Exploring the Dimensions of Resilience during Covid-19 : Unveiling the Role of Adaptation Measures and Recovery Interventions & Climate Action Synergies

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ABSTRACT: *Amidst grappling with the complex human interactions and systems, cities recently stood at the forefront of a dual predicament and cohesively worked on the pressing issue of environmental crisis alongside tackling the COVID-19 pandemic. Despite having some measures in place to combat the environmental concerns induced by climate hazards and maintain ecological sustainability, there is little evidence available of their effectiveness in recent times. Therefore, my research focuses on exploring the Social and Urban aspects of Resilience of cities during the COVID-19 pandemic. Throughout the entirety of this paper, the term "Resilience" is used to encompass both Social and Urban characteristics of Resilience as they attribute to the same phenomenon. To show the former, I exploit a quasi-experiment to study the impact of implementation of Adaptation Measures by cities as compared to those that did not implement them during the pandemic, on Social Risk attributing to Social Resilience. My analysis does not account for any heterogeneity among the cities selected for this study. In line with common wisdom, having Adaptation Measures in place results in an increase in Resilience. However, my research findings indicate that cities that implemented Adaptation Measures during the pandemic exhibited lower levels of Social Resilience compared to those that did not implement them. This finding is likely due to cities reallocating their resources and priorities towards addressing the COVID-19 induced concerns, which exposed the weaknesses of the frantic planning by the Government in these dire times. In addition, my research also aims to explore Urban Resilience of cities through studying the interplay between Recovery Interventions and Climate Action synergies implemented during the pandemic. The statistics indicate that only a fraction of the total cities had implemented at least one of the actions in 2021 with the objective of boosting Resilience. Correspondingly, the results from the descriptive statistics reveal that only one country, with two cities, successfully implemented all the synergies amidst the pandemic serving as an exemplary model for others to emulate for enhancing Resilience.*

Keywords: Resilience, Climate Hazards, Adaptation Measures, COVID-19 Recovery Interventions, Climate Action Synergies

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1. Introduction

Over the years, the delicate equilibrium of nature has been disrupted by human activities, leading to a cascade of climatic changes. The intricacies withheld in our natural surroundings has been deeply intertwined with the consequences of modernization resulting in an increase in climate hazards. These hazards can be briefly described as a broad range of natural disasters, extreme weather conditions and events such as floods, droughts, wildfires, storms etc. The occurrence of one of these hazards wrecks the livelihood and aggravates the existing issues dealt by the society, leaving behind a trail of destruction and hardship. From having devastating effects on urban areas to severe implications for human health and simultaneously disrupting critical services to resulting in economic losses, climate hazards have far-reaching consequences. Therefore, these hazards are no longer a remote threat but a stark reality that we all face today. Hence, it has become an important agenda for cities to find ways for mitigating the effects of climate hazards. Navigating through this challenging terrain of

climate-induced concerns, cities have profoundly altered and planned their course of action accordingly. In an effort to build Resilience which is a multi-dimensional concept comprising of different aspects like Social, Urban, Economical, etc. aiming to withstand any shocks and bounce back from it, cities are rapidly implementing measures to boost their Resilience and sustain the shocks and stresses caused by the hazards or other factors. Cities are increasingly adopting proactive actions, referred to as Adaptation Measures, to mitigate the impacts of climate hazards, enhance preparedness, build adaptive capacity, and promote sustainable practices. But in an attempt to enhance Resilience through the implementation of these measures to mitigate climate hazards, do cities experience any adverse effects on other fronts? This research highlights one potential avenue that was influenced by the implementation of Adaptation Measures during the pandemic.

This paper focuses on two dimensions of Resilience and explores how cities fared during the COVID-19 pandemic when implementing Adaptation Measures and synergizing Recovery Interventions & Climate Action synergies. The initial section of the paper explores Social Resilience which refers to the capacity of individuals, communities to adapt, recover, and thrive in the face of social challenges and disruptions by including adaptive strategies to enhance safety, well-being, and equitable access to resources. This part studies the Social dimension of Resilience by analysing the effects of the Implementation of Adaptation Measures by the cities as compared to those that did not adopt them during the pandemic on Social Risk. The second part explores Urban Resilience which encompasses the ability of cities and urban systems to withstand shocks and bounce back by building robust infrastructure, effective governance, and inclusive planning that addresses social, economic and environmental aspects. The societal challenges and individual concerns highlight the importance of understanding how cities are addressing the needs of their residents by developing inclusive infrastructure and beneficial schemes along with integrating sustainable solutions. An exploration of this dimension of Resilience involves studying the Recovery Intervention & Climate Action synergies adopted by cities in the year 2021.

My first econometric strategy to study Social Resilience is by using the Difference-In- Difference (diff-in-diff/ DID) approach. Having a panel data, spanning over five years allows me to study Resilience by juxtaposing the two groups of cities where one of them implemented the Adaptation Measures and the other did not. The estimates obtained through the diff-in-diff approach are statistically significant and the R-square value reports a 45% variation in the Social Risk that can be explained by the implementation of Adaptation Measures by the cities during the pandemic. The positive estimate of diff-in-diff reveals that the implementation of Adaptation Measures by cities during the pandemic years has increased the Social Risk, thereby pointing towards a reduced Social Resilience during the pandemic time.

To explore Urban Resilience from a novel lens, I present the descriptive statistics of the cities implementing the Recovery Intervention & Climate Action synergies for the year 2021 from data surveying 777 cities around the world. The statistics depict that 50% of the cities have at least implemented one of the COVID-19 Recovery Intervention & Climate Action synergies from a total number of twelve Recovery Intervention & Climate Actions. In addition to the following, the statistics obtained also point out that only two cities from a single country out of ninety-three countries surveyed had implemented all twelve Recovery Intervention & Climate Action synergies.

A large literature shows the impact of COVID-19 on the Social and Urban Resilience aspect of the countries, communities, cities by using different methodologies[1]. Yet, exploring the impact of implementation of Adaptation Measures during the pandemic on Social Risk attributing to Social Resilience still remains an unaddressed topic in the available scientific research. Comparatively, while there has been some discussion on the efforts of cities to enhance Urban Resilience through the adoption of various synergies during the pandemic, my work contributes to the existing literature by offering new insights. Given the limited existing scholarly work on the specific focus of my study, there is ample opportunity for me to investigate the causal effect between Resilience and the implementation of Adaptation Measures during the pandemic, as well as the interrelationships between COVID-19 Recovery Interventions & Climate Action synergies, thereby contributing to the emerging literature on this critical and relevant subject. Consequently, this paper can also be served as a valuable reference for formulating future policy developments in the context of unforeseen events, as it examines the Resilience exhibited during the COVID- 19 pandemic. Through this paper, I aim to provide insights on the aspects of Resilience by examining the implementation of measures and adoption of synergies during the pandemic and presenting the results from conducting comprehensive analysis and descriptive statistics.

This paper is organized into three key sections. The first section explores Resilience in relation to the implementation of Adaptation Measures by the cities during the pandemic. Additionally, it presents the results from the Sensitivity Analysis that was carried out to further validate our findings. The second section of the paper discusses statistics of cities that adopted

[1]The Impact of COVID-19 on Social Resilience: A Cross-Country Analysis" by Smith, J., et al. (2020), (2) The Resilience of Urban Systems During the COVID-19 Pandemic: A Comparative Analysis of Five Cities" by Thomalla, F.,Patt, A., & Shreve, C. (2021).

COVID-19 Recovery Interventions and Climate Actions to build Resilience during the pandemic, providing detailed descriptive insights of the implemented synergies. The final section summarizes the paper, emphasizing the main limitations of the study and provides a comprehensive discussion on the findings.

2. Related Literature

The research design adopted to explore the effects of implementing Adaptation Measures during the pandemic on Resilience bears resemblance to the approach used by Duflo, 2001 to study the impact of a school construction program on education and labor market outcomes in Indonesia. In Indonesia, there was a policy initiative to construct primary schools in under served areas. The author utilizes this policy as a natural experiment to assess the causal effects of school construction on schooling and labor market outcomes. The study uses an experimental design which is similar to the one used in this paper i.e. difference-in-differences (DID) approach, comparing the outcomes of individuals affected by the program (treated group) to those that were not (control group). The results of Duflo's paper suggest that individuals who were exposed to the program of constructing primary schools in their area i.e. (treated group) had higher educational attainment and consequently, experienced improved labor market outcomes. They were more likely to work in higher-skilled occupations, had higher wages and displayed higher rates of formal sector employment.

A similar study to my research is of Daniel Nohrstedt et al, 2022 where they examined the relationship between disaster impacts and Adaptation Actions in cities across the globe. The data used in Nohrstedt's paper to assess Adaptation Measures is sourced from the same organisation, CDP (formerly Carbon Disclosure Project) that I use for my research analysis. The findings of the study reveals that cities that have experienced more severe and frequent disasters are more likely to implement Adaptation Measures. This implies that the level of disaster exposure plays a significant role in driving proactive adaptation efforts. This key observation plays a significant role in my paper explaining a potential cause for the low performance on Resilience by cities that implemented Adaptation Measures during COVID-19. Additionally, the study also identifies some specific factors like the level of governance capacity, availability of financial resources, etc. that influence the adoption of Adaptation Actions. The research also highlights the importance of learning from past disaster experiences. Cities that have encountered disasters in the past are more inclined to undertake Adaptation Actions. In general, this paper is closely aligned with my research and its key findings provide a valuable support to my analysis.

3. Methodology

The data set obtained for this study is from CDP (formerly Carbon Disclosure Project) which is a non-profit charity that runs a global disclosure system for Investors, Companies, Cities, States and Regions to manage their environmental impacts. Each year, CDP conducts a survey where governments self-report through a questionnaire that entails information on emissions, climate actions and climate risks affecting their jurisdictions. This data is collected through the CDP-ICLEI Unified Reporting System available publicly from the CDP website[2].

The CDP dataset is populated with responses from cities, states and regions, reflecting their pivotal role in assessing the risks posed by climate change while recognizing the opportunities presented by proactive measures[13]. Therefore, this analysis centers on the Resilience of cities. The data enables them to benchmark their progress and learn best practices. This approach harmonizes with global reporting standards, fostering transparency, granting access to valuable resources, and facilitating informed decision-making in the context of climate change and environmental sustainability.

The questionnaires for my research was provided by the German Institute of Development and Sustainability, for my project work with them. This survey included a wide range of questions consisting of city's responses to Sustainability Targets, Risk Assessments, Climate Action Financing, Adaptation Measures, Climate Hazards, Social Risks, Emissions, etc. to name a few. The sections that I primarily focused on in this study are Adaptation, Climate Hazards And Vulnerability, Governance and Data Management. The survey questions cities about the main actions they had taken to reduce the risks and vulnerabilities of infrastructure, services, citizens, and businesses from climate change. Additionally, cities were also asked about the types of hazards they are facing, the social impacts of those hazards and how the COVID-19 economic response has affected their climate actions. They also responded on the possible overlaps and connections between interventions for COVID-19 recovery and those aimed at addressing climate change. In addition, my analysis also makes use of the data from the World Bank, a publicly accessible database containing information on the GDP of countries which was subsequently incorporated in the data set compiled for this research for the years used in this study.

3.1. Data Cleaning

The CDP data set used for this paper was in an illegible format which required cleaning and organising. As this study makes

[2]https://www.cdp.net/en/info/about-us

use of several years of data, it was necessary to compile the required variables for the analysis into a single data set. The cleaning and organising of the data was done using the statistical software Stata 16 which enables users to do data manipulation, visualization, statistics, and automated reporting[3]. For the purpose of this research, full data sets for years 2016-2021 were downloaded as a DTA (data) file format used by Stata and at a later stage compiled as a single data set in a xlsx (Microsoft Excel) format.

The process of sorting several variables for a range of years was a tedious task since most of the data provided by CDP was in string (text) format. To begin with, all of the responses were converted to integers for further steps. Subsequently, response variables were renamed for a better understanding. The process of organising included parsing of strings to integers for responses where the coding involved generating a dummy variable by running a loop over several columns as the responses of cities were spread out all across. Further, string matching of the text was done using Regular Expressions and the desired value i.e. “0” or “1” was assigned to the dummy variables. Several new variables were generated, predominantly dummy variables and values were assigned to some of the other variables for statistical analysis. Consequently, all the variables that were produced for this study were merged into a unified data set for further analysis.

For the first section of analysis, dummy variables were generated for the Adaptation Measures by giving a value of “1” to the measure that city responded and “0” for no measure taken. The responses provided by the cities were compiled into twelve Adaptation Measures. This study focuses on six primary Adaptation Measures that have been selected based on their significant impact, which have been realised through conducting validity tests. These measures account for Flood Mapping (map), Planning (plan), Urban, Preparedness (prep), Building (build), Other which have several actions under them. Generating dummy variables for Adaptation Measures through the specified years by iterating across various columns of responses and replacing the missing values with “0” was a repeated process. The same exercise was also used for the generation of ten dummy variables for Social Risk which signified the same relevance i.e “1” for the risk chosen by the city and “0” accounting for no risk. These Risk responses accounted for a range of concerns affecting cities like Fluctuating socio-economic conditions, Increased resource demand, etc. In the context of this study, the research identified a variety of resilience indicators under Social Risk variable which encompass a broad spectrum of factors that are taken into account when examining the concept of Resilience. By utilizing these indicators, we are able to analyse Social Risk that contribute to assessing of resilience. The methodology for choosing social risk as a variable in studying resilience was shaped through a review of relevant research papers[5, 6] which explored the indicators pertinent to assessing resilience. These sources organize Resilience indicators into broad categories like Economy and Society, Infrastructure and Ecosystems, Heath and Well- Being, Leadership and Strategy; each of these is composed of individual indicators assessing Resilience. The CDP dataset included many of these indicators for studying Resilience. Furthermore, the availability of comprehensive historical data for the selected indicators across all relevant years made them the logical choice for an analysis of Resilience. I provide a comprehensive table in the appendix 9.1 that includes a detailed description of actions under the main Adaptation Measures and all the factors under Social Risk variable.

Additionally, Climate Hazard variables were generated to be taken into account as a confounder. These variables were produced in a similar way like the Adaptation Measures where the responses provided by the cities were consolidated into eleven main Climate Hazards. The main hazards affecting the city accounted for Precipitation, Storm, Cold temperature, Hot temperature, Water Scarcity, Fire, Floods, Chemical Change, Mass Movement, Bio-organisms, Other. Similarly, Factors that affect the ability to adapt were also generated and included in the analysis as a confounder. These variables accounted for various factors like access to Basic Services, Resources, Education, Poverty, Inequality to name a few. For a better understanding, the appendix 9.1 includes a table providing a detailed description of the factors affecting the ability to adapt.

For the second part of this study, thirteen dummy variables for COVID-19 Recovery Intervention & Climate Action synergies using only the 2021 data set were generated by string matching and iterating over several columns of responses. The other variable of interest that was produced for this study was the COVID-19 Economic response on the city’s budget for financing climate actions. Integer values were assigned to the generated variable referring to “1” for Increased finance available for climate action, “2” for Decreased finance available for climate action, “3” for No change in finance available for climate action and “4” for Other reasons.

3.2. Pre-Tests

The exploration of Resilience in the first part of the study accounts for Adaptation Measures and Social Risk variables. As this research makes use of data for the years 2016-2021 excluding 2019, a sample size of 2996 observations for cities spanning over five years is used to study Social Resilience. For my analysis, dummy variable for Social Risk is used as the dependent variable whereas, dummy variable for Adaptation Measures is used as the Independent variable which further defines the “treated and control” groups. The other variables of interest that are used in this study as controls/confounders are dummy variables for Climate Hazards, Factors that affect the ability to adapt, GDP and Current Population.

[3] https://en.wikipedia.org/wiki/Stata

The reliability of these variables is checked by conducting various pre-tests. One of it being Cronbach's Alpha which is used for measuring the internal consistency of a questionnaire or a scale[4].

The results obtained for Social Risk variable in this test were in an acceptable range i.e. 0.7 or above. For Adaptation Measures, several tests were conducted to check the significance. As the responses in the survey recorded twelve Adaptation Measures, tests like ANOVA, Lasso, and F-test were conducted to select the ones that explained a higher significant effect on our dependent variable i.e. Social Risk. The results obtained from these tests helped in identifying six significant Adaptation Measures for our study. A variance inflation factor (VIF) test was conducted to check for multi-collinearity which refers to the occurrence of high inter correlations among two or more independent variables in a multiple-regression model. The results obtained by conducting the test on Adaptation Measures suggested no presence of multi-collinearity.

The second part of the study which analyses the efforts being taken towards building Urban Resilience makes use of a sample size of 777 cities for the year 2021. The Cronbach Alpha test was used on the Recovery Interventions & Climate Actions to test the reliability of the synergies. The results were in the acceptable range of the test i.e. 0.7 or above. A total number of thirteen actions were recorded as a response from the cities. For the purpose of this research, I make use of twelve actions eliminating one of the measures which accounted as "do not know" by the cities.

3.3. Techniques used for Analysis

The analysis for both the sections in this paper use distinct statistical methodologies using Stata. To analyze the causal effect after the implementation of measures during COVID-19 on Resilience, I carried out the analysis with the Difference-In-Difference (DID) approach. DID is a statistical technique used in econometrics and quantitative research in the social sciences that attempts to mimic an experimental research design using observational study data, by studying the differential effect of a treatment on a "treatment group" versus a "control group" in a natural experiment[5].

The mathematical representation of the Difference-In-Difference approach involves the utilization of the following coefficients:-

$$Y = \beta 0 + \beta 1 * [\text{Time}] + \beta 2 * [\text{Intervention}] + \beta 3 * [\text{Time*Intervention}] + \beta 4 * [\text{Covariates}] + \varepsilon$$

The interpretation of the coefficients in the following equation are as follows:- Y is the outcome/dependent variable, $\beta 0$ is the baseline average, $\beta 1$ is the time trend for treated and control group, $\beta 2$ reflects the difference between the two groups during Pre- treatment, $\beta 3$ is the interaction between time and treatment which measures the difference in changes over time, $\beta 4$ represents the confounders as covariates and $\in$ represents the error term.

For the purpose of my study, this was the best suited approach as the data in hand was Panel data which predominantly studied the same set of cities over time except adding a few every year. As my research compares the impact on Resilience when cities had implemented the Adaptation Measures during COVID-19 with those that did not, DID proved to be an optimal approach in studying the trends across different time intervals. Since, I had ten dummy variables for my dependent variable i.e. Social Risk , I struggled to unify them as a single variable. However, I found a solution and used the technique of grouping all the dummy variables into a single variable by taking the total/count of all Social Risk factors a city has responded. This new variable "Y" which reflects Social Risk is then used as my dependent variable consisting of frequency of the Social Risk factors a city has chosen. Following the methodology of generating the outcome variable, an independent variable referred to as "X" which reflects a single entity of Adaptation Measures was produced by taking the row total across all of the six measures that were selected after conducting the pre-tests from the cities responses. Following this, a treated variable was generated by giving the value "1" to the cities (1,710 cities) that had implemented at least 1 or more Adaptation Measures referring to them as "Treated group" and "0" to the cities (1,286 cities) that had implemented none of the Adaptation Measures thereby referring to them as the "Control group". A time variable was generated by assigning a value of "0" to the years from 2016-2018, which were the Pre-COVID-19 years, and a value of "1" was assigned to the years 2020-2021, which were COVID-19 years. Furthermore, in order to account for potential confounding factors, variables such as Climate Hazard (cc hazd) and Factors that affect the ability to adapt (cc_r) were generated in a similar way like the dependent variable "Y" by taking the row total of all the Hazards and Factors that the city responded. To help with a better understanding of the transformation of variables in use, the accompanying image provides a visual representation.

[4] https://www.statisticshowto.com/probability-and-statistics/statistics-definitions/cronbachs-alpha-spss/

[5] https://en.wikipedia.org/wiki/Difference in differences

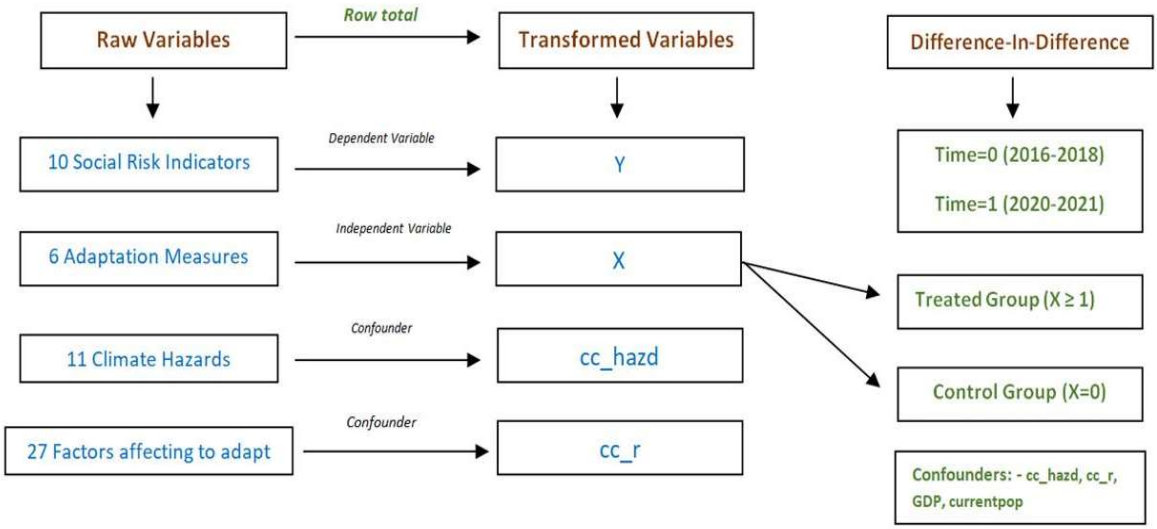

Figure 1. Transformation of Variables

After the transformation of variables, the difference-in-difference technique was then carried out including the following variables in order and specifying the robust option which controlled for any hetroskedasticity present. Following the results obtained from DID, summary statistics of the countries were generated. Additionally, to strengthen the robustness of the model, a sensitivity analysis section is included for the integration of Current Population (currentpop) data from the CDP questionnaires and GDP figures obtained from the World Bank data. By incorporating these variables, the analysis aims to test the stability and reliability of the results obtained, providing a more comprehensive evaluation of the model's performance. Moreover, to check the impact of COVID-19 on the implementation of Adaptation Measures during the same period, an analysis is conducted including the year 2019.

For the exploration of cities enhancing Urban Resilience, descriptive statistics was mainly used for producing inferential tables in Stata. To begin with, descriptive statistics for the variable outlining the Impact of COVID-19 economic response on city's budget which was assigned different values for responses was produced. Thereon, summary statistics were produced for the COVID-19 Recovery Intervention & Climate Action synergies and a list of countries were generated depicting the number of cities implementing the synergies. Following this, various tables displaying cities implementing varying numbers of synergies was generated for drawing inferences. Furthermore, statistics were produced for all twelve synergies to analyze the most frequently adopted ones. The tables for the following variables were subsequently exported to excel for creating visualisations like pie-chart and bar graphs. These tables were then used to create maps highlighting the countries representing cities on their implementation of synergies.

4. Analysing Adaptation Measures and Social Resilience

In recent years, the concerns induced by climate change have posed a significant risk and challenges to human societies, economies and natural systems. This ongoing issue has prompted cities to take actions to mitigate it's impact. The efforts made to address these concerns have shed light on the crucial role that cities play by implementing Adaptation Measures over time to curb the effects of climate hazards. Despite facing obstacles posed by the ongoing pandemic, many cities continued to adopt Adaptation Measures to progress towards building a Resilient environment. The map (Figure 2) illustrates the implementation of at least one of the Adaptation Measures adopted in 1,790 cities across various countries during the period from 2016 to 2021, excluding 2019. The legend on the top provides information about the distribution of cities across countries, where darker shades correspond to countries with a greater number of cities representing the implementation. The map showcases a pattern where cities in countries such as the United States of America, Canada,

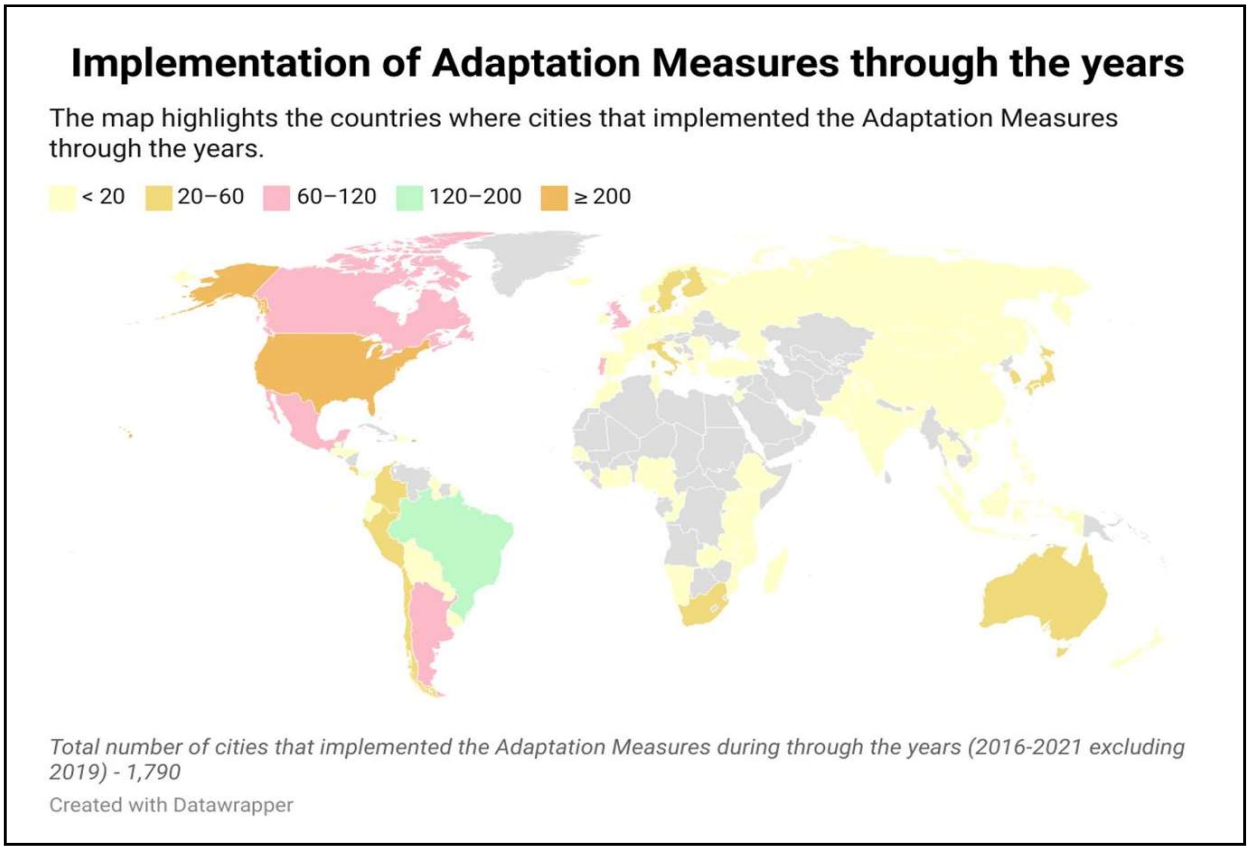

Figure 2. Implementation of Adaptation Measures by cities through the years

Table 1. Difference-in-Difference Results

Variables	Outcome variable Y
time	0.890*** (8.12)
treated	0.225* (2.46)
diff	0.587*** (4.09)
cc_hazd	0.555*** (26.03)
cc_r	0.113*** (7.14)
cons	0.209**(3.18)
R-sqaure	0.45
Observations	2996
t statistics in parentheses * p < 0.05, ** p < 0.01,*** p < 0.001	

Argentina and Brazil have consistently adopted these measures throughout the specified years. It is quite evident that a higher concentration of cities that implemented Adaptation Measures can be seen in the global west compared to other regions. One plausible explanation for this disparity could be attributed to the varying budgets and resources allocated for the implementation and operation of such measures. Nonetheless, while the implementation of Adaptation Measures aims to address climate induced concerns, it is important to acknowledge that these measures can potentially lead to unintended consequences on other facets of society in unforeseen times.

In this section, I will present the findings of the study that assess the impact of implementation of Adaptation Measures on the Resilience of cities during the "2020-2021, COVID-19" period. The implementation of Adaptation Measures could indirectly establish a potential connection between the impacts of the pandemic and its effects on Resilience, acting as a bridge between the two.

Figure 2 show the outcomes of how the implementation of Adaptation Measures during COVID-19, referred to as "treatment" in the context of Difference-in-Differences analysis, impacted Social Resilience in cities.

The table 1 presents the results of a Difference-in-Differences estimation controlling for two confounders with 2996 observations. The "time" variable represents the change in the Social Risk over time for both "Control" & "Treated" group. The coefficient for this variable is 0.890 with a t-statistic of 8.12, indicating that the variable is statistically significant at the 0.001 level. This suggests that from Pre-pandemic to pandemic, the outcome variable i.e. Social Risk increased by 0.890 units, keeping all other variables constant. The "treated" coefficient represents the difference in the outcome variable between the treated and control groups when time=0 (Pre-pandemic). The coefficient for the variable is 0.225 with a t-statistic of 2.46, indicating that the variable is also statistically significant at the 0.05 level. This suggests that the treatment had a positive effect on the outcome variable, increasing it by 0.225 units, holding all other variables constant. The positive DID estimate (_diff) of 0.587 which measures the change in the outcome variable "Y" between the treated and control groups after the treatment, relative to the change before the treatment suggests an increase in the Social Risk. The DID estimate is also statistically significant at the 0.001 level with a t-statistic of 4.09. My model also includes the two identified confounders i.e. Climate hazard (cc_hazd) and Factors that affect the ability to adapt (cc_r) that could possibly be correlated with both the Independent variable and the Outcome variable. Climate hazards can drastically affect the implementation of Adaptation

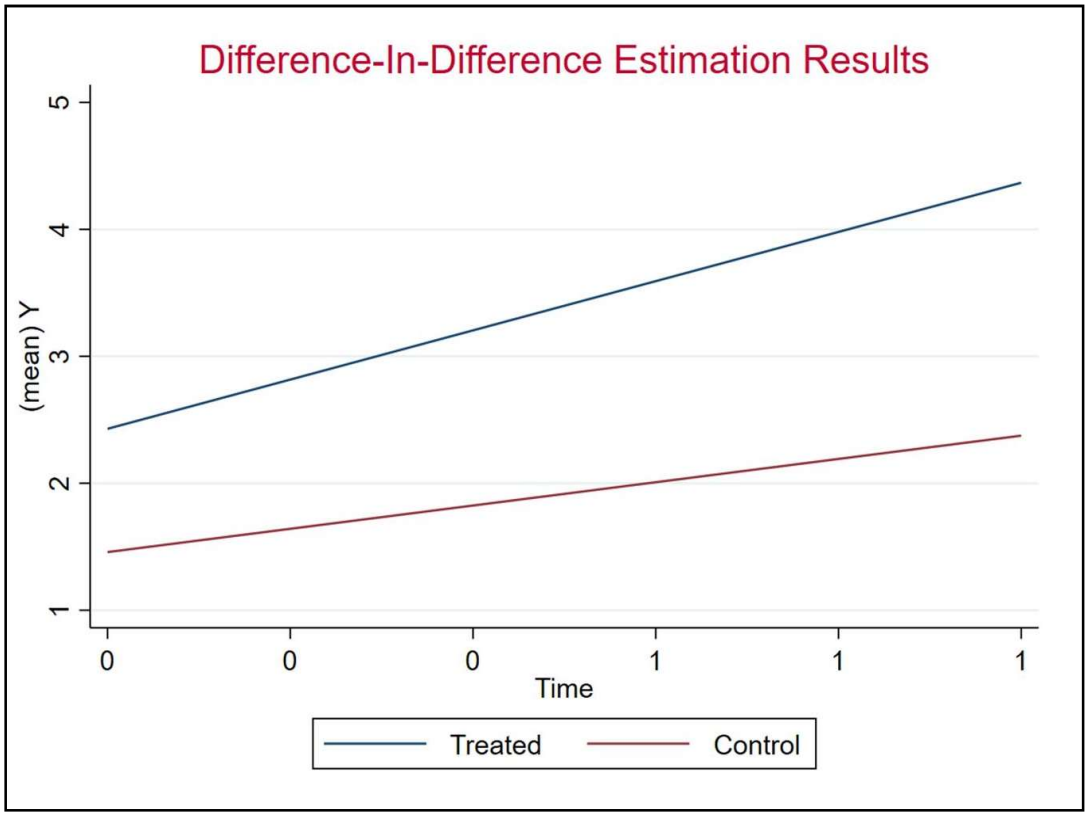

Figure 3. Difference-in-Difference Estimation Graph

Measures by posing challenges to the effectiveness and sustainability of the measures. For instance, extreme weather events such as floods, hurricanes, and droughts can damage or destroy infrastructure and facilities, making it difficult to implement and maintain Adaptation Measures. Furthermore, cities that face a higher frequency or severity of climate hazards are more likely to implement Adaptation Measures. In addition to all of this, extreme weather conditions often lead to the displacement of people from impacted regions like coastal areas and cause a loss of traditional jobs, like fishing resulting in an increase in Social Risk. Similarly, Factors that affect the ability to adapt have a direct correlation with the implementation of Adaptation Measures and their impact can be seen in the increase in Social Risk. These factors include Socioeconomic Status, Access to Resources and Education, among others. For instance, cities with higher levels of socioeconomic status and greater access to financial resources may be better equipped to fund and implement these Adaptation measures. Education and awareness also plays a crucial role in the implementation of Adaptation Measures as cities with higher levels of education may have more informed populace and policymakers who are better equipped to understand the risks and benefits of different measures. Therefore, controlling for these confounders in my model can minimize the risk of their impact. The estimates for cc hazd (Climate Hazards) of 0.555 with a t- statistic of 26.03 and cc_r (Factors affecting ability to adapt) of 0.113 with at-statistic of 7.14 are both statistically significant at 0.001 level indicating that these variables have a significant effect on our variables of interest.

The R-square value of 0.45 indicates that around 45% of the variation in the outcome variable “Y” can be explained by the treatment i.e. implementation of Adaptation Measures during pandemic. The standard errors are reported as robust, and the inference shows the level of significance of the estimates. The asterisks indicate the level of significance, where *** denotes $p<0.001$, ** denotes $p<0.01$, and * denotes $p<0.05$. The results are visually depicted in the graph (Figure 3) indicating that the cities that implemented the Adaptation Measures i.e. the “treated group” during the pandemic reflected an increase in Social Risk compared to those that did not adopt the measures i.e. the “control group”.

This graph further validates the assumption of parallel trends that can be observed at time=0 which is a crucial statistical assumption utilized in the difference-in-differences approach to assess the causal effect of the treatment. It assumes that in the absence of treatment (time=0), the trend in the outcome of interest for the treatment group and the control group would follow parallel paths over time[6]. This assumption is necessary to ensure that any observed differences in outcomes between the two groups can be attributed to the treatment, rather than to pre-existing differences in trends. Therefore, the graph provides visual evidence of the parallel trends assumption which shows that before the implementation of Adaptation Measures by cities during the pandemic, they followed the same trend as the cities that did not implement the measures during the same period. Additionally, this assumption serves to confirm that the observed changes in Social Risk can be attributed to the implementation of Adaptation Measures during the pandemic, rather than being influenced by other factors. Moreover, a placebo test was conducted to confirm the validity of the parallel trends assumption. The findings of this test are presented in Appendix 9.2.1.

The overall findings of this analysis suggest cities that implemented Adaptation Measures during the COVID-19 period showed an increase in the Social Risk indicating a lower performance in terms of Resilience. This observation is likely attributed to the fact that cities implementing such measures are inherently more vulnerable despite controlling for some of the key confounders in my analysis. Social Risk, being a reflection of a community’s vulnerability and capacity to cope with disasters and other shocks, reinforces this understanding. Another possible explanation for these results can be directly linked to the COVID-19 pandemic which brought about a lack of adequate resources and limited funding needed to carry out the Adaptation Measures effectively. Since the outbreak of COVID-19, there has been a shift in focus towards addressing the concerns induced by it. In response to the pandemic, Governments and Organizations worldwide allocated significant resources to address the various health and socioeconomic concerns caused by the outbreak. At that moment, this reallocation of resources became crucial in mitigating the immediate impact of the crisis and ensuring the safety and well-being of individuals and communities around the world. As these concerns took precedence, it is likely that the necessary resources needed for the successful implementation of Adaptation Measures were not assigned to them, resulting in an increase in Social Risk, depicting increased vulnerability of communities pointing to a decreased Social Resilience.

The map (Figure 4) highlights the number of cities that have implemented Adaptation Measures during the pandemic resulting in an increase in Social Risk for each represented country. The legend on the top provides information about the distribution of cities across countries, where darker shades correspond to countries with a greater number of cities represented. The chart indicates that the majority of countries have less than 20 cities showing an increase in Social Risk after implementing Adaptation Measures during COVID-19. However, certain countries in the global west such as the United States of America and Brazil exhibit a higher proportion of cities reporting a decline in Resilience. This observation is consistent with the pattern

[6] https://www.publichealth.columbia.edu/research/population-health-methods/difference-difference-estimation

depicted in Figure 2, that showed the greater number of cities implementing Adaptation Measures over time were in western countries. In other words, the higher implementation of Adaptation Measures in western countries coincides with a greater number of cities in those countries experiencing a decrease in Resilience. Overall, a total of 1,081 cities reflected reduced Social Resilience after the implementation of Adaptation Measures during the COVID-19 period.

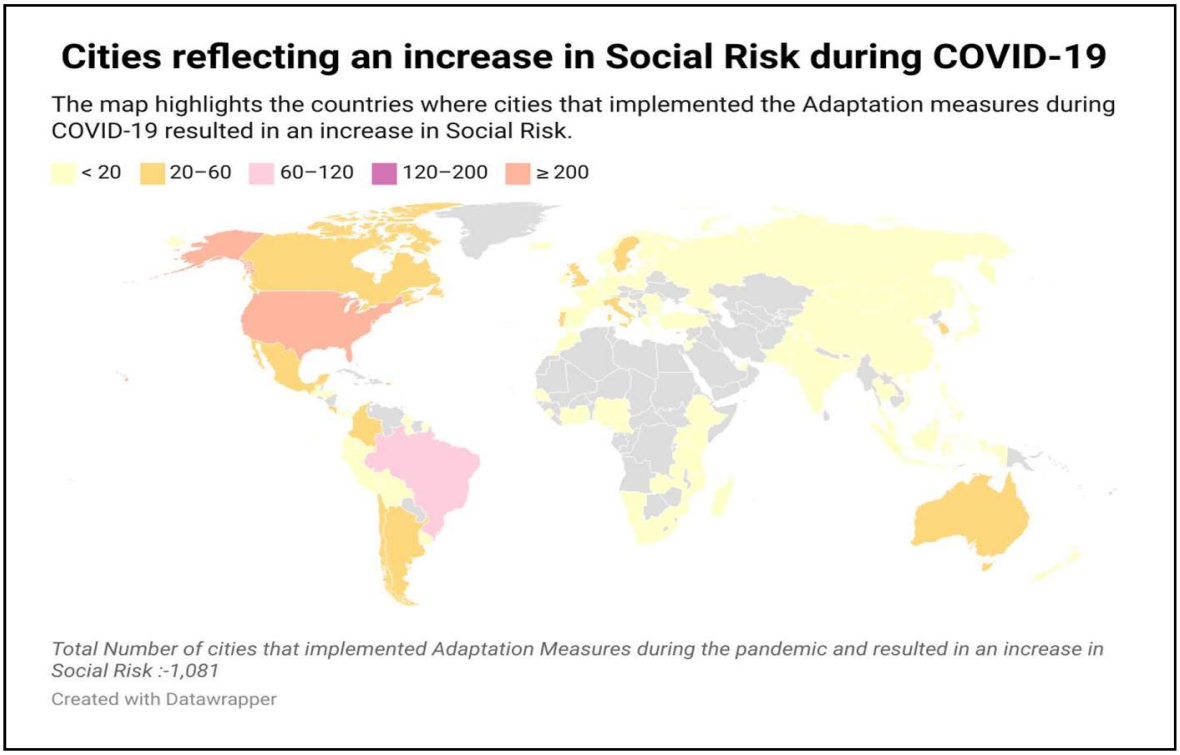

Figure 4. Implementation of Adaptation Measures by Cities Reflecting an Increase in Social Risk During Covid-19

4.1. Sensitivity Analysis

The validity of our analysis will be threatened and produce biased estimates if there are any other factors correlated with the implementation of Adaptation Measures and Social Risk that are not controlled. The results shown in Table 1 indicate that if we had not accounted for the two confounding factors i.e. Climate Hazard and Factors affecting the ability to adapt, our estimates would have been biased as they have a significant effect on our variables of interest. In this section, I substantiate my findings from the preceding table (Table 1) by performing a robustness check and controlling further for variables such as GDP and Current population (current pop) that could possibly be correlated with our Independent and Dependent variable resulting in producing biased estimates.

GDP is a crucial driver in the implementation of Adaptation Measures. During the pandemic, economic downturn strained national economies worldwide, leading to various challenges in funding and executing Adaptation Initiatives. One of the primary effects was the financial constraints faced by Governments and Organizations. With a decline in GDP due to reduced economic activity and disruptions, resources became limited and funding was redirected to address immediate health and economic needs. As a result, the allocation of financial resources towards Adaptation Measures may have been deprioritized, hindering their implementation. Similarly, Population density plays a crucial role in determining the vulnerability and Resilience of communities to climate hazards. High-density areas are more likely to face increased exposure and susceptibility to climate related risks, requiring targeted Adaptation Measures. Therefore, it becomes necessary to test our analysis with these additional confounders.

Table 2 presents the results obtained by undertaking the same approach of Difference- In-Difference, while including GDP and Current Population (current pop) as additional control variables. The results suggest that the estimate for GDP is significant at 0.05 level of significance and Current Population (current pop) does not have much influence. Despite their inclusion in the analysis, these additional variables have minimal impact on the primary relationship between our variables of interest and do not substantially alter the estimated results. This finding highlights that our results from the earlier analysis change remarkably little with the inclusion of these confounders. As a result, the potential risk to our variables of interest becomes insignificant.

Table 2. Robustness Check

Variables	Outcome Variable Y
time	0.894*** (8.15)
treated	0.210* (2.29)
_diff	0.598*** (4.16)
cc_hazd	0.552*** (25.84)
cc_r	0.113*** (7.09)
GDP	8.50e-15* (1.99)
currentpop	4.71e-10 (1.09)
_cons	0.173* (2.55)
R-Sqaure	0.45
Observations	2996
t statistics in parentheses * p < 0.05, ** p < 0.01, *** p < 0.001	

To further validate the impact of implementing Adaptation Measures during the pandemic resulting in an increase in Social Risk, an additional robustness check was conducted to examine the role of COVID-19 as a contributing factor. This check involved incorporating the year 2019 given time=0 into the analysis, and the results are presented in the appendix 9.2.2. The findings from the analysis conducted exhibit minimal deviation from Table 1, which supports the notion that COVID-19 affected the implementation of measures during that time leading to an increase in Social Risk. In order to encompass all possible perspectives, I also conducted an additional robustness check by incorporating individual dummy variables for Factors that influence the ability to adapt i.e. cc_r instead of using a count of these factors in my analysis. The inclusion of these variables did result in a lower Social Risk estimate for the cities, but at the same time omitted a number of observations due to the unavailability of data for these variables in 2016-2017. Therefore, this analysis can not be considered significant.

5. Analysing COVID-19 Recovery Interventions & Climate Actions and Urban Resilience

In the preceding section, having examined the impact of implementation of Adaptation Measures during the pandemic on the Social Resilience of cities, it would be now intriguing to explore the same set of cities embracing Urban Resilience by adopting Recovery Interventions & Climate Action synergies. Dealing with the critical issue of climate concerns and the pandemic simultaneously had put cities in a very stressful position. The drastic shift in the focus towards addressing the pandemic induced concerns became the need of the hour. Economies of many cities were impacted adversely by the pandemic outbreak, leading to a reduction in revenue and increased expenses for local governments. The unstable financial situation of the cities resulted in a strain on the budgets of many, including those that had previously committed to financing Climate Actions. Budget cuts were made to climate-related initiatives in order to free up resources for pandemic response efforts. Majority of the attention and resources during this period were allocated towards issues induced by the outbreak. As a result, Climate concerns had taken a back seat and were subjected to inadequate attention. In line with this discussion, the following graph reveals the impact of COVID-19 Economic response on the city's budget for financing Climate Actions where the responses of 777 cities from around the world were recorded for the year 2021.

Figure 5 illustrates that about 30 % of cities responded with reduced finance available for Climate Actions. This finding aligns with the earlier discourse on finance being allocated to cater to the pandemic-induced needs with several cities diverting their

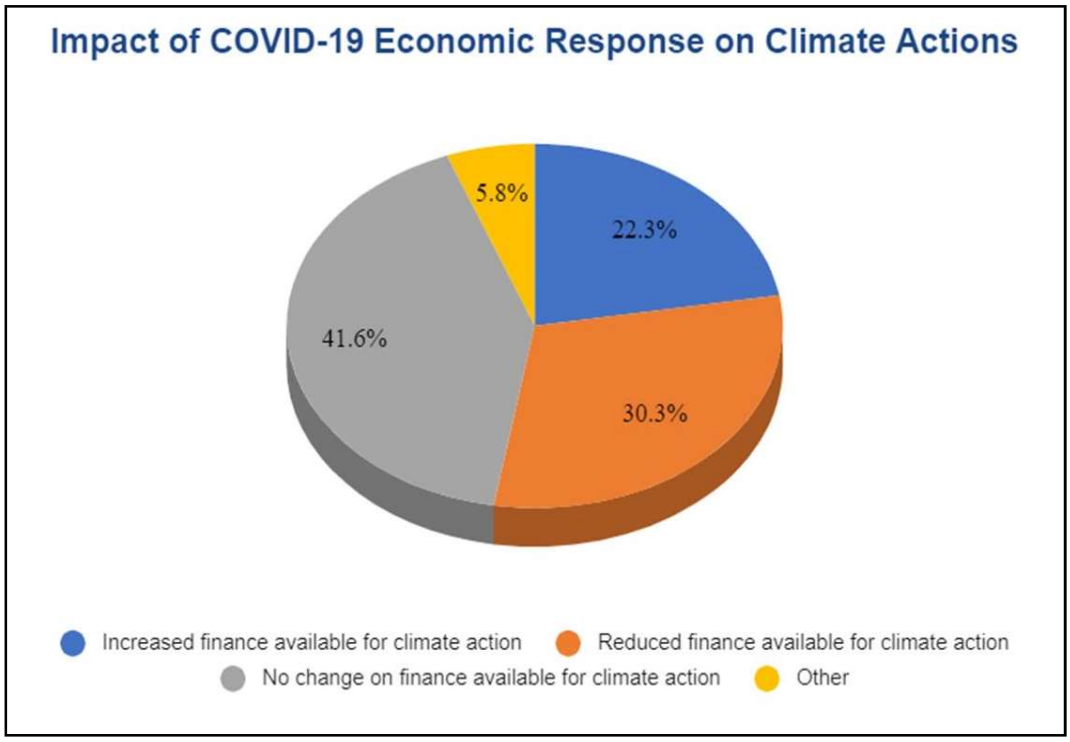

Figure 5. Economic Impact of COVID-19 on Climate Actions

resources towards it. On the other hand, it is quite interesting to see that about 42 % of cities responded with no change in finance available for Climate Action, followed by 22 % of cities prioritising climate concerns by responding with increased finance available for Climate Actions, despite dealing with the pandemic. This shows that many cities around the world recognized the importance of addressing climate change and found useful ways to spend their climate-related budgets amidst the pandemic. The cities identified the potential for synergies between COVID-19 Recovery Interventions & Climate Action initiatives and strategically decided to invest some of the pandemic recovery funds towards climate considerations. These actions included synergies that focused on various domains like strengthening Health Care and Sanitation Services, Sustainable Agriculture, Resilient Infrastructure, Providing Employment Opportunities and Training Programs in Green Sectors, Boosting Sustainable Transportation and Digital Technologies, Increasing Access to Urban Spaces, etc. A detailed description about all the synergies are included in the appendix 9.3.

Almost 50 % i.e. a total of 389 cities out of a sample size of 777 cities implemented at least one of the Recovery Interventions & Climate Action Synergies in the year 2021.

The chart (Figure 6) displays a world map with various countries highlighted in different colors to represent the number of cities that have reported on the implementation of Recovery Interventions & Climate Action synergies. The legend on the top of the chart provides a color scale to indicate the range of cities reporting for each country. The darker shades of colors represent a higher number of cities reporting, while the lighter shades of colors represent a lower number of cities reporting on the adoption of synergies. The chart provides a visual representation of the extent to which cities around the world are implementing at least one of the COVID-19 Recovery Interventions & Climate Action synergies in the year 2021, with some countries showing a higher level of progress than others. One can observe in the chart that the United States of America and Japan (highlighted in red) have more than 61 cities reporting on the implementation of at least one of the synergies. Being one of the world's strongest economies, it doesn't come as a surprise that cities in these countries are taking steps towards building Urban Resilience. Countries like Brazil, Mexico, Canada and United Kingdom are also increasing their efforts towards implementing the synergies and have 17-33 cities reporting on the implementation. It is evident from the chart that several countries have fewer cities i.e. less than 17 reporting on the implementation of the synergies. This result points in the direction of cities understanding and addressing the need to build a more environmentally conscious and developed urban space. As cities have taken steps towards rethinking their development pathways and embrace a more sustainable and resilient future by implementing the synergies, it is important to evaluate the extent to which they are implementing these measures. The charts below show the progress of cities in implementing a range of synergies.

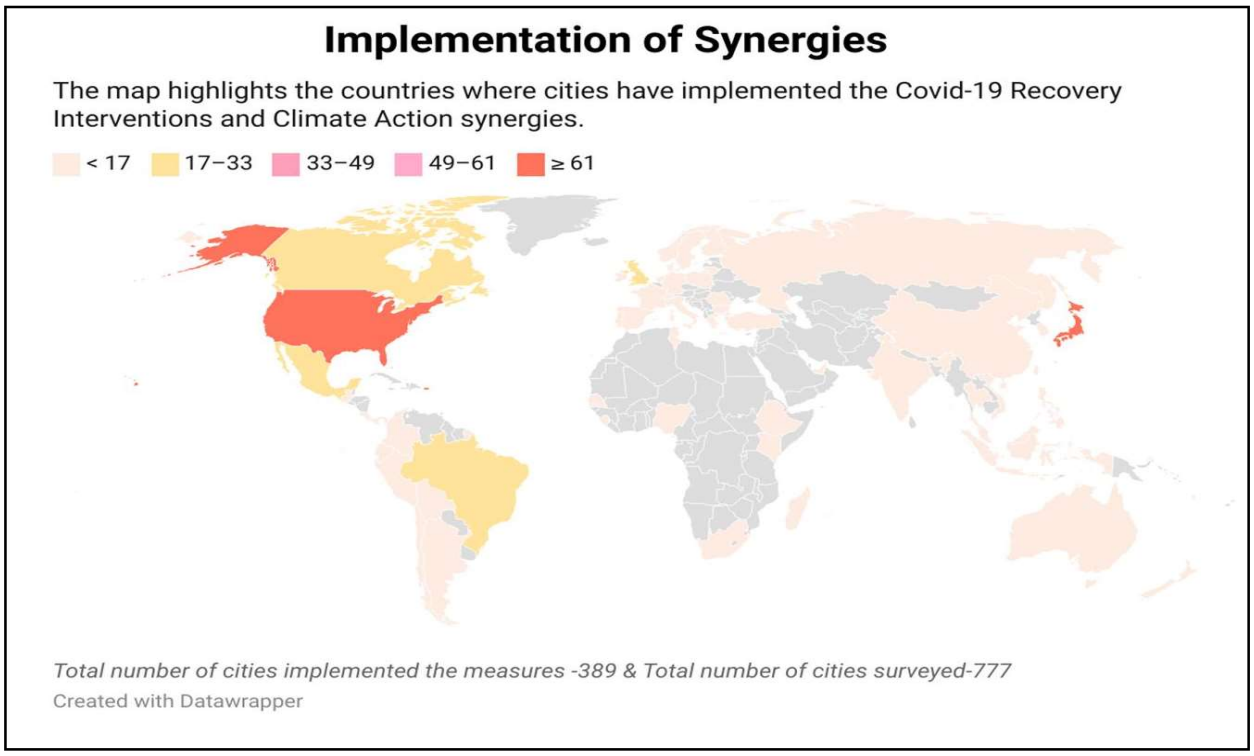

Figure 6. Cities implementing COVID-19 Recovery Interventions and Climate Action synergies

Figure 7 points out to cities implementing 1-4 synergies out of 12 possible COVID-19 Recovery Interventions & Climate Actions to build a sustainable and resilient urban development. From a total number of 389 cities implementing the synergies,

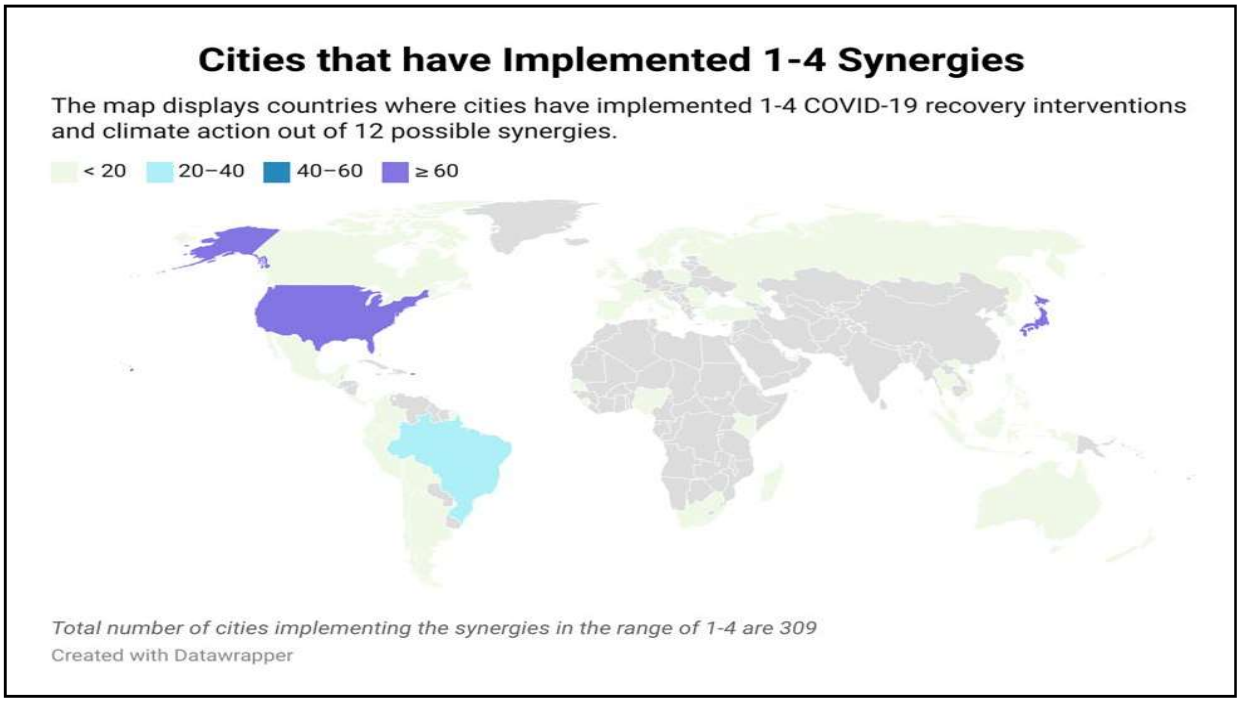

Figure 7. Cities Implementing 1-4 Synergies

309 cities have implemented 1-4 synergies. As cities have started to realise the importance of building a resilient living, this result points in the direction of their initial steps towards it. While the implementation of a limited number of synergies may indicate a slower pace of progress, it is still a positive sign that cities are taking actions to build a more sustainable future. Similarly, Figure 8 depicts the countries where cities have adopted a range of 5-8 COVID-19 Recovery Interventions & Climate Action measures out of a total of 12 possible synergies. Having implemented 5-8 synergies is a significant progress towards a building a resilient future. Even though, the number of cities implementing the synergies in the following range are limited to 65, their commitment towards addressing the challenges posed by COVID-19 and climate change are to be appreciated.

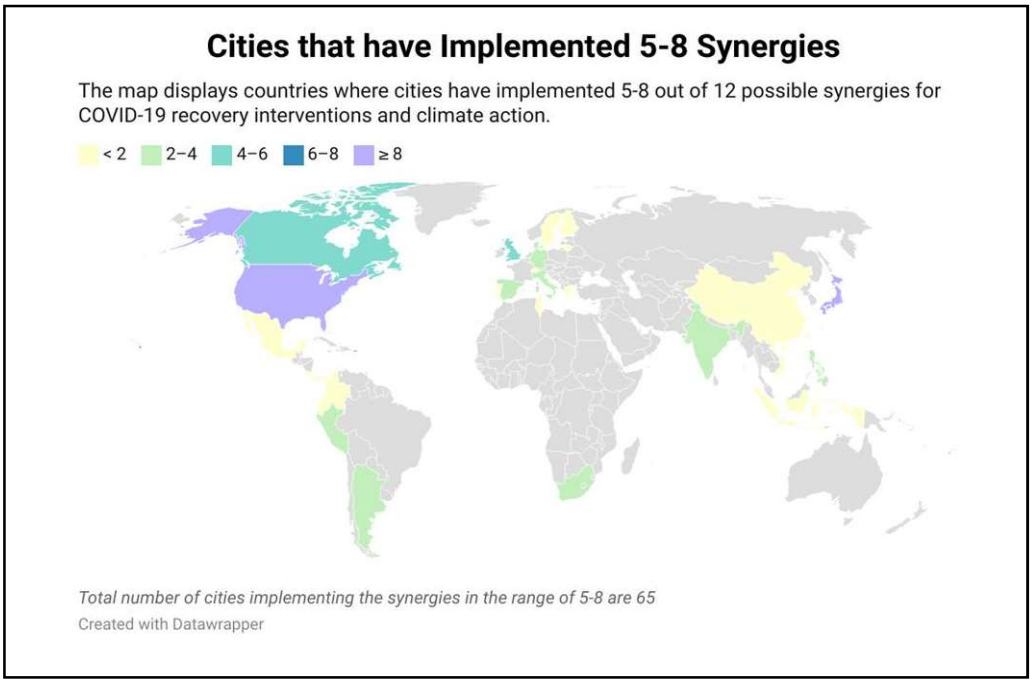

Figure 8. Cities Implementing 5-8 Synergies

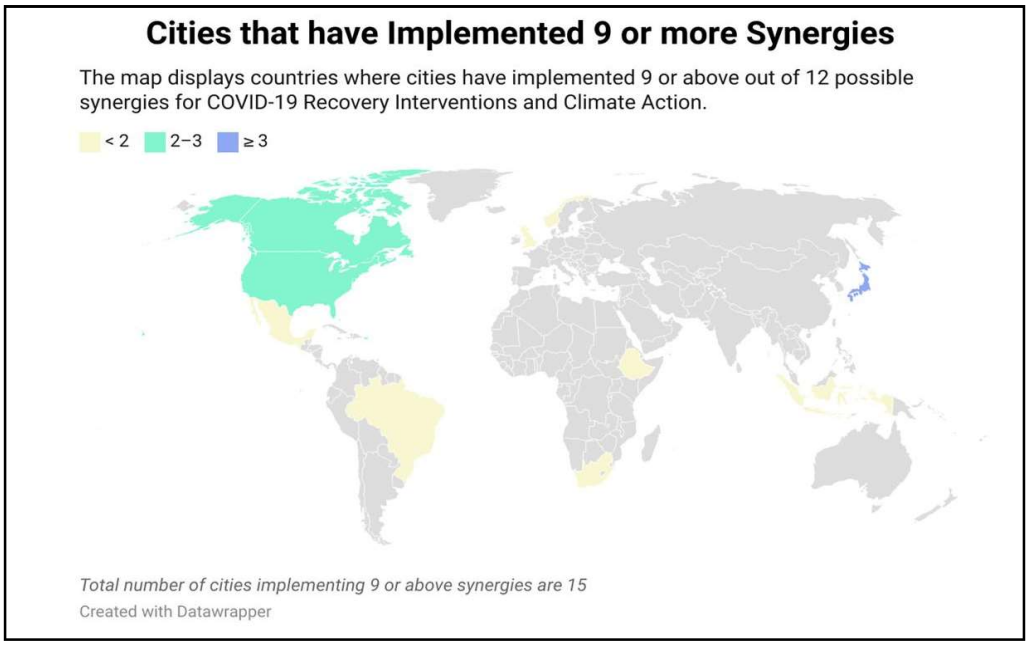

Figure 9. Cities Implementing 9 or more Synergies

In the same vein, Figure 9 points out to cities implementing 9 or more COVID-19 Recovery Interventions & Climate Action synergies. It is evident from the figure that cities implementing the synergies in this range are the least accounting to only 15 out of a possible 389 cities that had implemented the synergies, yet leading the way in sustainable and resilient urban development. Despite being only a handful of cities implementing several synergies, they serve as models for others seeking to implement comprehensive Recovery Interventions & Climate Action plans. A high implementation of synergies by these cities indicates that they are taking a holistic approach towards building Urban Resilience. Statistically, Japan stands out as the only country where both Iwakura City and Nanbu Town have successfully implemented all 12 synergies for COVID-19 Recovery Interventions & Climate Action. This accomplishment underscores the two Japanese city's strong commitment towards a resilient living. These cities are setting an example for others to follow in the pursuit of a sustainable and a resilient world for the future generations.

The above discussion on cities efforts to enhance their surroundings through the adoption of sustainable practices and building Urban Resilience highlights the significant role of finance as a key driving factor. Having adequate financial resources at their disposal, cities can effectively implement sustainable and resilience-building initiatives. Therefore, it can be inferred from our exploration that the cities which successfully embraced COVID-19 Recovery Interventions & Climate Action synergies can be regarded as financially better positioned, reflecting strategic investment in building a sustainable and resilient future. After examining the cities on their adoption of synergies, it also becomes important to analyze which of the following measures are most commonly implemented by all the cities.

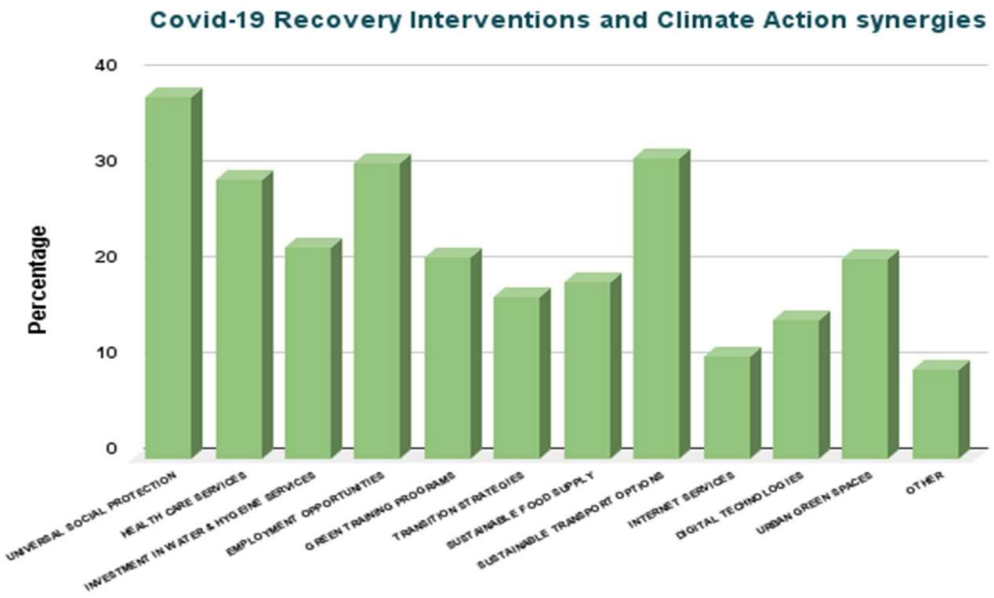

Figure 10. Percentage of Synergies adopted by cities

The bar graph in Figure 10 illustrates the percentage of cities implementing each of the 12 synergies. Notably, Universal Social Protection has the highest implementation rate, accounting for 37.6 % which has been implemented by most cities. Recovery interventions for Sustainable Transport Options and Employment Opportunities follow closely, accounting for approximately 31%. In contrast, Internet Services and Digital Technologies have the lowest implementation rates among the 12 synergies, accounting for only 10% and 14% respectively. One of the plausible inferences that can be drawn from these statistics is that most of the cities are focusing on investing in synergies which are reflecting the major concerns of the community. It is gratifying to see that despite dealing with the financial complexities posed by the pandemic, cities demonstrated proactive thinking and a commitment towards enhancing Urban Resilience by implementing synergistic measures for the future.

6. Results

This section presents a summary of the analysis conducted and highlights the key findings from the study. My research compared the impact on Social Risk by the cities that adopted Adaptation Measures during the pandemic with those that did

not. The results obtained by conducting the analysis indicated a positive difference-in-differences estimate inferring an increase in outcome variable i.e. Social Risk by the implementation of Adaptation Measures during the pandemic. The R-square value of 45% demonstrated the extent to which the Independent variable explained this positive relationship on the outcome variable. Further, this analysis illustrated that implementation of Adaptation Measures during COVID-19 by cities resulted in an increase in Social Risk leading to a decreased Social Resilience, despite accounting for all the possible confounders. This outcome is significant as Resilience is a critical aspect of a city's ability to respond to and recover from adverse events. Since the research did not find any heterogeneity among the sample of cities used for this study, this suggests that the findings are consistent across different locations. Consequently, the paper aimed at pointing out possible reasons for obtaining lower performance on Resilience by cities pointing towards a shift in focus on pandemic-induced concerns which may have diverted resources away from the effective implementation of Adaptation Measures, leading to an increase in the Social Risk. Overall, this research presents a key highlight in underscoring the importance of considering the trade-offs between pandemic response measures and long-term Resilience building. It suggests that policymakers need to carefully balance the allocation of resources to address immediate concerns while also investing in measures to enhance a city's Resilience.

In addition to exploring Social Resilience, this paper also provides insights into cities within countries that, despite performing relatively less effectively in terms of Social Resilience during the pandemic, still implemented synergistic interventions for COVID-19 Recovery Interventions & Climate Action during the same period to enhance Urban Resilience. The primary findings of this study indicated that only half of the cities in the sample had implemented the synergies in the year 2021. Among these, very few cities prioritized adopting more number of synergies while simultaneously dealing with the pandemic by implementing a variety of measures. The study also presented intriguing statistics indicating that only two cities from Japan had adopted all of the synergies. This result highlights that even in the wake of a pandemic cities were determined to work on building a Resilient future. On the whole, this indicates that cities were adopting a comprehensive approach to achieving Urban Resilience, while also acknowledging the importance of addressing climate concerns. Following the exploration of the varying range of adoption of synergies among cities, the statistics also illustrated the most number of actions implemented by the cities, which aided in addressing their immediate needs.

A notable observation throughout this paper brings forward the trend of adopting synergies remains consistent with the higher implementation of Adaptation Measures by the cities in the western region. Conclusively, it is riveting to observe that how cities in their pursuit of building Resilience adopted synergies during COVID-19, whereas their implementation of Adaptation Measures during the same period exposed some vulnerabilities impacting their performance on an aspect of Resilience.

6.1. Limitations

As discussed earlier, this paper mainly relies on the data from CDP, which includes a diverse range of cities from around the world that responded to the questionnaires. Since the sample size of the cities that responded to the questionnaire for each year was relatively small and due to the larger representation of US cities, there may be a slight presence of selection bias in the results. Therefore keeping this in mind, the analysis is conducted on the entire set of data which includes cities from around the world that responded to the survey. Additionally, cities included in the sample shared similar characteristics and trends regardless of their size or geographic location, related to the implementation of Adaptation Measures and adoption of synergies, which points in the direction of city's homogeneity of characteristics.

Another limitation of this study is the absence of control for the specific impact of COVID- 19 on different cities when examining the implementation of Adaptation Measures during this period and its association with low Social Resilience. Despite controlling for GDP as a confounder, it is important to consider other factors such as strain on healthcare systems and the effects of lockdown measures during the outbreak that could have also influenced the implementation of measures. Another possibility during the same period could be cities experiencing a climate hazard which led them to the implementation of Adaptation Measures during the COVID-19 outbreak and recognized the urgent need to address and mitigate future risks, including those related to climate change, which could potentially confound the results. This can be pointed in the direction of cities trying to aim at building Resilience and protect their economies from further disruptions by implementing the measures.

In other words, the observed association between Adaptation Measures and low Resilience may be influenced by the varying factors of the pandemic rather than solely the effectiveness of the measures themselves.

An additional limitation becomes evident as this paper explores Urban Resilience in cities, focusing on the assessment of COVID-19 Recovery Interventions and Climate Actions synergies for the year 2021. The research is constrained in its ability to extend the analysis to post-COVID synergies that would contribute to a more comprehensive exploration of Resilience primarily due to the unavailability of pertinent data.

7. Discussion

The comprehensive exploration of cities continuous efforts to build Resilience throughout the paper presents a valuable

opportunity to enhance our understanding about the factors that may have been a potential cause for the decrease in Social Resilience among cities that implemented the Adaptation Measures during the pandemic. By considering multiple lenses, we can gain deeper insights into the complex dynamics at play and identify key drivers that may have influenced a city's resilience in the face of challenges posed by the COVID-19 pandemic. As the world faced a standstill during this unforeseen time, Governments found themselves under pressure to revive the economy, which may have led to a shift in their priorities towards addressing these concerns. The widespread economic disruptions resulted in a pause in business activities, prompting cities to redirect their focus towards measures involving financial assistance to the people and businesses. At the same time, the sudden surge in COVID-19 cases overwhelmed the healthcare systems from shortage of medical supplies to healthcare personnel leading to a drastic shift in the priorities of cities away from the effective implementation of the measures. These reasons collectively indicate that while managing the immediate impacts arising from the pandemic, cities redirected their focus and allocated resources away from efforts to mitigate climate hazards.

Building upon the preceding discussion, prior to the effective implementation of the measures, cities with adequate funding and financial resources are able to conduct thorough risk assessments, develop comprehensive adaptation plans and implement strategies to mitigate the impacts of climate change. Similarly, personnel with expertise in climate domain, urban planning and policy development are essential for successful adaptation efforts as they work closely with local Government officials, Community Leaders and Stakeholders to ensure that Adaptation Measures are well-designed, effectively implemented in a timely manner. However, in the absence of funding and lack of personnel can lead to inadequate planning, delayed implementation timelines, hinder the ability to scale up adaptation efforts and limit the capacity for monitoring and evaluation. Thus, it is possible that the financial strain caused by the pandemic, might have hindered Government's capacity to carry out the essential groundwork required before the adoption of the Adaptation Measures hindering their successful implementation during that time.

Another way of looking at the disconcerting low performance on Resilience by the cities can be attributed to the magnitude and complexity of the pandemic that may have sur-passed the capacity of the implementation of Adaptation Measures, proving them insufficient to address the wide-ranging impacts of climate concerns. The perplexity of the pandemic, its rapid spread and the multifaceted impacts on various sectors of society may have overwhelmed the existing Adaptation Measures, which were designed to primarily address climate-related risks and may have stretched the limits of the implemented measures exposing their ineffectiveness. As a result, the Adaptation Measures that were originally put in place to enhance Resilience may not have been sufficiently equipped or comprehensive enough to handle the unprecedented challenges presented by the pandemic. Analogously, the pandemic may had exacerbated existing social inequalities, with disproportionately affecting marginalized communities and vulnerable population. All of these factors potentially culminated to affect the Resilience of cities and resulted in their low performance during this period.

In the same way, the limited funding and focus of shift due to the pandemic also dissuaded some cities from adopting the synergies. As the cities prioritised the pandemic induced needs, building a Resilient environment had inadequate consideration. This brings forward a key observation regarding the substantial but often unnoticed contribution of finance in bolstering and fostering Resilience. While it may often remain silent or go unnoticed, finance serves as a vital enabler, providing the necessary resources and funding to implement resilience-building initiatives.

In hindsight, these key problems highlight the need for adaptive and flexible approaches in developing Resilience measures in these unforeseen times. Governments and Policymakers should consider such contingencies into account while building a plan to effectively implement and operate the measures at all times along with creating a dedicated provision of funds and resources while ensuring their availability when needed. By incorporating flexibility, adaptability and resilience into the plan, it is of utmost importance that they create a framework that can withstand and respond effectively to unexpected events. By constructing a responsive plan, the officials can ensure the uninterrupted functioning and adoption of measures that contribute to long-term benefits, even in the face of future disruptions.

8. Appendix

8.1. Description of Adaptation Measures & Social Risk

Detailed description of Adaptation Measures, Social Risk indicators and Factors affecting ability to adapt used for this study.

Index Number	Adaptation Measures	Components
1	adaptact_map	Hood mapping Heat mapping and thermal Imaging Landslide risk mapping Sea level rise modeling

2	adaptact_prep	preparedness Implementing sea level rise and coastal storm preparedness measures Crisis management including warming and evacuation syste
3	adaptact_urban	Restrict development in at risk areal Incorporating climate change Sea level rise zoning/ building/land usacode policy Climato resilient land use codes and zaning
4	adaptact_build	Climate resilient building codes | Resilence and resistance measures for buildings | Hazardrmistant Infrastructure design and construction Soilreternion strategies Traw planting and/or creation of green space Green tooh/walls White rools | Shadingin public spaces, markets Cooling systems for critical Infrastructure Retrofit of existing buildings Cooling centers, poofs, water parks/plazasincluding policies to support development Cool pavements Nature-based solutions policyte strest Droes, grein roofs
5	adaptact_plan	Projects and policies targeted at those most vulnerable
6	adaptact_other	Other, please specify

Figure 11. Detailed description of Adaptation Measures

Index Number	Social Risk Indicators (Abbreviations)	Social Risk Indicators
1	res_dem	Increased resource demand
2	pub_dem	Increased demand for public services
3	confl	Increased conflict and/or crime
4	risk_vuln_pop	Increased risk to already vulnerable populations
5	fluc_soc_econ	Fluctuating socio-economic conditions
6	loss_jobs	Loss of traditional jobs
7	pop_displ	Population displacement
8	migr_cities	Migration from rural areas to cities
9	prev_disease	Increased incidence and prevalence of disease
10	other	Other, please specify

Figure 12. Detailed description of Social Risk Indicators

Index Number	Factors affecting ability to adapt
1	Access to basic services
2	Access to healthcare
3	Access to education
4	Public health

5	Cost of living
6	Housing
7	Poverty
8	Inequality
9	Unemployment
10	Underemployment
11	Migration
12	Safety and security
13	Economic health
14	Economic diversity
15	Rapid urbanization
16	Resource availability
17	Environmental conditions
18	Political stability
19	Political engagement /transparency
20	Government capacity
21	Budgetary capacity
22	Infrastructure conditions/maintenance
23	Infrastructure capacity
24	Land use planning
25	Community engagement
26	Access to quality / relevant data
27	Other, please specify

Figure 13. Detailed description of Factors affecting the ability to adapt (cc_r)

8.2. Analysis for Robustness

8.2.1. Placebo Test for Parallel Trends Assumption

Based on this analysis, estimates for the time and treated variables are significant at a p-value of 0.001 and have a positive relationship with the outcome variable. On the other hand estimate for placebo is not statistically significant suggesting that there is no significant difference in the outcome variable “Y” between the placebo and non-placebo groups implying that the treatment variable ”placebo” does not have a significant effect on the outcome. Additionally, it is evident that the coefficient of the interaction term “placebo and treated” shows a negative estimate. However, this negative effect is not statistically significant, suggesting that it may be a result of random variability rather than a meaningful relationship. This indicates that there is no significant difference in the treatment effect between the placebo group and the treated group. Therefore, we can interpret

that the parallel trends assumption is satisfied, indicating that any difference in the outcome variable between the treated and control groups can be attributed to the treatment effect rather than other factors affecting the trends over time.

Table 3. Placebo Test

Variables	Outcome Variable Y
time	1.529*** (18.33)
placebo	0.219*** (1.76)
treated	1.497*** (12.98)
placebo#treated	-0.0778 (-0.47)
cons	1.109*** (13.02)
R-Sqaure	0.21
Observations	2996
t statistics in parentheses ** p < 0.05, ** p < 0.01, *** p < 0.001*	

8.2.2. Robustness check including 2019

Table 4. Robustness Check including 2019

Variables	Outcome Variable Y
time	0.763*** (7.00)
treated	0.668*** (7.58)
_diff	0.135 (0.98)
cc_hazd	0.519*** (26.42)
cc_r	0.139*** (9.72)
GDP	2.48e-15 (0.61)
_cons	0.351*** (5.58)
R-Square	0.39
Observations	3810
t statistics in parentheses ** p < 0.05, ** p < 0.01, *** p < 0.001*	

The results displayed in table 4 exhibit a significant level of consistency with our primary Table 1. This further strengthens the underlying connection between the increase in Social Risk, subsequently leading to a decrease in Resilience and cities implementation of Adaptation Measures during the pandemic, highlighting the impact of COVID-19.

8.3. Description of COVID-19 Recovery Interventions and Climate Actions Synergies

A detailed description of the COVID-19 Recovery Interventions and Climate Action Synergies are provided in the table.

Index Number	Synergies (Abbreviations)	COVID-19 Recovery Interventions and Climate Action Synergies
1	UNIVERSAL SOCIAL PROTECTION	Recovery interventions that develop or strengthen universal social protection systems that enhance resilience to shocks, including climate change
2	HEALTH CARE SERVICES	Recovery interventions that develop or strengthen health/health care services in your city that enhance resilience to shocks, including climate change
3	INVESTMENT IN WATER & HYGEINE SERVICES	Recovery interventions that increase investment in Water, Sanitation, and Hygiene (WASH) services, facilities and/or infrastructure
4	EMPLOYMENT OPPORTUNITIES	Recovery interventions that focus on employment opportunities in green sectors
5	GREEN TRAINING PROGRAMS	Recovery Interventions that provide residents with effective access to training programs related to green sectors
6	TRANSITION STRATEGIES	Recovery interventions that support just transition strategies for workers and communities
7	SUSTAINABLE FOOD SUPPLY	Recovery interventions that channel investment in sustainable, resilient agriculture and food supply chains
8	SUSTAINABLE TRANSPORT OPTIONS	Recovery interventions that boost public and sustainable transport options
9	INTERNET SERVICES	Recovery interventions that build out broadband and internet services to those with inadequate access
10	DIGITAL TECHNOLOGIES	Recovery interventions that scale up investments in and access to digital technologies, funding mechanisms, and capacity-building solutions to enhance resilience to shocks, including climate change
11	URBAN GREEN SPACES	Recovery interventions that increase access to urban green spaces
12	OTHER	Other, please specify

Figure 14. Detailed description of the Synergies

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