertation sought to address the following question:

What is the methodological framework to be employed to construct an urban sustainability index for a distressed place?

The researcher used a participatory, systematic, holistic, multi-criteria analysis and integrated approach to developing a conceptual and methodological framework to construct a USI mainly designed for distressed urban areas.

Next, Duhok City, one of the Kurdistan Region's cities in northern Iraq, was used as a case study as it offered a practical example of USI's use in a distressed region. Duhoc City experienced rapid urbanization and growth, geopolitical dilemmas, and socio-economic issues in the study period. This case study's objective was to develop a functional framework of indicators to assess and measure urban sustainability for Duhok City after KR's declaration of autonomy in 1991. As such, this case study addressed several fundamental issues for sustainability measures in the city through investigating the following research questions:

1) What kind of urban sustainability progress has the city achieved?

2) How is urban growth affecting sustainability in Duhok City? In other words, what are the key factors that influence the pattern of urban sustainability, and how can they be used to promote future sustainable practices?

Three fundamental facts emerged based on the quantitative and qualitative analysis of urban sustainability in distressed places. First, there are no substantial empirical research studies that investigate the notion of sustainability and distressed places concurrently. The systematic literature analysis produced limited empirical research that investigated definitions and categories of distressed urban areas. Surprisingly, distressed urban areas have been mainly seen through two lenses: socioeconomic and environmental characteristics. However, this research argued that geopolitical stress and public health crises could be other characteristics by which our understanding of such phenomena significantly increases. More characteristics and themes could have been considered if the literature of distressed places had produced more definitions and research studies investigating distressed urban areas through the lens of sustainability.

Second, distressed places and communities have not emerged as an essential consideration in the literature review for measuring urban sustainability. Research studies have shown hardly any case studies that measure urban sustainability for distressed urban areas. Moreover, there is no consensus on selecting indicators and methodologies to assess urban sustainability progress among the myriad of substantial studies on urban sustainability. In general, measuring urban sustainability in distressed urban areas has been ill-represented in the body of literature. This study argues that distressed communities, like normal and healthy places, need to acknowledge when they succeed and fail. Continuous? Monitoring of the sustainability progress

of such places will overcome interlinked socio-economic and environmental issues and address the vicious decline in urban life-quality.

Third, numerous research studies used various sustainability indices such as Ecological Footprint, Green City Index, City Development Index, Human Development Index, and Sustainable Society Index to measure and gauge sustainability progress in cities and communities. However, the implementation of this research's empirical case study concludes that these sustainability indices are compromised in distressed places due to the complexity of these indices' nature and mechanism. Well-known indices do not comprehensively measure urban sustainability or explicitly cover different perspectives of a system they gauge. They used sophisticated mathematical algorithms that require a robust, concise, and documented dataset that is rarely available for distressed places.

The developed and implemented conceptual and methodological framework used in this research has simplified approaches to measure urban sustainability. In other words, the challenge of a simplified indicator system by creating an explicit conceptual framework, noted by Verma & Raghubanshi (2018), has been reduced. This conclusion responds to the call for "immediate concerted action" recommended by T Hák et al. (2018, p. 194) to develop a set of sustainability indicators and implement them systematically and extensively. This research study chooses appropriate weighting and aggregation methods for a specific sustainability assessment project to reinforce the criteria presented by Gan et al. (2017) to achieve T Hák et al. (2018) call. Duhok City was the specific sustainability assessment project used in this research.

For Duhok City, this study highlights the key factors that influence urban sustainability patterns and how they can be used to promote future sustainable practices. Overall, of 39 USIs, nine played an essential role in navigating the general trend of urban sustainability in the city of Duhok. Four of the nine indicators had relatively stable influences on urban sustainability trend:

1) Number of NGOs per 10,000 inhabitants;
2) Percentage of urban population;
3) Percentage of green open space; and
4) General air quality.

Duhok City authorities, urban planners, and urban policymakers are advised to note these indicators that can promote a sustainable living for Duhok City residents. Conversely, the population density indicator had a negative influence on urban sustainability. Surprisingly, two of the nine indicators played interchangeably various roles to shape the general trend of sustainability in Duhok City. The number of hospitals per 100,000 inhabitants had a positive influence, but the shortage of hospital numbers had a negative influence. Such a shift generally had a negative impact on urban sustainability. However, the rezoning permits issued indicator played the inverse role shifting from a negative to positive influence on urban sustainability (see Table 5).

In terms of urban policy recommendations for Duhok City, this study recommends five urban policies to promote future sustainable practices. First, increased community civic engagement levels, measured by the number of NGOs per 10,000 inhabitants, is necessary to improve urban sustainability. As democracy is one of the indispensable foundations for the

realization of sustainable development (L. Huang et al., 2015), Duhok City has, since 1991, produced many NGOs that work with the local government to address people's needs and issues. Indeed, the city's local government is advised to support more NGOs in partnership with the local government bodies to address community issues and enhance governance.

Second, with the city's policy of welcoming migrants from different parts of Iraq, there is a significant benefit for socio-economic urban sustainability. The urban population's percentage plays a pivotal role in shaping progress toward significant urban sustainability, although its increase leads to ecological and environmental issues. Post-2003, the Kurdistan Region of Iraq has witnessed voluntary internal movements, such as economic migration, due to several reasons such as job opportunities and cheaper housing (Eklund, 2012). In this respect, the local government in Duhok is encouraged to balance its migration policy and preserve its ecological system.

Third, since environmental protection is one essential premise of SD, the city should implement strategies to protect the city's environment and ecosystem. Two indicators, air quality and percentage of green open space, played a significant role in shaping urban sustainability. Although there were negative impacts on the environment and ecosystem, enhancing air quality and increasing green open space supported the vision of sustainable Duhok by 2032. Thus, the city needs to recognize the benefits of green design and increase the area of green space to reduce pollution, which, in turn, improves air quality.

Fourth, population density plays a negative influence on the urban sustainability trend of the city. Having said that, and during the two decades of the study, the variations and

unbalanced distribution in population density promoted an unsustainable city. As mentioned above, Duhok is a compact city, but such a model may have a negative impact on environmental and social urban sustainability. As such, a compact development strategy may not be promoting sustainability for Duhok City. These findings support existing theory and research about compact city development strategies outside Europe and United States (Dempsey, Brown, & Bramley, 2012).

Ultimately, the trend of urban sustainability can be improved by pursuing rezoning processes in the city. The findings show that increasing the rezoning rate promotes better land use either for mixed-use or commercial uses. One challenge for the government is to increase hospital space. The number of hospitals per 100,000 inhabitants, unfortunately, leads the city toward an unsustainable path. As such, the stakeholders' urgent policy is needed to address the adverse effects of urban growth on the health sector.

The developed USI framework applies to Duhok City. However, any city in KR or Iraq can successfully adopt it. This framework provides profound insights into the simultaneous cause of negative and positive progress towards urban sustainability. Moreover, it highlights what urban policy and planning implementations, the stakeholders may need to consider to enhance urban sustainability in the city. Practically, the city development goals can be achieved by adopting bottom-up planning, decentralization, and public participation (Agrawal & Gibson, 1999; Klooster, 2003). These urban planning strategies can be covered by further investigating other comparative case studies. In other words, the role of political stability, government effectiveness, and planning regulations quality in achieving significant progress towards urban sustainability is the basis of further research.

Although this research study has reached its goals and objectives and addressed its fundamental questions, the researcher is still aware of a few inevitable limitations. There are few limits to the conceptual frameworks and methodological refinements that can be devised and used in defining and measuring urban distress. These limitations were varied with the various social, political, and economic contexts. First, the concept and characteristics of distressed urban areas have not been comprehensively addressed in countries outside the developed world, such as the Organization for Economic Cooperation and Development (OECD) countries. Particularly, distressed geopolitical places, such as in the Middle East, that have been associated with wars, internal conflicts, and terrorist acts have not been profoundly investigated in the literature. Second, this study measures one city's sustainability, as a distressed place, due to the lack of data availability and accountability.

To this end, future research could undertake a comparison among various distressed cities. The 39 indicators used in the framework may not cover all of Duhok city's triple bottom line aspects. That is, more indicators are needed for further studies. All these limitations and challenges can be overcome and covered by potential investigation in diverse comparative case studies for distressed places.

APPENDICES

APPENDIX A

Common Methods for Weighting

Table 18: Common Methods for Indicator Weighting

Method Name	Type	Formulas	Benefits	Drawbacks
Equal weighting	Equal weighting	$\omega i = \omega$, $i = 1, \ldots, m$, where ω_i is the weight of the i^{th} indicator and ω a constant used as the weights for all the indicators	Simple, replicable and straightforward	No insights into indicator relationships; risk of double weighting.
Principle components analysis/Factor analysis	Statistic-based	$\omega i = rj(lij^2/Ej)$ $i = 1,\ldots,m$; $j = 1,\ldots,n$ where r_j is the proportion of the explained variance of factor j (or the intermediate composite j) in the data set, l_{ij} the factor loading of the i^{th} indicator on factor j and E_j the variance explained by the factor j	Reduces the risk of double weighting, classifying ungrouped indicators	Dimensions of sustainability are unpredictable, and weights may differ from reality.
Benefit of the doubt approach	Statistic-based	$\omega_c = a\,r\,g\,max \frac{\sum_{i=1}^{m} \omega_c, i^1 c, i}{max}$ $\omega_c, i \quad yij \in \{studied\ units\}^{\sum_{i=1}^{m} \omega_c, i^I j, i}$ $s.t. \sum_{i=1}^{m} \omega_c, i^I j, i \leq 1, \omega_{c,i} \geq 0$ $\forall\, i = 1, \ldots, m: \forall\, j = 1, \ldots, n$ where ω_c is the weight vector of unit c, $\omega_{c,i}$ the weight of the i^{th} indicator of unit c, $I_{c,i}$ the normalized score of the i^{th} indicator of unit c, and $I_{j,i}$ the normalized score of the i^{th} indicator of the j^{th} unit	The processes of weighting, aggregation, and index construction are efficiently integrated. Weights are selected to maximize the index for each unit	Results may not be comparable and lack transparency. A multiplicity of solutions exists.

Table 18 (cont'd)

Method Name	Type	Formulas	Benefits	Drawbacks
Regression analysis	Statistic-based	$\omega_i=\beta_i,\ i=1,\ldots,m$ where β_i is the regression coefficient of the i^{th} indicator	Results can be used for updating or validating weights	Either multi-collinearity among indicators or an improper dependent variable may lead to poor results
Unobserved component model	Statistic-based	$\omega_i = \frac{\delta_i^{-2}}{1+\sum_{i=1}^{m}\delta_i^{-2}}$ $i=1\ldots,m$ where δ_i is the variance of the i^{th} indicator	The processes of weighting, aggregation, and index construction are efficiently integrated. Statistical significance can be expressed when conducting comparisons	Results are sensitive to outliers. Problems of identification may occur if indicators are highly correlated. Reliability and robustness of the model may be lost when adequate data are not available
Budget allocation	Public/Expert opinion-based	-	Transparent and explicit	Measuring urgency instead of importance; region-specific
Public opinion	Public/Expert opinion-based	-	Transparent and participatory	Measuring concern instead of importance; region-specific

Table 18 (cont'd)

Method Name	Type	Formulas	Benefits	Drawbacks
Conjoint analysis	Public/Expert opinion-based	$\omega_{i=\frac{\partial P(I_1 \ldots . I_m)}{\partial I_i}}$ where P(I_1,…,I_m) is the preference function defined by researchers and I_i the i^{th} indicator	Results can be easily used for making sustainability plans Available for both quantitative and qualitative data.	Requires a large sample of respondents. Has complicated estimation process.
Analytic hierarchy process	Public/Expert opinion-based	$A\omega = \lambda\omega$ where A is the comparison matrix, λ the largest eigenvalue of A, and ω the weight vector as well as the eigenvector corresponding to λ	Has a hierarchical structure that is in line with the structure of sustainability frameworks. Simple and flexible. Providing consistent verification operation. Available for both quantitative and qualitative data.	Requirement of a high number of pairwise comparisons. Inconsistency and cognitive stress may exist if there are too many indicators in each cluster
Conjoint analysis	Public/Expert opinion-based	$\omega_{i=\frac{\partial P(I_1 \ldots . I_m)}{\partial I_i}}$ where P(I_1,…,I_m) is the preference function defined by researchers and I_i the i^{th} indicator	Results can be easily used for making sustainability plans Available for both quantitative and qualitative data.	Requires a large sample of respondents. Has complicated estimation process.

***Source**: (Gan et al., 2017, p. 495)*

APPENDIX B

Common Methods for Aggregation

Table 19: Common Methods for Indicator Aggregation

Common methods for aggregation	Formulas	Benefits	Drawbacks
Additive aggregation	$sI = \omega_1 I_1 + \omega_2 I_2 + \cdots + \omega_m I_m = \sum_{i-1}^{m} \omega_i I_i$ where *SI* is the sustainability index, ω_i the weight of the i^{th} indicator, and I_i the normalized score of the i^{th} indicator	Transparent and simple. Easy to execute sensitivity analysis and uncertainty quantification.	Rigorous prerequisites exist, such as mutually preferentially independence.
Geometric aggregation	$sI = I_1^{\omega 1} I_2^{\omega 2} \ldots I_m^{\omega m} = \prod_{i=1}^{m} I_i^{\omega i}$ where *SI* is the sustainability index, ω_i the weight of the i^{th} indicator, and I_i the normalized score of the i^{th} indicator.	Transparent and simple. Can be used for all kinds of ratio-scale variables.	Rigorous prerequisites exist, such as mutually preferentially independence.
Non-compensatory aggregation methods	Rank($Unit_i$) $s.t.\ \varphi* = \max \sum ejk$ $i = 1,\ldots,n$ where Rank ($Unit_i$) is the overall ranking of the *n* researched units, $\phi*$the corresponding score of the final ranking of the researched units, and e_{jk} the generic element of the outranking matrix.	No ad hoc restrictions.	Computational problems may be caused by the increasing number of units or indicators. Losing information on the intensity of sustainability.

***Source**: (Gan et al., 2017, p. 497)*

APPENDIX C

References for Urban Sustainability Programs

Table 20: The Indicators of Sustainable Seattle

Category	Indicator	Category	Indicator
Environment	Wild salmon	***Economy***	Housing affordability
	Ecological health		Children living in poverty
	Soil erosion		Emergency room use for non-ER purpose
	Air quality		Community reinvestment
	Pedestrian-and bicycle-friendly street	***Youth and Education***	High school graduation
	Open Space near urban villages		Ethnic diversity of teachers
	Impervious surfaces		Arts instruction
Population and Resources	Population		Volunteer involvement
	Water consumption		Juvenile crime
	Solid Waste generated and recycled		Youth involvement in community service
	Pollution prevention		Equity in justice
	Local farm production		Adult literacy
	Vehicle miles traveled and consumption	***Health and Community***	Low birth-weight infants
	Renewable and Nonrenewable energy use		Asthma hospitalizations for children
Economy	Energy use per dollar of income		Voter participation
	Employment concentration		Library and community center usage
	Unemployment		Public participation in the arts
	Distribution of Personal income		Gardening activity
	Health care expenditure		Neighborliness
	Work required for basic needs		Perceived quality of life

***Source**: (Seattle, 1993)*

Table 21: Mathematical Formulations of Composite Sustainability Indictors

Indicator	Formula
Ecological Footprint	= P/YN × YF × EQF where P is the amount of product harvested, YN is the average yield for P, and YF and EQF are the yield factor and equivalence factor
Green City Index	= CO_2 emissions + energy + buildings + land use + transport + water and sanitation + waste management + air quality + environmental governance
City Development Index	= (Infrastructure index + Waste index + Health index + Education index + Product index)/5 where: Infrastructure = 25 × Water connections + 25 × Sewerage + 25 × Electricity + 25 × Telephone Waste = Wastewater treated × 50 + Formal solid waste disposal × 50 Health = (Life expectancy - 25) × 50/60 + (32 - Child mortality) × 50/31.92 Education = Literacy × 25 + Combined enrolment × 25 Product = (log City Product - 4.61) × 100/5.99

***Source**: (L. Huang et al., 2015, p. 1182)*

Table 22: Central Texas Sustainability Indicators

Category	Indicator	Category	Indicator
Public Safety	Community safety	*Economy*	Exporting industries
	Safe families		Labor availability
	Equity in law enforcement		Diversity of employers
Education and Children	Childcare - access		Job availability
	Childcare - quality		Entrepreneurship
	Schools - quality		Technical innovation
	Schools – equity in educations	*Health*	Health insurance coverage
	Schools – academic performance		Health status - physical
	Higher education		Health status - mental
Opportunity	Affordable housing - ownership	*Natural Resources*	Water consumption
	Access to home loans		Water quality
	Affordable housing - rental		Energy use
	English proficiency		Attractiveness of the landscape
	Diversity in elected leadership		Air quality
Civic Engagement	Philanthropy & volunteerism		Solid waste
	Participation in the arts		Hazardous materials
	Neighborliness	*Land Use / Mobility*	Density of new development
	Civic participation		Rural land
Economy	Household income		Publicly – owned open space
	Cost of living		Time spent commuting
	Diversity of industries		Vehicle miles traveled

***Source**: (Bernhard, Cahill, & Gale, 2007)*

Table 23: Santa Monica Sustainable City Plan Indicators

Category	Indicator	Category	Indicator
Resource Conservation	Solid waste generation	*Economic development*	Cost of living
	Water use		Quality Job Creation
	Energy use		Income disparity
	Renewable Energy use		Resource efficiency of local businesses
	Greenhouse Gas Emission		Local employment of City staff
	Ecological Footprint for Santa Monica	*Open space and Land use*	Open Space
	Indicator of Sustainable procurement		Trees
	Green Construction		Parks - Accessibility
Environment and Public health	Santa Monica Bay		Land Use and Development
	Wastewater (sewage) generation		Regionally appropriate vegetation
	Vehicle miles traveled	*Housing*	Availability of affordable housing
	Air Quality		Distribution of affordable housing
	Residential household hazardous waste		Affordable housing for special needs groups
	City purchases of hazardous materials		Production of "livable" housing
	Toxic air contaminant (TAC) releases		Production of "green" housing
	Urban runoff reduction	*Community education and civic participation*	Voter participation
	Fresh, local, organic produce		Participation in civic affairs
	Organic produce – farmers Markets		Empowerment
	Restaurants produce purchases		Community involvement
	Food choice		Volunteer involvement
Transportation	Modal split		Participation in neighborhood organizations
	Residential use of sustainable trans. options		Sustainable community involvement 1
	Sufficiency of transportation options		Sustainable community involvement 2
	Bicycle lanes and paths	*Human dignity*	Basic Needs - Shelter
	Vehicle ownership		Basic Needs – Health Care Opportunity
	Bus ridership		Basic Needs – Economic
	Alternative fueled vehicles – City fleet		Basic Needs – Public Safety
	Traffic congestion		Residents‟ perception of safety
	Pedestrian and bicycle safety		Incidents of abuse
	Traffic impacts to emergency response		Incidents of discrimination
Economic development	Economic diversity		Education / Youth
	Business reinvestment in the community		Empowerment
	Jobs / Housing balance		Ability to meet basic needs

***Source**: (Bertone et al., 2006)*

Table 24: Sustainability Plan for San Francisco Indicators

Category	Indicator	Category	Indicator
Air Quality	Number of existing buildings that join the Building Air Quality Alliance Program (or similar voluntary programs).	*Human Health*	New cases of asthma Number of people attending organized wellness classes. Participation in organized youth programs at city recreation centers
	Number of people going to clinics for respiratory problems.	*Environmental Justice*	Mean income level of people in historically disadvantaged communities
	Percentage of new cars registered in San Francisco which are alternatively fueled (e.g., California Air Resources Board certified, low emission vehicles, ultra-low emission vehicles, or electric vehicles).		Proportion of environmental pollution sources in historically disadvantaged communities with respect to San Francisco's other communities
Biodiversity	Number of volunteer hours dedicated towards managing, monitoring, and conserving San Francisco's biodiversity.		Participation of historically disadvantaged communities as a whole and their indigenous self-selected representatives in decision-making processes
	Number of square feet of the worst invasive species removed from natural areas.	*Parks, Open Spaces and Streetscapes*	Percentage of the population with a recreational facility and a natural setting within a ten-minute walk
	Number of surviving indigenous native plant species planted in developed parks, private landscapes and natural areas.		Number of neighborhood green street corridors created annually
	Abundance and species diversity of birds, as indicated by the Golden Gate Audubon Society's Christmas bird counts.		Number of volunteer hours spent annually on maintenance of open space
Energy, Climate Change and Ozone Depletion	Ratio of renewable to non-renewable energy consumption.		Annual municipal expenditures on parks, open space, and streetscapes
	Energy cost per tax dollar.		

Table 24 (cont'd)

Category	Indicator	Category	Indicator
Hazardous Materials	Difference between motor oil purchased in the City and the amount that is properly recycled or disposed.	*Transportation*	Auto registration Parking-spot inventory Muni ridership Muni route running time on key routes
	Equitable distribution of the hazardous material/waste exposure load throughout the City. Number of contaminated sites within City borders. Public awareness of hazardous materials/waste issues (especially proper use and disposal and knowledge of alternatives) as measured by annual survey (to measure effectiveness of outreach).	*Municipal Expenditures*	Number of items of legislation adopted by the Board of Supervisors that advance sustainability goals Number of service providers and companies on the Green Vendors list Percentage of budget allocated utilizing sustainability criteria Percentage of budget that is devoted to facility maintenance
Water and Wastewater	Per capita water consumption measured by the San Francisco Water Department Mass of pollutants in wastewater Mass and frequency of combined sewer overflows Recycled water use Acres of habitat restored	*Public Information and Education*	Number of schools that integrate and progressively update environmental education in their curricula Conservation and waste reduction as measured by volume of garbage produced per capita and units of electricity used per capita Number of volunteers working on environmental projects as measured through the largest volunteer clearinghouse that refers or mobilizes people to do community service
Economy and Economic Development	Number of San Francisco neighborhoods with unemployment rates higher than the government defined "full employment" rate Difference between the highest neighborhood unemployment rate and the full employment rate. Number of San Francisco manufacturers using recovered secondary materials as raw material. Percentage of people employed in San Francisco who live in San Francisco	*Risk Management (Activities of High Environmental Risk)*	Number of businesses that train employees in the Neighborhood Emergency Response Teams program Number of seismically upgraded buildings Number of hazardous materials incidents

Table 24 (cont'd)

Category	Indicator	Category	Indicator
Food and Agriculture	Number of San Francisco enterprises adopting ISO 14000 standards	*Solid Waste*	Tons of waste land filled annually
	Number of public agricultural gardens.		Recycling rate as a percentage of material generated. Percentage of residents, businesses, and institutions that participate in
	Quantity of food and agricultural residuals recycled. Number of school, vocational and community education and training programs about sustainable agriculture and nutrition.		
	Number of public agricultural gardens.		recycling programs

***Source**: (City, 1996, pp. 173–177)*

Table 25: Urban Sustainability Indicators for Taipei's Urban Sustainability

Category	Purpose	Examples
Natural system	Resource base of a region and its capability of life support services	Natural area
Agricultural system	Resource production capacity of a region	Biodiversity
		Number of bird species
		Area productivity
Water resources	Availability and quality of municipal water supply	Availability of stream runoff
		Surface water quality
Urban system	Current states of urban society	Population density
		Transport mobility
		Housing vacancy
		Impervious ratio
		Frequency of traffic accidents
Life-support service	Contribution of life-support environments to the urban system	Ratio of indigenous agricultural
		production
		Per capita natural area
		Streamflow
Import sources	Dependency on external sources	Per capita electricity use Fossil fuel use
Urban production	Efficiency, vitality and structure of urban productivity	Per capita GDP
		Per capita weekly working hours
Waste treatment	Discharge, accumulation and treatment of municipal wastes	Per capita solid waste
Resource recycling	Performance of eco-technology	% of waste water treated
		% of solid waste, recycled
		% of public expenditure on
Environmental management	Effort on environmental protection	environmental protection
		No. of NGOs

Source: *(S.-L. Huang et al., 1998, p. 21)*

Table 26: Measuring the Sustainability in Cities

SD dimension	Category	No. indicators
Environmental	Energy (excluding transport)	8
	Transport	25
	Air quality	15
	Noise	3
	Drinking water	7
	Green space, ecosystems and heritage	16
	Waste	5
	Other indicators[12]	6
	Sub-total	***85***
Social and institutional	Demographics	10
	Housing	18
	Education	11
	Security	5
	Health	9
	Wellbeing	3
	Social and community services	11
	Governance	4
	Expenses and public administration	6
	Sub-total	***77***
Economic	Household income and expenses	13
	Employment	8
	Businesses	5
	Sub-total	***26***
Total		**188**

***Source**: (Tanguay et al., 2010, p. 411)*

[12] Ecological footprints, natural catastrophes, level of exposure to natural and industrial risks, consumption of equitable products, urban intensification, and soil use.

Table 27: Measuring Urban Sustainability in Europe

Components
Air quality
CO2 emissions
Non-car: Transportation Infrastructure
Energy consumption
Governance
Green spaces
Health
Solid waste
Climate resilience
Wastewater treatment
Water usage
Education
Civic engagement
Local resources
Housing
Inequality
Employment
Noise pollution
Safety
Cultural capacity
Smart infrastructure
Biodiversity
Economic productivity
Urban microclimate
Business climate
International embeddedness
Entrepreneurship

***Source**: (Meijering et al., 2018, p. 42)*

Table 28: United Nations Commissions on Human Settlements

Goals		Indicators
Shelter	Promote the right to adequate housing Provide security of tenure Provide equal access to credit Provide equal access to land Promote access to basic services	Durable structures Right to adequate housing Overcrowding Housing price and to rent-to-income Secure tenure Authorized housing Eviction
Social development and eradication of poverty	Provide equal opportunities for a safe and healthy life Promote social integration and support disadvantaged groups Promote gender equality in human settlements development	Housing finance Land price-to-income Access to safe water Access to improved sanitation Connection to services Under-five mortality Homicides Urban violence HIV prevalence Poor households Literacy rates Gender inclusion
Environmental Management	Promote geographically balanced settlement structures Reduce urban pollution Prevent disasters and rebuild settlements Promote effective and environmentally sound transportation systems Support mechanisms to prepare and implement local environmental plans and local Agenda 21 initiatives	School enrolment Women councilors Urban population growth Planned settlements Price of water Water consumption Wastewater treated Solid waste disposal Regular solid waste collection Disaster prevention and mitigation instruments Houses in hazardous locations Travel time Transport modes Local environmental
Economic Development	Strengthen small and microenterprises, particularly those developed by women employment opportunities	Informal employment City product Unemployment Local government revenue

Table 28 (cont'd)

Goals		Indicators
Governance	Promote decentralization and strengthen local authorities Encourage and support participation and civic engagement Ensure transparent, accountable and efficient governance of towns, cities and metropolitan areas	Decentralization Citizens participation Voters participation Civic associations Transparency and accountability

Source: *(Michael et al., 2014, p. 495; SAULE JÚNIOR & CARDOSO, 2004)*

Table 29: Malaysia's Set of Indicators

Dimensions	Themes	Indicators
Competitive economy	Economic growth Poverty	Employment growth rate Urban poverty rate Poverty rate
Sustainable environmental quality	Private investment Environment quality Risk management Environmental management	Growth rate of private investment River cleanliness Environmental air quality conditions Percentage of population living in flood prone area Percentage of per capita solid waste generation Total programs/environmental campaign carried out in the local authority area
Sustainable community	Housing Community & recreational facilities Quality of life	Percentage of quality affordable housing units Percentage of residential coverage within 400 m range of community facilities Ratio of cases relating to public nuisance complaints per 10,000 population Ratio of cases of water and vector borne diseases per 10,000 population Percentage of Grade A food premises Percentage of Grade A public toilets Happiness index
Optimal use of land and natural resources	Security Demography Land use changes Urban development Heritage conservation and tourism	The ratio of index crime per 10,000 population Dependency ratio The rate of change in land use from non-built-up to built-up Urbanization rate Ratio of public open space per 1000 inhabitants Unsold residential properties

Source: *(Michael et al., 2014, p. 496)*

Table 29 (cont'd)

Dimensions	Themes	Indicators
Efficient infrastructure and transportation	Efficiency utility Solid waste management Transportation Sewage management	Percentage change in the forest area The number of tourism attractions and recreation centers Total volume of daily domestic water consumption per capita Total domestic electricity consumption (KW) per capita Percentage of total waste recycled Percentage of domestic solid waste collection on schedule Number of integrated public transport terminals/stations Percentage of homes with centralized sewerage services
Effective governance	Delivery system Strengthening institutions Enforcement and monitoring	Residents' satisfaction level on local authority services Number of community programs implemented by local authorities Percentage of local authority revenue collection performance Percentage of total maintenance expenditures to overall local authority spending Percentage of approved planning applications that comply to the development plan/local plan Number of enforcement operations executed according to schedule by local authority

Source: *(Michael et al., 2014, p. 496)*

Table 30: Taiwan's Set of Indicators

Themes	Sub-themes	Indicators
Environment	Air quality Water quality Waste Environmental management	PSI Average
		Air pollutant concentration
		Water reservoir quality
		Marine environment quality
		Ratio of rivers suffering minor pollution
		BOD concentration
		Garbage recycling rate
		Daily per capita garbage volume
		EIA approval rate
		Number of publicly announced toxic substances placed under monitoring
		Ratio of environmental and ecological budget by the central government
		Financial measures in promoting pollution prevention and recycling
Energy Conservation and carbon reduction	Greenhouse gas emission Energy usage	Per capita CO_2 emissions due to fuel combustion
		Annual increase of CO_2 emissions due to fuel combustion
		Greenhouse gas emissions
		Daily per capita power consumption
		Energy concentration
		Ratio of resource-consumption-based industries to manufacturing industries
National land resource	Energy conservation, carbon reduction Land Forest Coasts Water resource Natural hazards	Percentage volume of renewable energy
		Energy conserved due to green buildings
		Bicycle path length per 10,000 people
		Slope variation ratio
		Subsidence land ratio
		Developed land ratio
		Forest coverage area
		Natural coast ratio
		Natural coastline loss ratio
		Effective water resource
		Ratio of water usage to production value of the manufacturing industry
		Underground water recharge volume
		Underground water usage volume
		Total national land area planting betel nuts
		Casualties due to natural disasters Economic
		loss due to natural disasters

Table 30 (cont'd)

Themes	Sub-themes	Indicators
Biodiversity	Heredity Species Terrestrial ecosystem Marina ecosystem	Genetic resources and species preservation Change in specific wildlife population Land area covered by specific exotic plants Populations of specific exotic invasive species Eco-sensitive area Ratio of protected area to total land area Marina protection area
Production	Material consumption Cleaner production Agriculture Fishery Labour Macro-economic effectiveness Public finance	Material strengths used in economic development Material strength used in non-manufacturing type of economic development
		Domestic supplies. Per capita GDP Non-manufacturing domestic supplies Per capita national gravel production Re-use rate of industrial waste rate of low-radioactive solid waste Area of organic cultivation Ratio of cultivated land Re-use rate of toxic industrial waste Reduction Fertilizer usage rate per hectare of farmland Pesticide usage rate per hectare of farmland Overfishing Labor production and unit production cost Ratio of females receiving salary in non-agricultural sector Ratio of gross domestic capital formation to GDP Annual increase in consumer price index Ratio of all levels of government borrowing above 1 year with outstanding non self-liquidating debt to GNP Percentage of population with access to suitable drinking water
		Sewage treatment rate
		Daily per capita water consumption
		Number of times public transport is utilized
		Domestic energy consumption by transport
		Times of tourist visits in Taiwan
		Road casualties per every 10,000 vehicles
		Road maintenance efficiency
		Green procurement amount of public and private sectors
		Number of green marks awarded

Table 30 (cont'd)

Themes	Sub-themes	Indicators
Livelihood	Water usage Transportation Green consumption	Percentage of population with access to basic infrastructure Infection immunity measures for children's diseases Usage rate of preventive health insurance Child nutrition condition Death rate of standardized cancer
Health	Medical care Nutrition Health risks	Infection rate of contagious disaster Smoking rate of those above 18 Eating betel nut rate of those above 18
Science and Technology	Research and Development Telecommunications	Percentage of GDP spent on domestic research and development Ratio of internet users Number of people using hand phones per every 100 people
Urban and rural culture	Cultural heritage Community Urban	The number of ancient monuments and sites appointed Number of villages in compliance with SDI Expansion rate of urbanization Green area per capita
Wellbeing	Poverty Income equality Social welfare	Ratio of low-income families Accommodation rate Difference in disposable income per household of each division Subsidy for the disadvantaged Elderly passport and their participation Suicide rate
Governance	Crime Education	Crime rate Dropout students Adult education participation ratio
Participation	International participation Public participation	Condition of Taiwan's participation in UN's international environmental organizations and other MEAs International environmental cooperation and assistance to other nations Civil participation Community-based participation of social welfare

Source: *(Michael et al., 2014, pp. 498–499)*

Table 31: China's Set of Indicators

Category		Components	Indicators
Society	Social welfare	Employment	Urban employment rate (%)
		Doctor resources	Number of doctors per capita (per thousand)
		Education	Middle school students in young population (%)
		Pension	Pension security coverage (%)
		Healthcare	Healthcare security coverage (%)
Environment	Cleanliness	Air pollution	Concentration of SO_2, NO_2, PM_{10} (mg per cubic meter)
		Industrial pollution	Industrial SO^2 discharged per unit GDP (tons per bn RMB)
		Air qualified days	Days of air quality equal or above level II[1] (%)
		Wastewater treatment	Wastewater treatment rate (%)
		Household waste management	Domestic waste treated (%)
	Built environment	Urban density	Persons per square kilometer of urban area
		Mass transit usage	Passengers using public transit (per capita)
		Public green space	Area of public green space (%)
		Public water supply	Public water supply coverage (%)
		Internet access	Household access to internet (%)
Economy	Economic development	Income level	Disposable income per capita
		Reliance on heavy industry	GDP from service industry (%)
		Capacity investment	Government investment in R&D (per capita)
Resources	Resource utilization	Energy consumption	Total energy consumption (SCE per unit GDP)
		Power efficiency	Residential power consumption (kwh per capita)
		Water efficiency	Total water consumption (liters per unit GDP)

Source: *(Michael et al., 2014, p. 497)*

Table 32: Indicators of Urban Sustainability in Mexico

Category	Indicator	Category	Indicator
Productivity	Gross Domestic Product Net Domestic Product adjusted environmentally for each inhabitant Annual consumption of energy per inhabitant Fossil Fuel Reserves	*Transportation*	Density of passenger per vehicle Highways, roads or streets per 1000 inhabitants Density of taxis Number of roads, highways or streets per type of transportation Density of pedestrian areas Bike paths Density of restricted traffic zones Number of parking spaces and paid parking lots Number of parking spaces and free parking Number of parking spaces and free parking lots close to public transportation Public transportation for passengers
Growth	Expenditure on research and experimentation in SD	*Transportation*	Train Infrastructure Train Tracks Subway Tracks Light Rail Tracks Trolley Lines Bus Lines Bicycles Motorbikes Private Cars
Consumption	Consumption of fossil fuels Consumption of Renewable Energy Goods from environmentally clean capital	*Education*	School population Study programs in higher education directly
Infrastructure, Services and Urban Equipment	Energy networks Potable water networks Sewage and drainage Residual water treatment Hospitals Schools & Workplaces Recreation sites Markets & Outdoor markets Social Security or Health Care buildings Firehouses Parks and gardens	*Housing*	Access to housing Availability of housing Quality of housing Type of housing & Cost of housing Family homes Rental properties Percentage of financed housing Vacant housing Abandoned housing Condition of the housing Ecological housing Partially ecological housing

Table 32 (cont'd)

Category	Indicator	Category	Indicator
Demographics	Area of the city	*Equality*	Justice in the distribution of wealth
	Population density		Justice in the exposure of polluting agents
	Number of homes		Justice in the distribution of potable water
	Growth rate of the urban population		Socio-economic segregation
	Life expectancy	*Global Climate Change*	Greenhouse gases (CO2) caused by transportation
	Loss of life in natural disasters		Greenhouse gases (CO2) caused by industry
	Immigration (as part of the management, provision and organization of the urban population in cities) (Chen, 2009).		The measuring of local and global warming
		Generation of waste	Generation of municipal solid waste
Combating poverty	Minimum wage		Generation of dangerous waste
	Groceries and food		Recycling and use of waste
	Dignified housing	*Soil Pollution*	Changes in the use of soil
	Paid work		Solid residual deposits
	Farming		Dangerous residual deposits
Health	Exposure to heavy metals in urban areas		Sediments with toxic substances
	Exposure to NO2 in urban areas		Erosion and desertification
	Exposure to CO2 in urban areas		Landfills
	Exposure to Volatile Organic Substances in urban areas		Area of protected forest
	Exposure to urban noise		Area of protected urban soil at risk of a change in use
	Deaths due to violence and delinquency	*Water*	Monthly precipitation Annual water extraction
	Deaths due to traffic accidents	*Other types of contamination*	Light pollution Vibration pollution Sound pollution Smell Pollution
	Number of sidewalk food stands		
	Diseases caused by fecal matter		
	Diseases caused by drinking contaminated water		

Table 32 (cont'd)

Category	Indicator	Category	Indicator
Biodiversity Integrity	Modification of biological diversity	*Quality of the environment*	Concentration of fecal particles in fresh water
	Modification of ecosystems		Biochemical demand for oxygen in bodies of water
Energy Consumption	Consumption by area		Consumption of water per inhabitant
	Consumption of electricity		Consumption of residential water per inhabitant
	Butane gas / Carbon gas / Natural gas		Consumption of water per area(industrial, residential, commercial, agricultural and other services)
	Diesel / Gasoline		Quantity of water wasted from its origin to its destination
	Wood burning		Quantity of treated water
	Other intermediate goods		Population with access to treated water
	Consumption of renewable energy		Quantity of rain water wasted and going to drains
	Consumption of alternate energies (photovoltaic, wind power, geothermal power, hydrogen power)		Polluted water Quality of the biotic resources Quality of a biotic resources Quality of the landscape Quality of the socio-cultural and urban environment
Changes in the use of urban soil	Area of changed soil		
	Type of changed soil		

Table 32 (cont'd)

Category	Indicator	Category	Indicator
Consumption of Raw Materials	Consumption of renewable raw materials	*Consumption of other intermediate goods*	Various materials and combustibles
	Consumption of non-renewable raw materials	*National Legal Instruments* *International Legal Instruments*	Creation and updating of urban regulations and sustainable architecture
			Revision of international norms
	With recycled content Recycled		Available environmental information
		Information and statistics	Number of times urban architectural information about the environment is offered
	Materials composed of a ceramic base	*Science and research for SD*	Number of scientists employed in the research of sustainable development
	Materials composed of a metallic base	*Air Pollution*	Emissions from other pollutants
	Materials composed of a polymer base		Air quality in urban zones
	Natural materials		Monitoring air pollution
	Synthetic materials		Number of days vehicles do not circulate
Regional Development	Agriculture Livestock Heavy industries Commerce Sources of employment		Acidification of gases from transportation
			Quality of Compound Volatile Organic Material from transportation
			Heavy metals in the atmosphere around transportation
Urban Reforestation and	Reforested areas in urban zones Creation of green spaces and gardens Area of changed soil Type of changed soil	*Policies and decision making*	Evaluation of the laws about environmental impact The group of evaluators of environmental impact

***Source**: (Moreno & Martinez, 2010, P.54-58)*

Table 33: Sustainable Cities Project in Malaysia

Category	Indicator	Category	Indicator
Demography	Percentage of urban population	*Environment*	Yearly allocation for landscape and tree planting
	Population density		activities
	Proportion of population with tertiary education		River water quality above preset thresholds Total solid waste recycled Number of complaints from noise disturbance
	Population growth rate	*Sociology and Social Impacts*	Poverty
	Dependence ratio of Local Authority		Health
Housing	Ratio of house price to income		Crime
	Ratio of house rent to income		Divorce cases per 1000 population
	Available floor space per person		Social deviance
	Rate of production of private dwellings	*Land Use*	Plan approval time
Economy	Unemployment rate		Area of state land available for public amenity development
	Employment growth rate		Number of residential homes in city center (%)
	Workforce	*Urban Form and Heritage*	Area of city allocated for beautification programmes
	Urban poverty		Area allocated for conservation
	Income distribution	*Transportation*	Number of students cycling to schools
Utility and Infrastructure	Water use per 1000 people		Percent of public transport users at peak hours
	Water loss		Area allocated for foot paths and cycle lanes
	Flood affected areas		Number of SOV in city center during peak hours
	Total solid waste		Number of vehicular accidents per 1000 population
	Number of houses connected to central sewage system		Time used in commuting to workplace

Table 33 (cont'd)

Category	Indicator	Category	Indicator
Demography	Percentage of urban population	*Environment*	Yearly allocation for landscape and tree planting
	Population density		activities
	Proportion of population with tertiary education		River water quality above preset thresholds Total solid waste recycled Number of complaints from noise disturbance
	Population growth rate	*Sociology and Social Impacts*	Poverty
	Dependence ratio of Local Authority		Health
Housing	Ratio of house price to income		Crime
	Ratio of house rent to income		Divorce cases per 1000 population
	Available floor space per person		Social deviance
	Rate of production of private dwellings	*Land Use*	Plan approval time
Economy	Unemployment rate		Area of state land available for public amenity development
	Employment growth rate		Number of residential homes in city center (%)
	Workforce	*Urban Form and Heritage*	Area of city allocated for beautification programmes
	Urban poverty		Area allocated for conservation
	Income distribution	*Transportation*	Number of students cycling to schools
Utility and Infrastructure	Water use per 1000 people		Percent of public transport users at peak hours
	Water loss		Area allocated for foot paths and cycle lanes
	Flood affected areas		Number of SOV in city center during peak hours
	Total solid waste		Number of vehicular accidents per 1000 population
	Number of houses connected to central sewage system		Time used in commuting to workplace

Table 33 (cont'd)

Category	Indicator	Category	Indicator
Social Amenities And Recreational Facilities	Hospital beds per 1000 people	*Management and finance*	Local Authority revenue per person
	Recreation areas per 1000 people		Percent revenue collected
	Number of pupils per teacher in primary schools		Level of cash flow for emoluments
Environment	Yearly allocation for environmental-health-sanitation		Capital expenses per capita per annum
			Population to staff ratio at local government level
	Astma cases per 1000 persons		Local Authority operating cost per capita

***Source**: (Hasan & Adnan, 2002, p. 14; Sani, 2001)*

Table 34: Potential Indicators for Malaysia Sustainable Development

Sustainability Category	Element	Descriptor	Indicator
Economy	Income measure	Adjusted netdomestic product	Time series of AND Pand GDP
	Genuine savings	Environmentally adjusted savings	Time series of GS as %GDP
	Sustainable timber yield	Timber resources	Stock and g, Regeneration rate
	Maximum sustainable yield	Fisheries resources	Stock and g, Regeneration rate
	Resource rents for oil and gas	Oil and gas resources	Stock and depletion allowance
	Income distribution	Income inequality	GINI coefficient
	Expenditures on environmental improvement	Expenses in preventive maintenance, mitigatory and replacements	Expenses on environmental improvements VSannual budget
Environment and Resources	Air quality	Air pollution	Air pollutant index
	Ozone depletion	Ozone depleting substances (ODS)	Progress in ODS phase-out
	Greenhouse gases	Change in emission in a period of time	Trends in emission of greenhouse gases
	Emission of Sox and NOx	Change in emissions over a period of time	SOx and NOx emission intensities
	Land availability for food production	Agricultural land	% agricultural land for food productionVS total land area
	Environmentally safe agricultural practices	Use of fertilizers and pesticides	Extent of fertilizers and pesticides use per unit amount of produce
	Solid waste disposal	Recycling, collection, safedisposal	Solid waste recycling programmes, waste generated and collected, waste disposed in sanitary landfills
	Safe hazardous waste handling	Hazardous waste treated of amount generated	% treated VSgenerated
	Fresh water quality	Number of clean rivers	Extent of clean rivers
	Renewable energy	Sustainable energy use	Renewable energy VS total energy use

Table 34 (cont'd)

Sustainability Category	Element	Descriptor	Indicator
Environment and Resources	Mangrove deforestation	Rate of loss	Loss of mangroves VS mangrove area in baseline year
	Cover of forest area	Area of forest cover	Forested area VS total land area
	Biodiversity protection	System of protected area	Totally protected areaVS total forest area Vs total land area
	Public transport	Usage of public transport	Passengers in public transport VS in private transport
Social	Population distribution	Trends in urbanization	Urbanization rates
	Wealth distribution	Incidence of poverty and hard-core poverty	Poverty rates
	Spending on education	Improvement in tertiary education	GDP spent on tertiary education
	Public security	Incidences	Theft and burglary rates

***Source**: (Hasan & Adnan, 2002, pp. 16–17)*

APPENDIX D

Data Collection Resources for the Case Study

Table 35: List of Dataset Resources Used for the Case Study of Duhok

Official Statistics (Published Dataset)
1. Annual Statistical Abstract for the years 1983, 1987–2010. Central Organization for Statistics and Information Technology, Ministry of Planning & Development Cooperation, Republic of Iraq.
2. Economic Development Assessment, 2008. Final report, USID/Iraq.
3. Iraq living conditions survey 2004. Ministry of Planning & Development Cooperation, Republic of Iraq.
4. Iraq Household Socio-Economic Survey, 2007. Central Organization for Statistics & IT, Kurdistan Region Statistics Office, The World Bank.
5. Unsatisfied Basic Needs Mapping and Living Standards in Iraq, 2006. UNDP, Central Organization for Statistics & Information Technology, Ministry of Planning & development cooperation, Republic of Iraq.
6. Annual Statistical Abstract for the year 2007. Kurdistan Region Statistics Office
Local Statistics Report (Unpublished Dataset)
1. Directorate of Electricity in Duhok Governorate, 1985–2010. Ministry of Electricity, Kurdistan Regional Government/Iraq.
2. Directorate of Health in Duhok Governorate, 2000–2010. Ministry of Health, Kurdistan Regional Government/Iraq.
3. Directorate of Education in Duhok Governorate, 1991–2010. Ministry of Education, Kurdistan Regional Government/Iraq.
4. Directorate of Health in Duhok Governorate, 2000–2010. Ministry of Health, Kurdistan Regional Government/Iraq.
5. Directorate of Water and Sewage in Duhok Governorate, 2000–2010. Ministry of Health, Kurdistan Regional Government/Iraq.
6. Directorate of Environment and Weather in Duhok Governorate, 2000–2010. Kurdistan Regional Government/Iraq.
7. Directorate of Municipalities in Duhok Governorate, 2000–2010. Ministry of municipalities and tourist, Kurdistan Regional Government/Iraq.
8. University of Duhok, 1994–2010. Ministry of higher education and scientific research, Kurdistan Regional Government/Iraq.
9. Directorate of Urban Planning in Duhok Governorate, 2000–2010. Ministry of municipalities and tourist, Kurdistan Regional Government/Iraq.
10. Duhok Governorate Council, 1997–2010. Kurdistan Regional Government/Iraq.

BIBLIOGRAPHY

BIBLIOGRAPHY

Aboulnaga, M. M., Elwan, A. F., & Elsharouny, M. R. (2019). Climate Change Impacts on Urban Areas and Infrastructure. In *Urban Climate Change Adaptation in Developing Countries* (pp. 49–75). Springer.

Agol, D., Latawiec, A. E., & Strassburg, B. B. N. (2014). Evaluating impacts of development and conservation projects using sustainability indicators: Opportunities and challenges. *Environmental Impact Assessment Review*, *48*, 1–9.

Agrawal, A., & Gibson, C. C. (1999). Enchantment and disenchantment: the role of community in natural resource conservation. *World Development*, *27*(4), 629–649.

Ahmed, Z., Zafar, M. W., & Ali, S. (2020). Linking urbanization, human capital, and the ecological footprint in G7 countries: an empirical analysis. *Sustainable Cities and Society*, *55*, 102064.

Ali-Toudert, F., & Ji, L. (2017). Modeling and measuring urban sustainability in multi-criteria based systems — A challenging issue. *Ecological Indicators*, *73*. https://doi.org/10.1016/j.ecolind.2016.09.046

Alkaabi, I., & Soliman, A. (2017). Qatar as Full Island Overnight: Psychological and Social Consequences of Blockade as Reflected in the Social Media. *The Arab World Geographer*, *20*(2–3), 130–141.

American Psychological Association, T. F. on S. S. (2007). Report of the APA task force on socioeconomic status. *Washington, DC: Author*.

Anand, S., & Sen, A. (2000). Human development and economic sustainability. *World Development*, *28*(12), 2029–2049.

Asare, P., & Barfi, R. (2021). The Impact of Covid-19 Pandemic on the Global Economy: Emphasis on Poverty Alleviation and Economic Growth. *Economics*, *8*(1), 32–43.

Atkinson, G., Hamilton, K., & Pearce, D. (1997). Genuine savings as an indicator of sustainability.[In:] CSERGE Working Paper GEC 97-03. *Environment Department, World Bank, Washington*.

Ayres, R., van den Berrgh, J., & Gowdy, J. (2001). Strong versus Weak Sustainability. *Environmental Ethics*, *23*(2), 155–168. https://doi.org/10.5840/enviroethics200123225

Bakar, A. A., Osman, M. M., Bachok, S., Zen, I., & Abdullah, M. F. (2017). A REVIEW ON SUSTAINABLE WELLBEING INDICATORS FOR HUMAN INTERRELATIONSHIPS WITH THE

ENVIRONMENT. *PLANNING MALAYSIA JOURNAL*, *15*(1).

Bank, W. (2016). The cost of air pollution: strengthening the economic case for action. *Washington: World Bank Group*.

Bank, World. (2020). The global economic outlook during the COVID-19 pandemic: A changed world. *World Bank Feature Story*.

Barredo, J. I., & Demicheli, L. (2003). Urban sustainability in developing countries' megacities: Modelling and predicting future urban growth in Lagos. *Cities*, *20*(5), 297–310. https://doi.org/10.1016/S0264-2751(03)00047-7

Basiago, A. D. (1998). Economic, social, and environmental sustainability in development theory and urban planning practice. *Environmentalist*, *19*(2), 145–161. https://doi.org/10.2779/61700

Baum, A., Fleming, R., & Singer, J. E. (1985). Understanding environmental stress: strategies for conceptual and methodological integration. *Advances in Environmental Psychology*, *5*, 185–205.

Baum, A., Singer, J. E., & Baum, C. S. (1981). Stress and the environment. *Journal of Social Issues*, *37*(1), 4–35.

Bell, S., & Morse, S. (2012). *Sustainability indicators: Measuring the immeasurable? Second edition*. *Sustainability Indicators: Measuring the Immeasurable? Second Edition*. https://doi.org/10.4324/9781849772723

Bell, S., & Morse, S. (2018). Sustainability Indicators Past and Present: What Next? *Sustainability*, *10*(5), 1688.

Bemanian, M., Mæland, S., Blomhoff, R., Rabben, Å. K., Arnesen, E. K., Skogen, J. C., & Fadnes, L. T. (2021). Emotional Eating in Relation to Worries and Psychological Distress Amid the COVID-19 Pandemic: A Population-Based Survey on Adults in Norway. *International Journal of Environmental Research and Public Health*, *18*(1), 130.

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *NursingPlus Open*, *2*, 8–14.

Bernhard, J., Cahill, K., & Gale, C. (2007). *Sustainability Indicator Projects : Profiles & Findings Sustainability Indicator Projects : Profiles & Findings*.

Bertone, G., Parry, S. C., Kubani, D., & Wolch, J. (2006). Indicators in action: The use of sustainability indicators in the City of Santa Monica. In *Community Quality-of-Life Indicators* (pp. 43–60). Springer.

Biermann, F. (2013). Curtain down and nothing settled: global sustainability governance after the 'Rio+ 20'Earth Summit. *Environment and Planning C: Government and Policy*, *31*(6), 1099–1114.

Black, A. W. (2004). The quest for sustainable, healthy communities. *Australian Journal of Environmental Education*, 33–44.

Boettke, P. J., & Powell, B. (n.d.). The Political Economy of the COVID-19 Pandemic. *Available at SSRN 3764085*.

Böhringer, C., & Jochem, P. E. P. (2007). Measuring the immeasurable—A survey of sustainability indices. *Ecological Economics*, *63*(1), 1–8.

Bolay, J.-C. (2020). *Urban Planning Against Poverty: how to think and do better cities in the global south*. Springer Nature.

Booth, E. G., Zipper, S. C., Loheide II, S. P., & Kucharik, C. J. (2016). Is groundwater recharge always serving us well? Water supply provisioning, crop production, and flood attenuation in conflict in Wisconsin, USA. *Ecosystem Services*, *21*, 153–165.

Braat, L. (1991). The predictive meaning of sustainability indicators. In "Search of Indicators of Sustainable Development". Kuik OK and Verbruggen H. Kluwer Academic Publishers.

Bradley Guy, G., & Kibert, C. J. (1998). Developing indicators of sustainability: US experience. *Building Research & Information*, *26*(1), 39–45.

Braulio-Gonzalo, M., Bovea, M. D., & Ruá, M. J. (2015). Sustainability on the urban scale: Proposal of a structure of indicators for the Spanish context. *Environmental Impact Assessment Review*, *53*, 16–30. https://doi.org/10.1016/j.eiar.2015.03.002

Brink, P. J. (1998). *Advanced design in nursing research*. Thousand Oaks, CA: Sage Publications, Inc.

Brundtland, G. H. (1987). Our Common Future: Report of the World Commission on Environment and Development. *United Nations Commission*, *4*(1), 300. https://doi.org/10.1080/07488008808408783

Burkle, F. M., Bradt, D. A., & Ryan, B. J. (2021). Global public health database support to population-based management of pandemics and global public health crises, part I: the concept. *Prehospital and Disaster Medicine*, *36*(1), 95–104.

Burton, I. (1990). Factors in urban stress. *J. Soc. & Soc. Welfare*, *17*, 79.

Cachanosky, N., Cutsinger, B., Hogan, T. L., Luther, W. J., & Salter, A. W. (2020). The Federal

Reserve's Response to the COVID-19 Contraction: An Initial Appraisal. *AIER Sound Money Project Working Paper*, (2021–01).

Caldara, D., & Iacoviello, M. (2018). Measuring Geopolitical Risk. *International Finance Discussion Paper*, *2018*(1222), 1–66. https://doi.org/10.17016/ifdp.2018.1222

Calef, D., & Goble, R. (2007). The allure of technology: How France and California promoted electric and hybrid vehicles to reduce urban air pollution. *Policy Sciences*, *40*(1), 1–34.

Camagni, R. (1998). Sustainable urban development: definition and reasons for a research programme. *International Journal of Environment and Pollution*, *10*(1), 6–27.

Cato, M. S. (2009). *Green economics: an introduction to theory, policy and practice*. Earthscan.

Chamie, M. (2004). World Urbanization Prospects: The 2003 Revision. United Nations.

Charles, E. J., Mehaffey, J. H., Hawkins, R. B., Fonner, C. E., Yarboro, L. T., Quader, M. A., … Kron, I. L. (2019). Socioeconomic distressed communities index predicts risk-adjusted mortality after cardiac surgery. *The Annals of Thoracic Surgery*, *107*(6), 1706–1712.

Choi, I. H. (2010). Awareness of sustainable development: why did the Saemangeum Tideland Reclamation Project lead to the first national controversy over sustainable development in South Korea? Texas A & M University.

City, S. (1996). The sustainability plan for the City of San Francisco. *Retrieved December*, *3*, 2005.

Cohen, J. E. (2019). Cities and Climate Change: A Review Essay. *Population and Development Review*, *45*(2), 425–435.

Collier, M. J., Nedović-Budić, Z., Aerts, J., Connop, S., Foley, D., Foley, K., … Verburg, P. (2013). Transitioning to resilience and sustainability in urban communities. *Cities*, *32*, S21–S28.

Commission, J. R. C.-E. (2008). *Handbook on constructing composite indicators: Methodology and user guide*. OECD publishing.

Conway, M., & Konvitz, J. (2000). Meeting the Challenge of Distressed Urban Areas. *Urban Studies*, *37*(4), 749–774. https://doi.org/10.1080/00420980050004008

Costanza, R. (1992). *Ecological economics: the science and management of sustainability*. Columbia University Press.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Daly, H. (2008). *Ecological economics and sustainable development: Selected essays*. New York, NY, USA: Edward Elgar.

Davies, A., & Vergriete, P. (1998). *Integrating distressed urban areas*. Org. for Economic Cooperation & Development.

Dekker, K. (2007). Social Capital, Neighbourhood Attachment and Participation in Distressed Urban Areas. A Case Study in The Hague and Utrecht, the Netherlands. *Housing Studies*, *22*(3), 355–379. https://doi.org/10.1080/02673030701254103

Dekker, K., & Van Kempen, R. (2004). Large housing estates in Europe: current situation and developments. *Tijdschrift Voor Economische En Sociale Geografie*, *95*(5), 570–577.

Dempsey, N., Brown, C., & Bramley, G. (2012). The key to sustainable urban development in UK cities? The influence of density on social sustainability. *Progress in Planning*, *77*(3), 89–141. https://doi.org/10.1016/j.progress.2012.01.001

Deng, D., Liu, S., Wallis, L., Duncan, E., & McManus, P. (2017). Urban Sustainability Indicators: how do Australian city decision makers perceive and use global reporting standards? *Australian Geographer*, *48*(3), 401–416. https://doi.org/10.1080/00049182.2016.1277074

Dhar, T. K., & Khirfan, L. (2017). Climate change adaptation in the urban planning and design research: missing links and research agenda. *Journal of Environmental Planning and Management*, *60*(4), 602–627.

DiSano, J. (2002). Indicators of sustainable development: Guidelines and methodologies. *United Nations Department of Economic and Social Affairs, New York*.

Distressed area | Definition of Distressed area at Dictionary.com. (n.d.). Retrieved March 8, 2021, from https://www.dictionary.com/browse/distressed-area

Dizdaroglu, D. (2015). Developing micro-level urban ecosystem indicators for sustainability assessment. *Environmental Impact Assessment Review*, *54*, 119–124.

Dizdaroglu, D. (2017). The role of indicator-based sustainability assessment in policy and the decision-making process: A review and outlook. *Sustainability*, *9*(6), 1018.

Drakakis-Smith, D. (1996). Third world cities: sustainable urban development II—population, labour and poverty. *Urban Studies*, *33*(4–5), 673–701.

Dresner, S. (2008). *The principles of sustainability*. Earthscan.

Economic Innovation Group. (2018). 2018 Distressed Communities Index (DCI). Retrieved October 6, 2019, from https://eig.org/dci

Ehteshami, A., Huber, D., & Paciello, M. C. (2017). *The Mediterranean Reset: Geopolitics in a New Age*. Retrieved from https://www.globalpolicyjournal.com/sites/default/files/inline/files/Final E-book Med Reset (PDF with Cover)_0.pdf#page=104

Eklund, L. (2012). Migration Patterns in Duhok Governorate, Iraq, 2000-2010. *The Open Geography Journal*, *5*(1), 48–58. https://doi.org/10.2174/1874923201205010048

Ekstam, H. (2015). Residential Crowding in a "Distressed" and a "Gentrified" Neighbourhood–Towards an Understanding of Crowding in "Gentrified" Neighbourhoods. *Housing, Theory and Society*, *32*(4), 429–449.

Ellison, C. W., & Maynard, E. S. (1992). Healing for the City. *Grand Rapids: Zondeivan*.

Elmqvist, T., Fragkias, M., Goodness, J., Güneralp, B., Marcotullio, P. J., McDonald, R. I., … Seto, K. C. (2013). *Urbanization, biodiversity and ecosystem services: challenges and opportunities: a global assessment*. Springer.

Esty, D. C., Levy, M. A., Kim, C. H., de Sherbinin, A., Srebotnjak, T., & Mara, V. (2008). Environmental performance index. *New Haven: Yale Center for Environmental Law and Policy*, *382*.

Esty, D. C., Levy, M., Srebotnjak, T., & De Sherbinin, A. (2005). Environmental sustainability index: Benchmarking national environmental stewardship. *New Haven: Yale Center for Environmental Law & Policy*, 47–60.

European Commission. (2015). *Indicators for sustainable cities*. https://doi.org/10.2779/61700

European Environment Agency. (2008). *Urban stress - The problem*. Retrieved from https://www.eea.europa.eu/publications/92-826-5409-5/page037new.html

Fabre, C. (2017). *Urban Crises*. Retrieved from https://www.oecd.org/development/humanitarian-donors/docs/urban_crises_oecd.pdf

Fiksel, J. R., Eason, T., & Frederickson, H. (2013). *A framework for sustainability indicators at EPA*. Citeseer.

Fleming, A., Wise, R. M., Hansen, H., & Sams, L. (2017). The sustainable development goals: A case study. *Marine Policy*, *86*, 94–103.

Gan, X., Fernandez, I. C., Guo, J., Wilson, M., Zhao, Y., Zhou, B., & Wu, J. (2017). When to use what: Methods for weighting and aggregating sustainability indicators. *Ecological Indicators*, *81*(May), 491–502. https://doi.org/10.1016/j.ecolind.2017.05.068

Georgescu-Roegen, N. (2002). Four challenges of sustainability. *Conservation Biology*, *16*(6), 1457–1460.

Gholipour, H. F., & Farzanegan, M. R. (2018). Institutions and the effectiveness of expenditures on environmental protection: evidence from Middle Eastern countries. *Constitutional Political Economy*, *29*(1), 20–39. https://doi.org/10.1007/s10602-017-9246-x

Gilbert, R., Stevenson, D., Girardet, H., & Stren, R. (2013). *Making cities work: Role of local authorities in the urban environment*. Routledge.

Gómez-Álvarez, D., López-Moreno, E., Bilsky, E., Ochoa, K. B., & Osorio, E. (2018). Indicators for measuring urban sustainability and resilience. *The Urban Planet: Knowledge towards Sustainable Cities; Elmqvist, T., Bai, X., Frantzeskaki, N., Griffith, C., Maddox, D., McPhearson, T., Parnell, S., Patricia Romero-Lankao, P., Simon, D., Watkins, M., Eds*, 163–179.

Gonzalez-Garcia, S., Manteiga, R., Moreira, M. T., & Feijoo, G. (2018). Assessing the sustainability of Spanish cities considering environmental and socio-economic indicators. *Journal of Cleaner Production*, *178*, 599–610. https://doi.org/10.1016/j.jclepro.2018.01.056

Gotham, K. F., & King, A. J. (2019). Urbanization. *The Wiley Blackwell Companion to Sociology*, 267–282.

Gottdiener, M. (1985). Symposium: Whatever happened to the urban crisis? *Urban Affairs Quarterly*, *20*(4), 421–427.

Goyal, S. K., Ghatge, S. V, Nema, P., & Tamhane, S. M. (2006). Understanding urban vehicular pollution problem vis-a-vis ambient air quality–case study of a megacity (Delhi, India). *Environmental Monitoring and Assessment*, *119*(1), 557–569.

Group, E. I. (2016). The 2016 distressed communities index: An analysis of community well-being across the United States.

Group, W. B. (2014). *World development indicators 2014*. World Bank Publications.

Grytten, O. H. (2020). The Wealth of a Nation: Norways Road to Prosperity. *NHH Dept. of Economics Discussion Paper*, (17).

HABITAT II, U. N. (1996). United nations conference on human settlements (HABITAT II). *Istanbul: Sn*.

Habitat, U. (2006). State of the World's Cities 2006/2007. *New York: United Nations*.

Habitat, U. N. (1996). The habitat agenda goals and principles, commitments and the global plan of action. *Istanbul: UN Habitat*.

Habitat, U. N. (2015). Sustainable cities and communities: SDG goal 11 monitoring framework. *New York, NY: UN-Habitat*.

Haines, A., Alleyne, G., Kickbusch, I., & Dora, C. (2012). From the Earth Summit to Rio+ 20: integration of health and sustainable development. *The Lancet*, *379*(9832), 2189–2197.

Hák, T, Janoušková, S., Moldan, B., & Dahl, A. L. (2018). Closing the sustainability gap. *Ecological Indicators*, *87*, 193–195. https://doi.org/10.1016/j.ecolind.2017.12.017

Hák, Tomáš, Janoušková, S., & Moldan, B. (2016). Sustainable Development Goals: A need for relevant indicators. *Ecological Indicators*, *60*, 565–573.

Halász, L. (2019). Rakonczai, J.: Global and Geopolitical Environmental Challenges. *Hungarian Geographical Bulletin*, *68*(2), 191–194. https://doi.org/10.15201/hungeobull.68.2.7

Hall, P. (1997). Regeneration policies for peripheral housing estates: inward-and outward-looking approaches. *Urban Studies*, *34*(5–6), 873–890.

Hamilton, A., Mitchell, G., & Yli-Karjanmaa, S. (2002). The BEQUEST toolkit: a decision support system for urban sustainability. *Building Research & Information*, *30*(2), 109–115.

Happy Planet Index. (n.d.). Retrieved October 20, 2020, from http://happyplanetindex.org/

Haque, A. (1998). Use of Geographic Information Systems in Mapping Distressed Areas of Cities. *Journal of Urban Technology*, *5*(3), 47–59.

Hardi, P., & Canada, C. I. (1997). *Measuring sustainable development: Review of current practice*. Industry Canada.

Hardoy, J. E., & Satterthwaite, D. (1991). Environmental problems of Third World cities: a global issue ignored? *Public Administration and Development*, *11*(4), 341–361.

Hasan, M., & Adnan, A. (2002). Sustainable Development Indicator Initiatives in Malaysia–Novel Approach and Viable Framework. *Southeast Asia Regional Committee, Taiwan, Available …*. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Sustainable+Development+Indicator+Initiatives+in+Malaysia+-+Novel+Approaches+and+Viable+Frameworks+.#0

Hassan, A., & Kotval-K, Z. (2019). A Framework for Measuring Urban Sustainability in an Emerging Region: The City of Duhok as a Case Study. *Sustainability*, *11*(19), 5402. https://doi.org/10.3390/su11195402

Hawkins, R. B., Charles, E. J., Mehaffey, J. H., Williams, C. A., Robinson, W. P., Upchurch, G. R., … Group, V. V. (2018). Socioeconomic Distressed Communities Index associated with worse limb-related outcomes after infrainguinal bypass.

Heal, G. (2012). Reflections--Defining and Measuring Sustainability. *Review of Environmental Economics and Policy*, *6*(1), 147–163. https://doi.org/10.1093/reep/rer023

Hens, L., & Nath, B. (2003). The Johannesburg Conference. *Environment, Development and Sustainability*, *5*(1–2), 7–39.

Hernández-Moreno, S., & de Hoyos-Martínez, J. (2010). Indicators of urban sustainability in Mexico. *Theoretical and Empirical Researches in Urban Management*, *5*(7 (16), 46–60.

Hiremath, R. B., Balachandra, P., Kumar, B., Bansode, S. S., & Murali, J. (2013). Indicator-based urban sustainability—A review. *Energy for Sustainable Development*, *17*(6), 555–563.

Hodson, M., & Marvin, S. (2010). Can cities shape socio-technical transitions and how would we know if they were? *Research Policy*, *39*(4), 477–485.

Holden, E., Linnerud, K., & Banister, D. (2014). Sustainable development: our common future revisited. *Global Environmental Change*, *26*, 130–139.

Holden, M. (2006). Revisiting the local impact of community indicators projects: Sustainable Seattle as prophet in its own land. *Applied Research in Quality of Life*, *1*(3–4), 253–277.

Huang, L., Wu, J., & Yan, L. (2015). Defining and measuring urban sustainability: a review of indicators. *Landscape Ecology*, *30*(7), 1175–1193. https://doi.org/10.1007/s10980-015-0208-2

Huang, S.-L., & Chen, L.-L. (2002). Urban indicators as measurements of Taiwan's sustainability. In *Forum on Urbanizing World and UN Human Habitat II* (p. 67).

Huang, S.-L., Wong, J.-H., & Chen, T.-C. (1998). A framework of indicator system for measuring Taipei's urban sustainability. *Landscape and Urban Planning*, *42*(1), 15–27.

Huang, S. L., Wong, J. H., & Chen, T. C. (1998). A framework of indicator system for measuring Taipei's urban sustainability. *Landscape and Urban Planning*, *42*(1), 15–27. https://doi.org/10.1016/S0169-2046(98)00054-1

Ibrahim, G. R. F., Rasul, A., Ali Hamid, A., Ali, Z. F., & Dewana, A. A. (2019). Suitable site selection for rainwater harvesting and storage case study using Dohuk Governorate. *Water*, *11*(4), 864.

Imbroscio, D. L. (1993). Overcoming the economic dependence of urban America: A review of

strategies. *Journal of Urban Affairs*, *15*(2), 173–190.

IMF, J. (2020). A crisis like no other, an uncertain recovery. *World Economic Outlook Update*.

Janoušková, S., Hák, T., & Moldan, B. (2018). Global SDGs Assessments: Helping or Confusing Indicators? *Sustainability*, *10*(5), 1540.

Jencks, C., & Mayer, S. E. (1990). The social consequences of growing up in a poor neighborhood. *Inner-City Poverty in the United States*, *111*, 186.

Karlenzig, W., Marquardt, F., White, P., Yaseen, R., & Young, R. (2007). *How Green is your city?: The SustainLane US city rankings*. New Society Publishers New York.

Karmaker, C. L., Ahmed, T., Ahmed, S., Ali, S. M., Moktadir, M. A., & Kabir, G. (2021). Improving supply chain sustainability in the context of COVID-19 pandemic in an emerging economy: Exploring drivers using an integrated model. *Sustainable Production and Consumption*, *26*, 411–427.

Kasarda, J. D., & Irwin, M. D. (1991). National business cycles and community competition for jobs. *Social Forces*, *69*(3), 733–761.

Kates, R. W. (2018). What is sustainable development?

Kazmierczak, A., Curwell, S. R., & Turner, J. C. (2007). Assessment methods and tools for regeneration of large urban distressed areas. In *Proceedings of the International Conference on Whole Life Urban Sustainability and its Assessment, Glasgow, available at: http://download. sue-mot. org/Conference-2007/Papers/Kazmierczak. pdf (accessed 24 July 2009)*.

Keyfitz, N. (1989). Impact of Trends in Resources, Environment and Development on Demographic Prospects. *Population and Resources in a Changing World*.

Klooster, D. (2003). Green Development: Environment and Sustainability in the Third World. Taylor & Francis.

Koch, F., & Krellenberg, K. (2018). How to contextualize SDG 11? Looking at indicators for sustainable urban development in Germany. *ISPRS International Journal of Geo-Information*, *7*(12), 464.

Kolsrud, G., & Torrey, B. B. (1992). The importance of population growth in future commercial energy consumption. In *Global Climate Change* (pp. 127–141). Springer.

Kotharkar, R., Pallapu, A. V., & Bahadure, P. (2019). Urban Cluster–Based Sustainability Assessment of an Indian City: Case of Nagpur. *Journal of Urban Planning and Development*,

145(4), 4019018.

Kounani, A., & Skanavis, C. (2019). Resilient Cities in a Sustainable World BT - Industry, Innovation and Infrastructure. In W. Leal Filho, A. M. Azul, L. Brandli, P. G. Özuyar, & T. Wall (Eds.) (pp. 1–10). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-71059-4_76-1

Kovar, J. D. (1993). A short guide to the Rio declaration. *Colo. J. Int'l Envtl. L. & Pol'y*, *4*, 119.

KRG, D. of D. U. P. (2009). *Master Plan of Duhok and Urban Development*.

Kurdistan Board of Investment. (n.d.). *Investment Guide Kurdistan Region-Iraq*. Retrieved from http://www.kurdistaninvestment.org/docs/InvestmentGuideEnglish.pdf

La Viña, A. G. M., Hoff, G., & DeRose, A. M. (2003). The outcomes of Johannesburg: Assessing the world summit on sustainable development. *SAIS Review*, *23*(1), 53–70.

Land, K. C. (2006). The Foundation for Child Development Child and Youth Well-Being Index (CWI), 1975-2004, with projections for 2005. *Duke University Durham, NC*.

Landrigan, P. J., Fuller, R., Acosta, N. J. R., Adeyi, O., Arnold, R., Baldé, A. B., … Breysse, P. N. (2018). The Lancet Commission on pollution and health. *The Lancet*, *391*(10119), 462–512.

Lawn, P. A. (2003). A theoretical foundation to support the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), and other related indexes. *Ecological Economics*, *44*(1), 105–118.

Lawrence, G. (1997). Indicators for sustainable development. *The Way Forward: Beyond Agenda*, *21*, 179–189.

Lee, Y.-J., & Huang, C.-M. (2007). Sustainability index for Taipei. *Environmental Impact Assessment Review*, *27*(6), 505–521.

Lee, Y. J., & Huang, C. M. (2007). Sustainability index for Taipei. *Environmental Impact Assessment Review*, *27*(6), 505–521. https://doi.org/10.1016/j.eiar.2006.12.005

Leezenberg, M. (2015). Politics, Economy, and Ideology in Iraqi Kurdistan since 2003: Enduring Trends and Novel Challenges. *Arab Studies Journal*, *23*(1), 154.

Levent, T. B. (2011). *Sustainable city and creativity: promoting creative urban initiatives*. Ashgate Publishing, Ltd.

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., … Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of

studies that evaluate healthcare interventions: explanation and elaboration. *BMJ (Clinical Research Ed.)*, *339*. https://doi.org/10.1136/bmj.b2700

Lombardi, P., & Brandon, P. (2007). The multimodal system approach to sustainability planning evaluation. *Sustainable Urban Development, The Environmental Assessment Methods*, *2*, 47e64.

Longoni, A., & Cagliano, R. (2015). Environmental and social sustainability priorities. *International Journal of Operations & Production Management*.

Luo, M., & Lau, N. (2018). Increasing heat stress in urban areas of eastern China: Acceleration by urbanization. *Geophysical Research Letters*, *45*(23), 13–60.

Marnn, P., Htoo, H., Zin, P. M. M., Win, T. Z., Jean Claude, N., Ali, H., … Al-aizari, A. R. (2021). COVID-19 Pandemic Impact on Public Distress, Economy and Education of Bago Division in Myanmar. *Technium Soc. Sci. J.*, *15*, 549.

Matthews, T. K. R., Wilby, R. L., & Murphy, C. (2017). Communicating the deadly consequences of global warming for human heat stress. *Proceedings of the National Academy of Sciences*, *114*(15), 3861–3866.

Mcgranahan, G., & Satterthwaite, D. (2002). The environmental dimensions of sustainable development for cities. *Geography*, 213–226.

Meadowcroft, M. (1992). Kurdistan Elections for Iraqi Kurdish National Assembly and Leader of the Kurdistan Liberation Movement, 19 May 1992, Monitoring Report. London: Electoral Reform Consultancy Services.

Meadows, D. H. (1998). Indicators and information systems for sustainable development.

Mega, V., & Pedersen, J. (1998). *Urban sustainability indicators*. Office for Official Publications of the European Communutics.

Meijering, J. V., Tobi, H., & Kern, K. (2018). Defining and measuring urban sustainability in Europe: A Delphi study on identifying its most relevant components. *Ecological Indicators*, *90*(January), 38–46. https://doi.org/10.1016/j.ecolind.2018.02.055

Meloni, A., Fornara, F., & Carrus, G. (2019). Predicting pro-environmental behaviors in the urban context: The direct or moderated effect of urban stress, city identity, and worldviews. *Cities*, *88*, 83–90.

Merino-Saum, A., Halla, P., Superti, V., Boesch, A., & Binder, C. R. (2020). Indicators for urban sustainability: Key lessons from a systematic analysis of 67 measurement initiatives. *Ecological Indicators*, *119*, 106879.

Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education. Revised and Expanded from" Case Study Research in Education.".* ERIC.

Messerli, P., Kim, E. M., Lutz, W., Moatti, J.-P., Richardson, K., Saidam, M., … Glassman, A. (2019). Expansion of sustainability science needed for the SDGs. *Nature Sustainability*, *2*(10), 892–894.

Messerli, P., Murniningtyas, E., Eloundou-Enyegue, P., Foli, E. G., Furman, E., Glassman, A., … Moatti, J.-P. (2019). Global Sustainable Development Report 2019: The Future is Now–Science for Achieving Sustainable Development.

Michael, F. L., Noor, Z. Z., & Figueroa, M. J. (2014). Review of urban sustainability indicators assessment - Case study between Asian countries. *Habitat International*, *44*, 491–500. https://doi.org/10.1016/j.habitatint.2014.09.006

MICROBUSINESS | meaning in the Cambridge English Dictionary. (n.d.). Retrieved March 8, 2021, from https://dictionary.cambridge.org/dictionary/english/stress

Miethe, T. D. (1995). Fear and withdrawal from urban life. *The Annals of the American Academy of Political and Social Science*, *539*(1), 14–27.

Milgram, S. (1970). The experience of living in cities: A psychological analysis. In *Annual Meeting of the American Psychological Association., Sep, 1969, Washington, DC, US; This paper is based on an Invited Address presented to the Division of General Psychology at the aforementioned meeting.* American Psychological Association.

Miller, C. A. (2005). New civic epistemologies of quantification: Making sense of indicators of local and global sustainability. *Science, Technology, & Human Values*, *30*(3), 403–432.

Mischen, P. A., Homsy, G. C., Lipo, C. P., Holahan, R., Imbruce, V., Pape, A., … Holmes, L. M. (2019). A foundation for measuring community sustainability. *Sustainability*, *11*(7), 1903.

Mohammed, A. O. (2013). *Evaluation of Multi-Storey Housing Projects in the Context of Sustainability/The city of Duhok*. University of Duhok.

Mohammed, H., & Ali, M. (2014). Monitoring and prediction of urban growth using GIS techniques: A Case study of Dohuk City Kurdistan Region of Iraq. *Int. J. Sci. Eng. Res*, *5*, 1480–1488.

Mohammed, J. (2013). Rapid urban growth in the city of Duhok, Iraqi Kurdistan Region: An integrated approach of GIS, Remote Sensing and Shannon Entropy application. *International Journal of Geomatics and Geosciences*, *4*(2), 325.

Moldan, B., Janoušková, S., & Hák, T. (2012). How to understand and measure environmental

sustainability: Indicators and targets. *Ecological Indicators*, *17*, 4–13.

Montiel, L. M., Nathan, R. P., & Wright, D. J. (2004). *An update on urban hardship*. Nelson A. Rockefeller Institute of Government, State University of New York ….

Mori, K., & Christodoulou, A. (2012). Review of sustainability indices and indicators: Towards a new City Sustainability Index (CSI). *Environmental Impact Assessment Review*, *32*(1), 94–106. https://doi.org/10.1016/j.eiar.2011.06.001

Mori, K., & Yamashita, T. (2015). Methodological framework of sustainability assessment in City Sustainability Index (CSI): A concept of constraint and maximisation indicators. *Habitat International*, *45*(P1), 10–14. https://doi.org/10.1016/j.habitatint.2014.06.013

Morrison, N. (1999). Addressing the difficulties in letting social housing across the UK. In *Paper to ENHR Conference, Balatonfüred, Hungary* (pp. 25–29).

Morton, S., Pencheon, D., & Squires, N. (2017). Sustainable Development Goals (SDGs), and their implementationA national global framework for health, development and equity needs a systems approach at every level. *British Medical Bulletin*, 1–10.

Moynihan, D. P. (1993). Defining deviancy down. *The American Scholar*, *62*(1), 17–30.

Muhammad, Z. (2001). Development of Urban Indicators: A Malaysian Initiative. *Geoindicators for Sustainable Development, Bangi: Institut Alam Sekitar Dan Pembangunan (LESTARI)*.

Munda, G., & Nardo, M. (2005). Constructing consistent composite indicators: the issue of weights. *EUR 21834 EN*, 1–11.

Munier, N. (2007). *Handbook on urban sustainability*. Springer.

Munoz, A., & Shanks, K. (2019a). The Impact of Internal Displacement in the Kurdistan Region of Iraq: Internally displaced people, interethnic relations, and social cohesion in Duhok. In *Routledge Handbook on Middle East Cities* (pp. 334–351).

Munoz, A., & Shanks, K. (2019b). The Impact of Internal Displacement in the Kurdistan Region of Iraq.

Murayama, Y., & Estoque, R. C. (2020). Urbanization: Concept, Mechanism, and Global Implications. In *Human Geoscience* (pp. 261–282). Springer.

Mustafa, Y., Ali, R., & Saleh, R. (2012). Monitoring and evaluating land cover change in the Duhok city, Kurdistan region-Iraq, by using remote sensing and GIS. *International Journal of Engineering Inventions*, *1*(11), 28–33.

Musterd, S. (2005). Social and ethnic segregation in Europe: Levels, causes, and effects. *Journal of Urban Affairs*, *27*(3), 331–348.

Nasrollahi, Z., Hashemi, M., Bameri, S., & Taghvaee, V. M. (2020). Environmental pollution, economic growth, population, industrialization, and technology in weak and strong sustainability: using STIRPAT model. *Environment, Development and Sustainability*, *22*(2), 1105–1122.

Nassauer, J. I., Wu, J. G., & Xiang, W.-N. (2014). Actionable urban ecology in China and the world: Integrating ecology and planning for sustainable cities. *Landscape and Urban Planning*, *125*, 207–208. https://doi.org/10.1016/j.landurbplan.2014.02.022

Natali, D. (2013). The Kurdistan Region of Iraq: Stabilizer or Spoiler? *Georgetown Journal of International Affairs*, 71–79.

National Academies of Sciences and Medicine, E. (2016). *Pathways to urban sustainability: challenges and opportunities for the United States*. National Academies Press.

Nations, U. (2014). *World Urbanization Prospects: The 2014 Revision, Highlights. Department of Economic and Social Affairs*. *Population Division, United Nations*.

Nations, United. (2013). *Agenda 21: Earth Summit: The United Nations Programme of Action from Rio*. CreateSpace.

Neal, S. G., & Bunce, H. L. (1994). Socioeconomic changes in distressed cities during the 1980s. *Cityscape*, *1*(1), 123–152.

Nelson, A. L. (1995). J. John Palen, The Suburbs. New York: McGraw-Hill, 1995. 236 Pages. Taylor & Francis.

Nelson, A. L., Schwirian, K. P., & Schwirian, P. M. (1998). Social and economic distress in large cities, 1970–1990: A test of the urban crisis thesis. *Social Science Research*, *27*(4), 410–431.

Neumayer, E. (1999). Weak versus strong sustainability. *Books*.

Newman, P., & Jennings, I. (2008). Cities as sustainable ecosystems: principles and practices. Washington DC.

Newman, P. W. G. (1999). Sustainability and cities: extending the metabolism model. *Landscape and Urban Planning*, *44*(4), 219–226.

Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A., Al-Jabir, A., Iosifidis, C., … Agha, R. (2020). The socio-economic implications of the coronavirus and COVID-19 pandemic: a review. *International Journal of Surgery*.

Niemeijer, D., & de Groot, R. S. (2008). Framing environmental indicators: moving from causal chains to causal networks. *Environment, Development and Sustainability*, *10*(1), 89–106. https://doi.org/10.1007/s10668-006-9040-9

Noori, N. N. (2018). The failure of economic reform in the Kurdistan region of Iraq (1921–2015): the vicious circle of uncivic traditions, resource curse, and centralization. *British Journal of Middle Eastern Studies*, *45*(2), 156–175. https://doi.org/10.1080/13530194.2016.1225258

Nordin, M., & Hezri, A. A. (2001). Sustainable Development Indicators Initiative in Malaysia-Novel Approaches and Viable Frameworks. LESTARI.

Nourry, M. (2008). Measuring sustainable development: Some empirical evidence for France from eight alternative indicators. *Ecological Economics*, *67*(3), 441–456.

Nutbeam, D. (1998). Health promotion glossary. *Health Promotion International*, *13*(4), 349–364.

OECD. (1998). *Integrating distressed urban areas*. OECD Publishing.

OECD. (2001). Towards Sustainable Development: Indicators to measure progress. In *OECD Rome Conference* (p. 417).

OECD. (2015). *Resilient Cities*. *Organisation for Economic Co-operation and Development*. Retrieved from http://www.oecd.org/cfe/regionaldevelopment/resilient-cities.htm

OECD. (2017). *Urban Crises*.

OECD, O. (1993). Core set of indicators for environmental performance reviews. *Environmental Monograph*, *83*.

Olewiler, N. (2006). Environmental sustainability for urban areas: The role of natural capital indicators. *Cities*, *23*(3), 184–195.

Omer, W. M. (2016). The Effect of UGM on the Implementation of City Master Plan Duhok City as Case Study. *ZANCO Journal of Pure and Applied Sciences*, *28*(2).

Othman, H. A. (2014). The Role of Investment Law in Housing Construction in Duhok City , Kurdistan Region, *4*(26), 95–105.

Özgen, C. (2009). Planning Methods For Guiding Urban Regeneration Processes In High-Risk Areas. Citeseer.

Parikh, J. K., & Radhakrishna, R. (1991). Indira Gandhi Institute of Development Research,". In *Consumption Patterns: The Driving Force of Environmental Stress"(presented at the United*

Nations Conference on Environment and Development.

Parris, T. M., & Kates, R. W. (2003). Characterizing and measuring sustainable development. *Annual Review of Environment and Resources*, *28*(1), 559–586.

Pearce, D. W., Atkinson, G. D., & Dubourg, W. R. (1994). The economics of sustainable development. *Annual Review of Energy and the Environment*, *19*(1), 457–474.

Pelling, M. (2008). 6.3 The Rio Earth Summit. *The Companion to Development Studies*.

Petrović, M., & Trajković, S. (2010). Air pollution as the cause of urban stress: A case study: Nemanjića Boulevard, Niš, Serbia. *Facta Universitatis-Series: Architecture and Civil Engineering*, *8*(4), 403–412.

Pikridas, M., Barmpounis, K., Biskos, G., & Lelieveld, J. (2018). Aerosol sources and properties in the Mediterranean and the Middle East: First results of the AQABA campaign. In *EGU General Assembly Conference Abstracts* (Vol. 20, p. 6991).

Pintér, L., Hardi, P., Martinuzzi, A., & Hall, J. (2012). Bellagio STAMP: Principles for sustainability assessment and measurement. *Ecological Indicators*, *17*, 20–28.

Pipa, A. F. (2019). Shaping the global agenda to maximize city leadership on the SDGs: The experiences of vanguard cities.

Pirouz, B., Shaffiee Haghshenas, S., Shaffiee Haghshenas, S., & Piro, P. (2020). Investigating a serious challenge in the sustainable development process: analysis of confirmed cases of COVID-19 (new type of coronavirus) through a binary classification using artificial intelligence and regression analysis. *Sustainability*, *12*(6), 2427.

Power, A. (2006). The changing face of cities. *Environment on the Edge*.

Prescott-Allen, R. (2001). *The wellbeing of nations*. Island Press.

Pupphachai, U., & Zuidema, C. (2017). Sustainability indicators: A tool to generate learning and adaptation in sustainable urban development. *Ecological Indicators*, *72*, 784–793.

Rakodi, C., Nunan, F., & McCallum, J. D. (2002). *Sustainable urbanisation: achieving Agenda 21*. Un-habitat.

Ramadan, E. (2015). Sustainable urbanization in the Arabian Gulf region: problems and challenges. *Arts and Social Sciences Journal*, *6*(2), 1–4.

Raswol, L. M. (2017). Form & Structure of urban Housing in Duhok City. *Academic Journal of Nawroz University*, *6*(3), 95–100.

Reba, M., Reitsma, F., & Seto, K. C. (2016). Spatializing 6,000 years of global urbanization from 3700 BC to AD 2000. *Scientific Data*, *3*. https://doi.org/10.1038/sdata.2016.34

Reed, M. S., Fraser, E. D. G., & Dougill, A. J. (2006). An adaptive learning process for developing and applying sustainability indicators with local communities. *Ecological Economics*, *59*(4), 406–418.

Rees, W. E. (1992). Ecological footprints and appropriated carrying capacity: what urban economics leaves out. *Environment and Urbanization*, *4*(2), 121–130.

Remko, V. H. (2020). Research opportunities for a more resilient post-COVID-19 supply chain–closing the gap between research findings and industry practice. *International Journal of Operations & Production Management*.

Rice, L. (2021). Healthy cities, diseasogenic cities and the Global South. In *Environment and Development* (pp. 37–65). Springer.

Riley, J. (2001). Multidisciplinary indicators of impact and change: key issues for identification and summary. *Agriculture, Ecosystems & Environment*, *87*(2), 245–259.

Riposa, G. (2004). Reinventing Paradise: Santa Monica's Sustainable City Program. *Public Administration Quarterly*, 222–251.

Rishi, P., & Khuntia, G. (2012). Urban Environmental Stress and Behavioral Adaptation in Bhopal City of India.

Rizzo, A. (2017). Sustainable urban development and green megaprojects in the Arab states of the Gulf Region: limitations, covert aims, and unintended outcomes in Doha, Qatar. *International Planning Studies*, *22*(2), 85–98.

Rodrigues, M., & Franco, M. (2020). Measuring the urban sustainable development in cities through a Composite Index: The case of Portugal. *Sustainable Development*, *28*(4), 507–520.

Ross, C. E., Mirowsky, J., & Pribesh, S. (2001). Powerlessness and the amplification of threat: Neighborhood disadvantage, disorder, and mistrust. *American Sociological Review*, 568–591.

Ruá, M. J., Huedo, P., Civera, V., & Agost-Felip, R. (2019). A simplified model to assess vulnerable areas for urban regeneration. *Sustainable Cities and Society*, *46*, 101440. https://doi.org/10.1016/j.scs.2019.101440

Sailer, M., & Roll, S. (2017). Three scenarios for the Qatar crisis: regime change, resolution or Cold War in the Gulf.

Salmond, J., Sabel, C. E., & Vardoulakis, S. (2018). Towards the Integrated Study of Urban Climate, Air Pollution, and Public Health. Multidisciplinary Digital Publishing Institute.

Sani, S. (2001). *Developing Urban Sustainability Indicators for Malaysia*. Institute for Environment and Development, Universiti Kebangsaan Malaysia.

Satterthwaite, D. (1992). Sustainable cities: introduction. *Environment and Urbanization*, *4*(2), 3–8.

SAULE JÚNIOR, N., & CARDOSO, P. de M. (2004). Urban indicators guidelines: monitoring the habitat agenda and the Millennium Development Goals. *Nairobi: UN-HABITAT*.

Savabieasfahani, M., Ali, S. S., Bacho, R., Savabi, O., & Alsabbak, M. (2016). Prenatal metal exposure in the Middle East: imprint of war in deciduous teeth of children. *Environmental Monitoring and Assessment*, *188*(9), 505.

Science for Environment Policy. (2015). *Indicators for sustainable cities. In-depth report 12*. *European Commission*. https://doi.org/10.2779/121865

Seabrooke, W., Yeung, S. C. W., Ma, F. M. F., & Li, Y. (2004). Implementing sustainable urban development at the operational level (with special reference to Hong Kong and Guangzhou). *Habitat International*, *28*(3), 443–466.

Seattle, S. (1993). *The sustainable Seattle 1993: indicators of sustainable community: a report of citizens on long-term trends in our community*. Sustainable Seattle, c/o Metrocenter YMCA.

Secretariat, C. (2017). Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable (SDG 11).

Segnestam, L., Aguilera Klink, F., Winograd, M., Farrow, A., Eade, J., Canter, L. W., … Bryant, D. A. (2003). *Indicators of environment and sustainable development: theories and practical experience*. World Bank, Washington, DC (EUA).

Selye, H. (1974). Stress without distress. *New York*, 26–39.

Senge, P. M., Carstedt, G., & Porter, P. L. (2001). Next industrial revolution. *MIT Sloan Management Review*, *42*(2), 24–38.

Shamsuddin, S., & Rashid, A. A. (2013). Malaysian urban rural national indicators network on Sustainable development (MURNInets). *Measuring Sustainability and Urban Form across Cities*, 1–13.

Shang, C., Wu, T., Huang, G., & Wu, J. (2019). Weak sustainability is not sustainable:

Socioeconomic and environmental assessment of Inner Mongolia for the past three decades. *Resources, Conservation and Recycling*, *141*, 243–252. https://doi.org/10.1016/J.RESCONREC.2018.10.032

Shanks, K. (2019). The politics of IDP education provision: Negotiating identity and schooling in the Kurdistan Region of Iraq. *International Migration*, *57*(2), 32–47.

Shen, L.-Y., Ochoa, J. J., Shah, M. N., & Zhang, X. (2011). The application of urban sustainability indicators–A comparison between various practices. *Habitat International*, *35*(1), 17–29.

Shields, K., Langer, H., Watson, J., & Stelzner, K. (2009). European Green City Index: Assessing the environmental impact of Europe's major cities. *Siemens AG. Munich, Germany*.

Shilani, H. (2019). Kurdistan officials warn of alarming levels of air pollution in Duhok. Retrieved September 3, 2019, from https://www.kurdistan24.net/en/news/34c679d8-bf5e-4dd9-adaf-06bd755b6094

Singh, R. K., Murty, H. R., Gupta, S. K., & Dikshit, A. K. (2012). An overview of sustainability assessment methodologies. *Ecological Indicators*, *15*(1), 281–299. https://doi.org/10.1016/j.ecolind.2011.01.007

Sirgy, M. J., Phillips, R., & Rahtz, D. R. (2009). *Community quality-of-life indicators: Best cases II*. Springer.

Spain, D. (1990). Housing quality and affordability among female householders. *Housing Demography: Linking Demographic Structure and Housing Markets*, 86–108.

Stanners, D., & Bourdeau, P. (1995). Europe's environment: the Dobris assessment. In *Europe's environment: the Dobrís assessment*. Office for Official Publication of the European Communities.

Stansfield, G. R. V. (2003). *Iraqi Kurdistan: Political development and emergent democracy*. Routledge.

Starke, L. (2007). *State of the world 2007: our urban future: a Worldwatch Institute report on progress toward a sustainable society*. WW Norton & Company.

Stearns, L. B., & Almeida, P. D. (2004). The formation of state actor-social movement coalitions and favorable policy outcomes. *Social Problems*, *51*(4), 478–504.

Subramanian, S. V, Lochner, K. A., & Kawachi, I. (2003). Neighborhood differences in social capital: a compositional artifact or a contextual construct? *Health & Place*, *9*(1), 33–44.

Suchday, S., Kapur, S., Ewart, C. K., & Friedberg, J. P. (2006). Urban stress and health in

developing countries: Development and validation of a neighborhood stress index for India. *Behavioral Medicine*, *32*(3), 77–86.

Sustainable Society Index. (n.d.). Retrieved October 20, 2020, from http://www.ssfindex.com/

Taha, D. A. (2012). *Analysis and Evaluation for The Reality of Secondary Schools in Duhok City Using Planning Criteria*. University of Duhok.

Tanguay, G. A., Rajaonson, J., Lefebvre, J.-F., & Lanoie, P. (2010). Measuring the sustainability of cities: An analysis of the use of local indicators. *Ecological Indicators*, *10*(2), 407–418.

Teaford, J. C. (2016). *The twentieth-century American city: Problem, promise, and reality*. JHU Press.

Teixeira, E. I., Fischer, G., Van Velthuizen, H., Walter, C., & Ewert, F. (2013). Global hot-spots of heat stress on agricultural crops due to climate change. *Agricultural and Forest Meteorology*, *170*, 206–215.

The United Nations. (2019). SDG Summit 2019. Retrieved from https://sustainabledevelopment.un.org/sdgsummit

Tsai, W.-L., McHale, M. R., Jennings, V., Marquet, O., Hipp, J. A., Leung, Y.-F., & Floyd, M. F. (2018). Relationships between characteristics of urban green land cover and mental health in US metropolitan areas. *International Journal of Environmental Research and Public Health*, *15*(2), 340.

Tuczek, M., Degirmenci, K., Desouza, K. C., Watson, R. T., Yigitcanlar, T., Garcia Hansen, V., … Breitner, M. H. (2019). Toward a Decision Support System for Mitigating Urban Heat.

Un-Habitat. (2012). *Cities in a globalizing world: global report on human settlements*. Routledge.

UN-Habitat. (2009). Urban Indicators Guidelines. United Nations Human Settlements Programme Nairobi, Kenya.

UN-Habitat. (2016). Sustainable Cities and Communities. SDG Goal 11 Monitoring Framework,".

UN. (2017). Sustainable Development Goals-17 goals to transform our world. *United Nations,[Online]. Available: Https://Www. Un. Org/Sustainabledevelopment/Energy/.[Accessed 04 June 2018]*.

UN, D. of E. and S. A. (2013). *World Economic and Social Survey 2013: Sustainable Development Challenges*. UN.

UNCHS. (2001). The state of the world's cities 2001. *United Nations for Human Settlements, Nairobi, Kenya*.

UNDP. (2005). *Human Development Report 2005*. Retrieved from http://hdr.undp.org

UNECE, E., Eurostat, O., & Force, T. (2013). Framework and suggested indicators to measure sustainable development.

UNHCR. (2007). *Governorate Assessment Report - Dahuk*. Retrieved from http://www.refworld.org/pdfid/471f4c9ba.pdf

Unit, E. I. (2009). *European green city index: assessing the environmental impact of Europe's major cities*. Siemens AG.

United, N. (2007). *Indicators of Sustainable Development: Guidelines and Methodologies*. *New York*.

United Nations Development Programme. (2021). Socio-economic impact of COVID-19 | UNDP. Retrieved March 9, 2021, from https://www.undp.org/content/undp/en/home/coronavirus/socio-economic-impact-of-covid-19/

Urban China Initiative. (2012). Urban Sustainability Index (USI). Retrieved March 23, 2021, from http://www.urbanchinainitiative.org/en/research/usi.html

Van de Kerk, G., & Manuel, A. R. (2008). A comprehensive index for a sustainable society: The SSI—the Sustainable Society Index. *Ecological Economics*, *66*(2–3), 228–242.

Verma, P., & Raghubanshi, A. S. (2018). Urban sustainability indicators: Challenges and opportunities. *Ecological Indicators*, *93*(May), 282–291. https://doi.org/10.1016/j.ecolind.2018.05.007

Vojnovic, I. (2012). *Urban Sustainability: A global perspective*. Michigan State University Press.

Vojnovic, I. (2014). Urban sustainability: Research, politics, policy and practice. *Cities*, *41*, S30–S44. https://doi.org/10.1016/j.cities.2014.06.002

Voller, Y. (2014). Countering Violence against Women in Iraqi Kurdistan: State-Building and Transnational Advocacy. *International Journal of Middle East Studies*, *46*(2), 351–372.

Waas, T., Hugé, J., Block, T., Wright, T., Benitez-Capistros, F., & Verbruggen, A. (2014). Sustainability assessment and indicators: Tools in a decision-making strategy for sustainable development. *Sustainability (Switzerland)*, *6*(9), 5512–5534. https://doi.org/10.3390/su6095512

Wackernagel, M., & Rees, W. E. (1997). Perceptual and structural barriers to investing in natural capital: Economics from an ecological footprint perspective. *Ecological Economics*, *20*(1), 3–24.

Wang, X., Salat, S., & Painter, D. (2018). *Urban Sustainability Framework (USF)*. World Bank Group.

Weckström, S. (2012). Self-assessed consequences of unemployment on individual wellbeing and family relationships: A study of unemployed women and men in Finland. *International Journal of Social Welfare*, *21*(4), 372–383.

Wilson, M. C., & Wu, J. (2017). The problems of weak sustainability and associated indicators. *International Journal of Sustainable Development & World Ecology*, *24*(1), 44–51. https://doi.org/10.1080/13504509.2015.1136360

Wolman, H., Hill, E. W., Blumenthal, P., & Furdell, K. (2008). Understanding economically distressed cities.

Wolman, M. G. (1993). Population, land use, and environment: A long history. *Population and Land Use in Developing Countries*.

Wong, C. (2015). A framework for 'City Prosperity Index': linking indicators, analysis and policy. *Habitat International*, *45*, 3–9.

World Wildlife Fund. (1998). Living planet report. WWF International, London: New Economics Foundation and Cambridge: World ….

Wouters, H., De Ridder, K., Poelmans, L., Willems, P., Brouwers, J., Hosseinzadehtalaei, P., … Demuzere, M. (2017). Heat stress increase under climate change twice as large in cities as in rural areas: A study for a densely populated midlatitude maritime region. *Geophysical Research Letters*, *44*(17), 8997–9007.

Wu, J. (2010). Urban sustainability: an inevitable goal of landscape research. *Landscape Ecology*, *25*(1), 1–4. https://doi.org/10.1007/s10980-009-9444-7

Wu, J. (2013). Landscape sustainability science: ecosystem services and human well-being in changing landscapes. *Landscape Ecology*, *28*(6), 999–1023.

Wu, J. (2014). Urban ecology and sustainability: The state-of-the-science and future directions. *Landscape and Urban Planning*, *125*, 209–221. https://doi.org/10.1016/j.landurbplan.2014.01.018

Wu, J., & Wu, T. (2012). Sustainability indicators and indices: an overview. In *Handbook of sustainability management* (pp. 65–86). World Scientific.

Yanarella, E. J. (1999). Local sustainability programmes in comparative perspective: Canada and the USA. *Local Environment*, *4*(2), 209–223.

Yarime, M., Takeda, Y., & Kajikawa, Y. (2010). Towards institutional analysis of sustainability science: a quantitative examination of the patterns of research collaboration. *Sustainability Science*, *5*(1), 115–125. https://doi.org/10.1007/s11625-009-0090-4

Yigitcanlar, T., Dur, F., & Dizdaroglu, D. (2015). Towards prosperous sustainable cities: A multiscalar urban sustainability assessment approach. *Habitat International*, *45*, 36–46. https://doi.org/10.1016/j.habitatint.2014.06.033

Yigitcanlar, T., Kamruzzaman, M., Foth, M., Sabatini-Marques, J., da Costa, E., & Ioppolo, G. (2019). Can cities become smart without being sustainable? A systematic review of the literature. *Sustainable Cities and Society*, *45*, 348–365.

Yigitcanlar, T., & Teriman, S. (2015). Rethinking sustainable urban development: towards an integrated planning and development process. *International Journal of Environmental Science and Technology*, *12*(1), 341–352. https://doi.org/10.1007/s13762-013-0491-x

Yin, R. K. (1993). Case study research design and methods applied. *Social Research Methods Series*, *5*.

Yin, R. K. (2015). *Qualitative research from start to finish*. Guilford publications.

Zander, K. K., & Mathew, S. (2019). Estimating economic losses from perceived heat stress in urban Malaysia . *Ecological Economics* . Elsevier B.V . https://doi.org/10.1016/j.ecolecon.2019.01.023

Zander, K. K., Mathew, S., & Garnett, S. T. (2018). Exploring heat stress relief measures among the Australian labour force. *International Journal of Environmental Research and Public Health*, *15*(3), 401.

Zhao, C., Zhou, B., & Su, X. (2014). Evaluation of urban eco-security—A case study of Mianyang City, China. *Sustainability*, *6*(4), 2281–2299.

Zhao, J. (2011). *Towards sustainable cities in China: analysis and assessment of some Chinese cities in 2008*. Springer Science & Business Media.

Zhao, J. Z., Cui, S. H., Yan, C. Z., & Guo, Q. H. (2009). Theoretical thinking in sustainable city construction of China. *Huan Jing Ke Xue= Huanjing Kexue*, *30*(4), 1244–1248.

Zimm, C., Sperling, F., & Busch, S. (2018). Identifying Sustainability and Knowledge Gaps in Socio-Economic Pathways Vis-à-Vis the Sustainable Development Goals. *Economies*, *6*(2), 20.

Zubairu, S., & Adedayo, O. (2017). *INCLUSIVE CITY GROWTH AND THE POOR : Policies , Challenges and Prospects*. (S. N. ZUBAIRU, Ed.). Community Participation Research Group (COPAREG).