CLIMATE JUSTICE IN COMMUNITY DESIGN: INVESTIGATING ALTERNATIVE METRICS OF ECONOMIC VULNERABILITY TO EXTREME HEAT IN METRO PHOENIX, ARIZONA

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ABSTRACT
Vulnerability, which considers exposure, sensitivity to hazards, and adaptive capacity, is frequently assessed using income or poverty levels, neglecting affordability factors in the heat vulnerability index. Heat adaptation strategies, providing legal resources to vulnerable groups, effectively address extreme heat impacts. However, the higher living costs in metro Phoenix's Maricopa County, compared to state and national averages, underscore the limitations of relying solely on US Census poverty estimates of residents' living expenses. The question arises, Who is most affected during extreme heat? what is the relation between household income and cost of living in metro Phoenix areas by considering their vulnerability to extreme heat? This paper introduces an alternative economic vulnerability metric--Household Expenditure and Income Gap Highlighter Tool (HEIGHT) developed as a joint effort between Arizona State University Knowledge Exchange for Resilience and the Valley of the Sun United Way to measure and visualize the true costs of living at the neighborhood scale. This tool highlights the emerging gap between household income and living costs by counting for food, housing, health care, childcare, and utilities expenses. The HEIGHT tool's results as an adaptive capacity index reveal the true cost of living in each county and neighborhood, emphasizing the disparity between household income and living expenses. We examine regional spatial variation and vulnerability clustering in metropolitan areas by using Geographic Weighted Regression (GWR), which reveals high vulnerability clusters around city centers. This study highlights the need to use alternative methods, beyond Census poverty data, for more accurate socio-economic vulnerability assessment, addressing income and living cost disparities. Recognizing socioeconomic factors is vital for landscape architects and urban designers to integrate economic vulnerability, affordability, and climate justice in community-based nature-focused solutions for climate change resilience.

Keywords*:* Economic vulnerability; urban-induced heat; poverty; Living costs; community resilience

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1. Introduction

Climate change and urbanization have both contributed to an increase in the frequency, length, and intensity of extreme heat waves during the last few decades creating urban-induced heat in cities and posing threats to human health and the economic system in the Metro Phoenix Area (AlKhaled et al., 2020). The Metro Phoenix Area including the City of Phoenix and surrounding twenty-six cities and Native American tribal communities in central Arizona is one of the nation's largest and fastest expanding urban areas in terms of population and geographical area (U.S. Census 2022). In the meantime, Arizona has the second-highest number of hazardous heat days in the country more than 50 days on average each year. With a changing climate and a rise in the aging population, Arizona will have extreme heat over 80 days a year by 2050 and more vulnerable populations to heat will be exposed to such hazards (America's Preparedness Report Card 2015). Addressing the multiple implications of climate change is a significant topic for planners and designers because it examines the roles of professionals in constructing resilient communities in order to the economic and social matters. There are concerns about whether vulnerable groups have the adaptive capabilities needed to deal with the problems posed by climate change, as well as whether planners and designers have the proper tools to represent community resilience and address climate justice in community design. We ask: How can residents estimate their living costs during the period of extreme heat and who are the most impacted by? What is the relation between household income and cost of living in metro Phoenix areas by considering their vulnerability to extreme heat? The purpose of this research is to estimate the economic repercussions to the Phoenix Metro Area of failing to act against severe heat, as well as to assess household living cost measures aimed at addressing the household's adaptive capacity to heat hazards.

2. Climate Justice and Heat Vulnerability

Climate justice, according to 'The Mary Robinson Foundation' and Bulkeley et al. (2012), is the relationship between development and human well-being, defending the rights of the most vulnerable people and sharing the responsibilities and benefits of climate change. A climate justice assessment method considering social-ecological-technological systems vulnerability to climate change impacts in various spatial scales has been developed to provide a robust evidence-based policy framework (Cheng, 2019). Community resilience to climate change impacts have been connected to their adaptive capacity to mitigate, respond to, and recover from hazards (Ngo 2001; Heinz Center 2002; O'Brien 2006; Mayhorn 2005; National Research Council 2006). Socially vulnerable populations lacking financial assets, with diminished physical or cognitive capacities to respond to warnings, and with a lack of strong and long-term social support systems have the least capacity for risk management and therefore are the most vulnerable to a hazardous event (Yang et al., 2021). Cutter and Finch (2008) discovered that factors such as age, race and ethnicity, gender, and the built environment quality were responsible for half of the geographic variance in social and economic vulnerability in the counties of the United States. Between 1960 and 2000, there were significant changes in distribution, with high susceptibility being increasingly concentrated along the US-Mexico border region.

High social vulnerability to hazards is related to urbanization, race and ethnicity, and poverty. At the sub-national level, Cutter, Mitchell, and Scott (2012) assessed vulnerability in Georgetown County, South Carolina, using both biophysical and social indices. They discovered that places with the greatest biophysical vulnerability did not correspond with areas with the greatest social vulnerability. This conclusion is significant since it just takes a moderate-level physical disaster to impair the livelihoods and well-being of many inhabitants. Numerous attempts have been made to examine Phoenix's susceptibility to hazards from the perspectives of environmental equity and social justice (Watson et al. 2000; Grineski et al. 2008). Bolin et al. (2000), for example, analyzed the demographics of persons exposed to hazardous industrial and toxic waste sites and discovered that they were disproportionately concentrated in regions populated by low-income, racial and ethnic minorities. The geographical concentration of hazardous facilities, along with the city of Phoenix's separated disadvantaged communities, resulted in a severely disproportionate environmental cost faced by the region's lower-income and racial minority populations. Heat stress is recognized a hazard in Phoenix due to the worsening urban-induced heat and the anticipated warmer environment linked with climate change. Harlan et al. (2006) studied eight cities in the Phoenix metropolitan area with varying socioeconomic factors and created a human outdoor thermal indicator (a measure of heat stress) based on a person's energy balance in relation to the surrounding microclimate and thermal reactive

environment (Reid et al., 2012). High heat stress exposure was substantially and positively connected with high population and large Hispanic populations and adversely associated with access to public spaces and income level. Homes located in areas with greater-than-average physical heat exposure were, on average, poorly adapted to heat stress in addition to less well-formed social networks. Moreover, many impoverished districts exposed to extreme heat contained inhabitants who knew only Spanish and were often newcomers to the city (Saraswat & Kumar, 2016). Combined the factors of high physical exposure and high social vulnerability, impoverished inhabitants were particularly exposed to the effects of excessive heat. Furthermore, social and ecological systems are inextricably linked with physical exposure, since individuals with high income and high social status tend to modify their immediate surroundings (for example, by planting trees, keeping lawns, and living in lower densities) to improve thermal comfort and reduce heat stress. Physical exposure consequently impacts social groups unequally, with the most vulnerable populations feeling the brunt of the heat (Teixeira et al. 2016). Hence, addressing exposure to heat and economic vulnerability among people requires a multi-pronged approach that combines public health measures, climate adaptation strategies, economic diversification, and policy development to ensure the well-being of residents and the resilience of the state's economy in the face of increasing temperatures. For example, between 1990 and 2000, Phoenix witnessed substantial expansion in both population (2.24 to 3.25 million; a 45 percent increase) and land area (1,223 to 2,069 km2; an increase of 69 percent). These changes in surface conditions caused by rapid urbanization drastically altered the surroundings, which caused the high temperature. During a four-day heat wave in July 2005, Ruddell et al. (2010) developed a "riskscape" of heat stress all over forty City of Phoenix neighborhoods and discovered that (1) the distribution of extreme heat varied in space; (2) neighborhoods exposed to higher temperatures significantly correlated with survey respondents who perceived greater heat stress; and (3) minority and low-income residents were more exposed to heat stresses than other counterparts**.**

3 METHODOLOGY

3.1 HEIGHT

In this section, we delve into the intricacies of economic vulnerability within Maricopa County's Phoenix urbanized area, utilizing an innovative tool known as the Household Expenditure and Income Gap Highlighter Tool (HEIGHT). Our study focused on the Phoenix urbanized area of Maricopa County as defined by the 2020 U.S. Census. Analysts and policymakers often compare income to the federal poverty threshold to determine an individual's ability to live within a certain standard of living. However, poverty thresholds do not account for living costs beyond a basic food budget. The Census Bureau determines poverty status by using an official poverty measure that compares pre-tax cash income against a threshold that is set at three times the cost of a minimum food diet in 1963 and adjusted for family size. Our study applies an alternative economic vulnerability metric--Household Expenditure and Income Gap Highlighter Tool (HEIGHT)--developed as a joint effort between Arizona State University Knowledge Exchange for Resilience and the Valley of the Sun United Way to measure and visualize the true costs of living at the neighborhood scale. HEIGHT tool measures the different aspects of cost, such as costs of housing, transportation, childcare, health care has risen far more rapidly than food costs, and even faster than wages. Based on mentioned information, the Census poverty estimates not only limit poverty assessment criteria to food costs but also neglect regional variations in the cost of living. The local cost differentials in many neighborhoods, especially in Maricopa County, are significantly higher than state or national averages. The HEITHT tool builds a living cost budget for various family sizes. We selected two Adults and one child for our study. Analyzing those local costs of living with the household’s income data, the tool determines how many households are struggling to meet basic living costs across neighborhoods. Moreover, the HEIGHT tool also utilizes Public Use Microdata Areas (PUMAs) for demographic analyses. PUMAs are contiguous neighborhood clusters consisting of 100,000 to 200,000 people and are defined at the conclusion of every decennial census. There are currently 59 neighborhood clusters in Arizona. The adoption of PUMAs offers us the ability to examine what the living cost looks like across and within counties and is generally more statistically reliable than the units of counties and census tracts. PUMAs cover the entirety of the United States, Puerto Rico, and Guam.

3.2 Data Selection and Sources

This section underscores the importance of assessing socio-economic vulnerability, focusing on demographic and economic aspects, to enhance heat adaptation methods for community resilience. It is vital to identify socio-economic vulnerability by considering two dimensions of demographic vulnerability (DVI) and economic vulnerability (EVI) to give insight into enhancing heat adaptation techniques for building community resilience (Lai et al, 2021). Hence, we developed a metric for heat stress vulnerability based on measures of heat exposure and human population adaptive capacity (e.g., income and social stability). Then we examined the alternative metrics of economic vulnerability (Praharaj, 2022) and determined what percentage of different racial and ethnic minority populations lived above a critical security vulnerability threshold in the Phoenix metro area. The HEIGHT tool uses data from the American Community Survey (ACS) 5-Year Estimates (2014-2019) for investigating the income, family structure, gender, and race/ethnicity to determine the level of poverty in counties and the neighborhood clusters, PUMAs (Height Poverty Dashboard, 2022).

3.3 Socio-Economic Vulnerability Index (SEVI)

The socio-economic vulnerability index (SEVI) was computed as a function of heat temperature (HT) measured by land surface temperature, demographic sensitivity (DS) measured by Hispanic population, and adaptive capacity (AC) measured by HEIGHT household living costs affordability, which shows in Eq. 1.

$$SEVI = HT + DS - AC \quad (1)$$

3.4 Land surface temperature (LST)

The daytime Land Surface Temperature (LST) produced from Thermal Infrared Sensor (TIRS) Landsat 8 was used to illustrate the change of thermal field at city level (Yang et al., 2021). We chose a Landsat 8 picture on July 20th, 2020, at around 12pm local time to represent a typical summertime in the study area. The single technique used to recover the LST from Landsat 8 TM10 band data (Shao et al., 2015) was based on the following formulas in Eq. 2, 3, and 4:

$$T_s = (a(1 - C - D) + \frac{b(1-C-D)T_{10} - DT_a}{C - 273.15} \quad (2)$$

$$C = \varepsilon\tau \quad (3)$$

$$D = (1 - \tau)[1 + (1 - \varepsilon)\tau] \quad (4)$$

Where T_s is the LST (degrees Celsius); T_{10} is the brightness temperature (K) on the Landsat Thermal Infrared Sensor (TIRS) sensor; T_a is the average atmospheric temperature (K); and a and b are reference coefficients. ε is the T_{10} land surface emissivity, τ is the atmosphere transmittance of T_{10}. Finally, data from daytime LST retrieval were included in the heat exposure analysis.

3.5 Spatial Statistical Analysis

We constructed a spatial regression model for estimating and validating geographical heterogeneity (Chang et al., 2019; Chen et al., 2022). When variables are locally fluctuating, geographically dependent, and autocorrelated, spatial regression techniques are very effective as making them an obvious choice for geographical dependencies and correlations data.

We applied Geography Weighted Regression (GWR) analysis to examine the relationship between household cost, heat temperature, and race in the study area. After merging the geo-referenced data layers, GWR calculates the local interaction between the control and response variables. GWR is most successful when the data being investigated is geographically diverse or nonstationary. According to Fotheringham (2009), GWR can readily compute locally variable parameter estimates and is successful in producing precise spatially explicit maps of locational changes in relationships.

For the poverty rate, we used Moran's I to analyze spatial pattern, which is defined in Eq. 5 as:

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \times \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(x_i - \bar{x})(x_i - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})(x_i - \bar{x})} \quad (5)$$

where n is the total number of counties in the province; i and j represent separate counties; x_i is the residual of i :: $\bar{x}$ is the mean of residuals;, and W_{ij} is a measure of the spatial closeness of i and j pairings. Moran's I values range between -1 and 1. Negative autocorrelation values indicate that nearby places are scattered. Positive autocorrelation values, on the other hand, suggest that the nearby places are comparable.

4 RESULTS

In this part, we have undertaken a comprehensive analysis of the interplay between socio-economic vulnerability, heat temperature, demographic sensitivity, and adaptive capacity within Maricopa County, Arizona. The results of this study demonstrate the relation among the socio-economic vulnerability index (SEVI), heat temperature (HT), demographic sensitivity (i.e., race), and adaptive capacity (AC) comparing US Census poverty and HEIGHT poverty measurement in PUMAs within Maricopa County.

First, our analysis revealed that the HEIGHT poverty tool appears to provide a more detailed and nuanced perspective on economic vulnerability at the household level compared to the US Census. It has identified critical hotspots of poverty, particularly in urban areas, pinpointing regions where a substantial percentage of households struggle to meet basic living costs. This insight is invaluable for policymakers aiming to address economic disparities within the county. Second, our examination of heat temperature patterns in Maricopa County, driven by its temperature and geography, highlighted specific areas that experience extreme heat. This information is vital for managing heat-related challenges, especially in urban environments. Identifying the hottest regions within the county enables targeted interventions to mitigate the impacts of extreme heat events. Furthermore, The concentration of the Hispanic or Latino population in certain areas, particularly Downtown and Sky Harbor International Airport of Phoenix, as well as in cities like Tolleson, Glendale, Tempe, and Mesa, emphasized the need for inclusive and equitable decision-making across various domains of society. Finally, our spatial statistical analysis, employing the Geographically Weighted Regression (GWR) program, demonstrated that the relationships between heat, race, and poverty vary across the study area. These variations underline the importance of tailoring policies to address regional poverty while taking into account the unique social characteristics and geographic context of each region.

4.1 Adaptive Capacity

Figure 1 compares two spatial patterns of poverty data using US Census (left) versus HEIGHT poverty tool (right). The census map shows little number of households are under the poverty level compared to large portions of urban areas in Maricopa County having over 58% of households struggling to meet living costs (shown in red area under HEIGHT poverty tool). The hotspots of HEIGHT poverty include cities of El Mirage, Sun City, Glendale, Phoenix (i.e., Maryvale, Downtown and Sky Harbor International Airport, and South Phoenix), Tolleson, Tempe, and Mesa. While the HEIGHT tool calculates the poverty rate for specific household sizes, the Census estimates poverty with respect to the total population for a given area. Considering the HEIGHT poverty map as an appropriate tool for indicating economic vulnerability at the household level, further analysis demonstrates results of correlations among three vulnerability indexes and their effects.

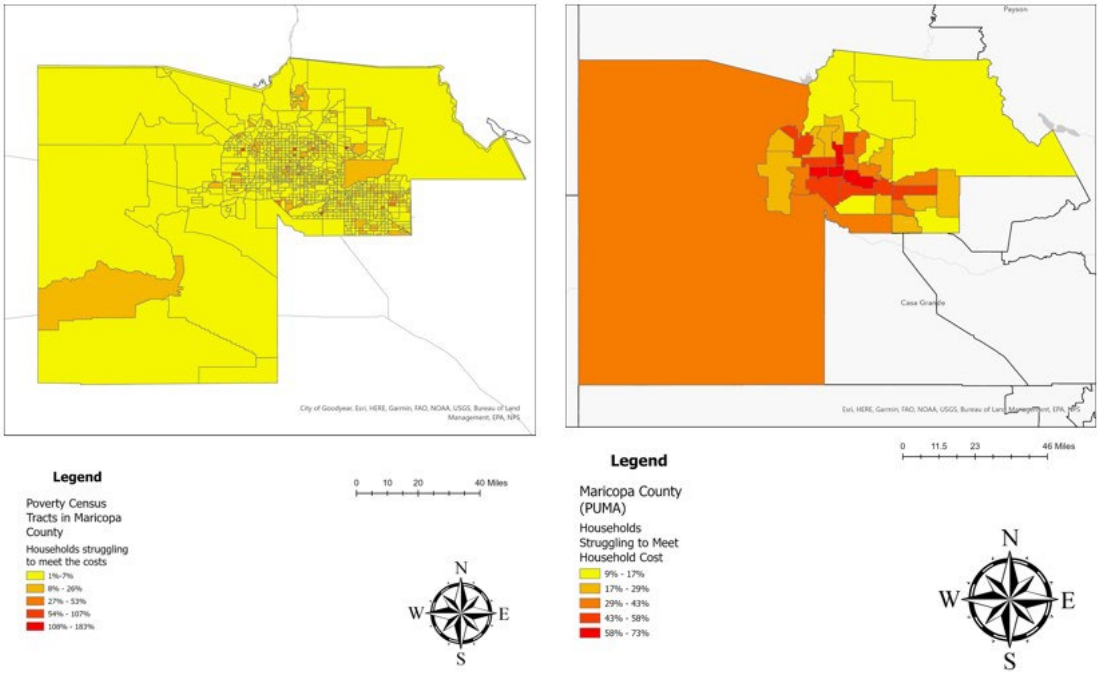

Figure 1: Comparison between HEIGHT (right) and Census tract poverty (left) in Maricopa County, Arizona

4.2 Surface Temperature

Arizona, including Maricopa County, is known for its scorching hot temperatures, especially during the summer months. The heat in Arizona is influenced by its desert climate, with large expanses of arid land and low humidity levels. Land surface temperature (LST) in Maricopa County, can vary significantly depending on the time of year, weather conditions, and geographical location. LST is measured by remote sensing instruments and in this part we used the LST map as a direct indicator of the heat present at the Maricopa's surface. LST is valuable for understanding and managing heat-related issues, including those associated with urban environments and extreme heat events. Figure 2 demonstrates the results of LST in Maricopa County. This map shows the exposure to the heat in different parts of area. The hottest parts of the study area shown in red color nclude the cities of Mesa, Tempe, Chandler, El Mirage, and Sun City.

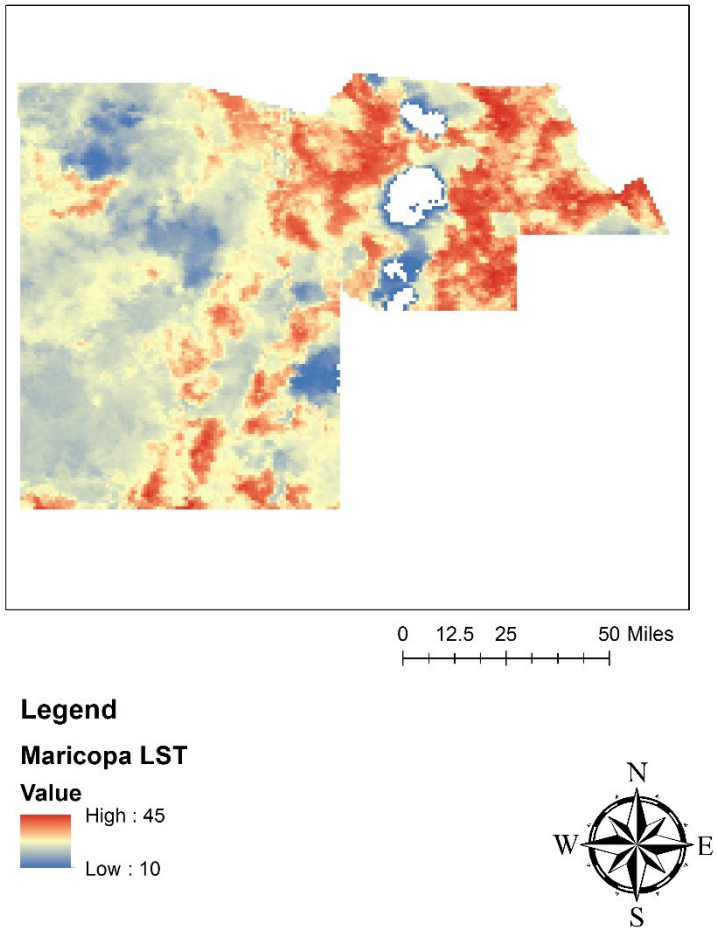

Figure 2: LST in Maricopa County, Arizona

Source: Knowledge Exchange for Resilience

4.3 Demographic sensitivity

In this part, we introduced demographic sensitivity to recognize one size does not fit all and individuals and communities are diverse in their backgrounds, needs, and experiences. It is essential for promoting equity, inclusivity, and effective decision-making across various domains of society. Since the Hispanic or Latino population are most vulnerable in Maricopa County, the following Figure 3 shows where the most Hispanic people reside in Downtown and Sky Harbor International Airport of Phoenix, as well as the Cities of Tolleson, Glendale, Tempe, and Mesa.

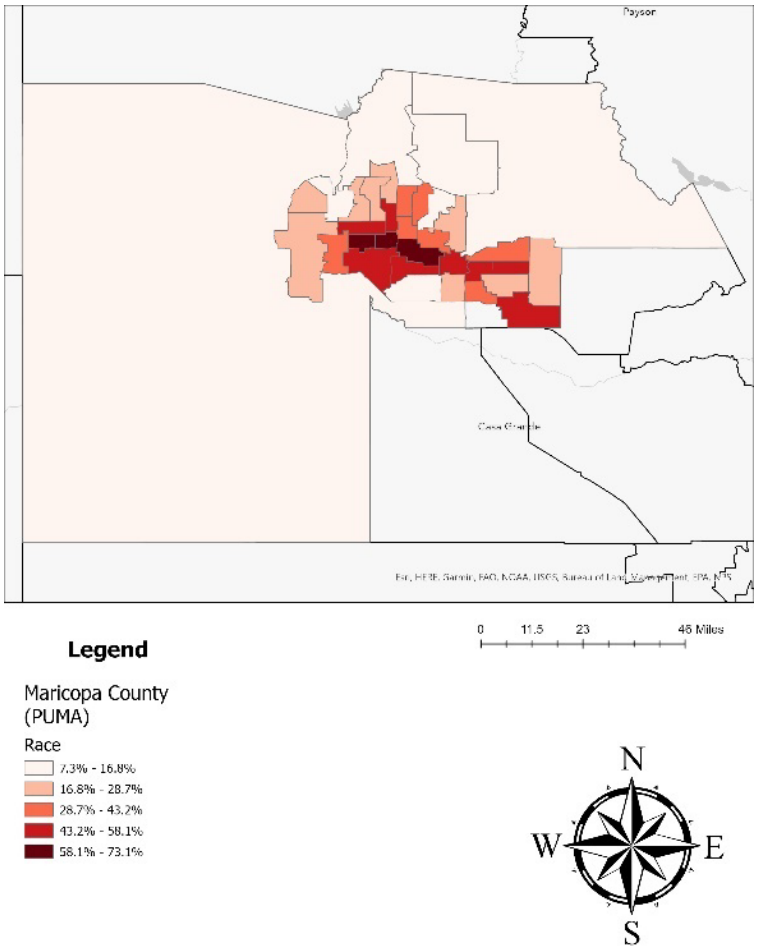

Figure 3: Distribution of the Hispanic population in Maricopa County, Arizona

4.4 Spatial Statistical Analysis

To understand the effects of heat on demographic sensitivity, we used the coefficient technique between the heat index and demographic index using the Geographically Weighted Regression (GWR) model. As shown in Figure 4, the spatial distribution of Residual Variations for heat and race index (-1.5 _ 1.48) and for heat and poverty (-2.5 _1.5) is not consistent across the study area. The clustering of Local R^2 values by various areas revealed the spatial impacts of poverty levels on physical geographic characteristics in Figure 5, suggesting the benefit of the Geographically Weighted Regression (GWR) in revealing associations when regressing variables with geographical heterogeneity and spatial autocorrelation, relationships are revealed. These maps were created with visualization techniques such as the modified classification method and standard deviation classification. The pseudo t values at the 90% level show that the correlations between the dependent and each predictor variables are not significant for some counties (in white color) in Figures 4 and 5, implying that the coefficients of each independent variable, whether positive or negative, are meaningless in these counties. It is critical for effective and focused policymaking to reduce regional poverty. Furthermore, these regulations must be tailored to the social characteristics of the region. For example, in Table 1, the prediction accuracy of heat and race, the GWR model goes up from 19% to 66%. Higher coefficient values indicate more explanatory power, which demonstrates that the local GWR model exceeds geographic regression models in terms of properly assessing spatial dependency among data, which is significant (*P*-value level $\cong 0.009$). In Table 2, the GWR model in heat and poverty has increased from 13% to 38% in comparison with heat and race analysis. Nevertheless, the *P*-value level remains the same with a consistent number (level $\cong 0.009$).

Table 1. Overall Summary of GWR Regression Model Indicating the Linkages Between the Heat/Temperature and Race

Factor	Variables	Parameters	Spatial regression model (GWR)	Observed Moran's	P-value Level of significance
Heat and Race Cases	N=6	Local R-squared Std Residual	0.199 – 0.666 -1.5 – 1.48		
Heat	N=6			0.139	0.009
Race	N=6			0.147	0.008
Heat and race case	N=6				0.009

Note: $n = 6$ includes six variables: (1) population density, (2) 2 adults and 1 child population, (3) income and cost, (4) race or ethnicity (Hispanic and Latin), (5) employed population, (6) heat temperature.

Table 2. Overall Summary of GWR Regression Model Indicating the Linkages Between the Heat/Temperature and Poverty

Factor	Variables	Parameters	Spatial regression model (GWR)	Observed Moran's	P-value Level of significance
Heat and Poverty (household cost)	N=6	Local R-squared Std Residual	0.134 – 0.383 -2.5 – 1.5		
Heat	N=6			0.139	0.009
Poverty (household cost)	N=6			0.165	0.003
Heat and Poverty (household cost)	N=6				0.009

Note: $n = 6$ includes six variables: (1) population density, (2) 2 adults and 1 child population, (3) income and cost, (4) race or ethnicity (Hispanic and Latin), (5) employed population, (6) heat temperature.

4.5 Map examination

Since we identified the red color over the LST map, which is classified by various temperature data, to diagnose the heat exposure parts of the area, the map configuration is a diagrammatic process of the methodology assessment in this section.

In Figure 4, the standardized residual refers to the difference between the observed value and the predicted value of a dependent variable for a specific location. The spatial distribution of Residual Variations for heat and race index, and for heat and poverty is not consistent across the study area. In the left picture, the distribution percentage of the standardized residual between household cost and heat exposure for the specific parts of the area (purple color) approximately is 25% while in the right picture, it is about 75% - it shows the prediction accuracy of heat and race in local GWR model exceeding the properly assessing

spatial dependency. By the way, the residual values are often minimal across districts, indicating that the regression analysis successfully explained the essential component of the dependent variable's fluctuation. However, the high residual values presented by the model in the Maricopa County districts, as well as a significant observed Moran's I for some models, indicate that there is some unexplained difference that is not fully captured by the independent variables in the regression model, and further research is required.

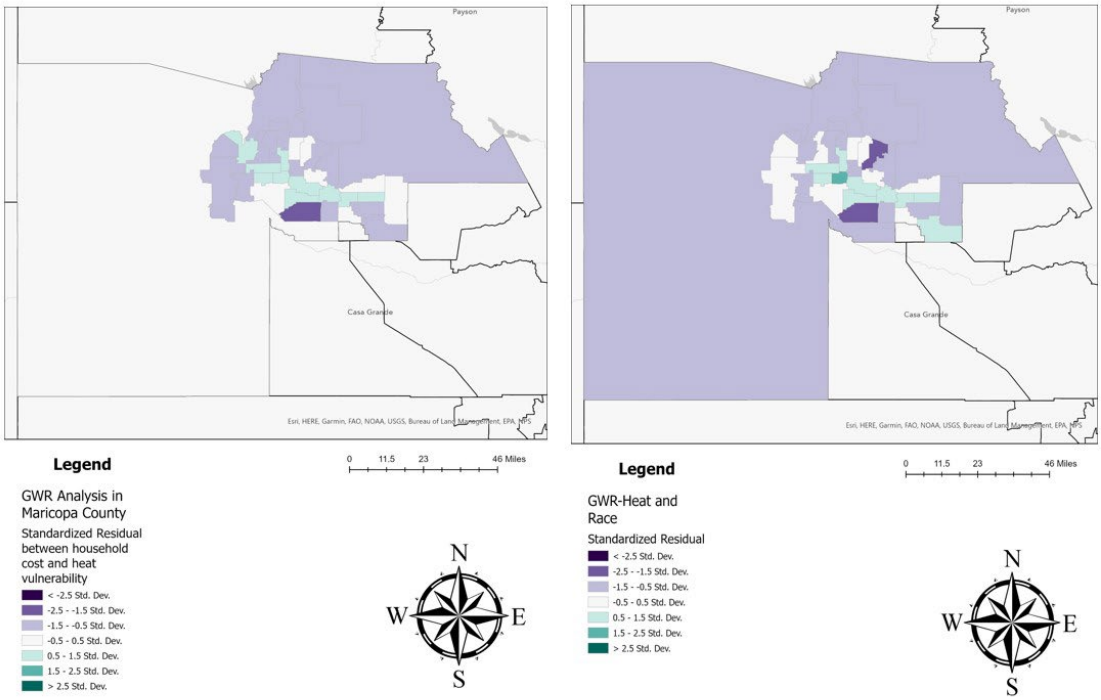

Figure 4: Residual variations from spatial regression analysis between heat and race (Hispanic population), heat and cost across Maricopa County, Arizona

Moreover, adaptive capacity pertains to the system's ability to adapt to climate change, mitigate potential harm, exploit opportunities, or deal with consequences. Six variables were employed and combined into sub-components (refer to Tables 1 and 2). The examination in this part revealed that the region under study exhibited a comparatively low level of adaptive capacity, with approximately less than 0.2~ of the area displaying extremely limited capability in handling impacts (refer to Figure 5, where low adaptive capacity is indicated in purple color in the left picture). In fact, in Figure 5, we mapped the R^2 values to uncover the relationship and effect of the independent factors with the heat cases the R-squared value of 0.1 to 0.2 indicates that the regression model explains 10% - 20% of the variation of poverty vulnerability as the independent variable at that location. While in the right picture, the R-squared value is rather close to 0.3 showing higher variation of race /social vulnerability as the independent variable. In other words, the most percentages of the interaction between heat and Hispanic people living in Maricopa County (West) and Gila River Indian Community (Northwest) explains the greatest share of the variation when considering local R^2 values for the instances ($R^2 = 0.666$) in the right picture. While, on the left side, the most percentage of the interaction between heat and people economically struggling to meet their living cost based on the local R^2 values is 0.382.

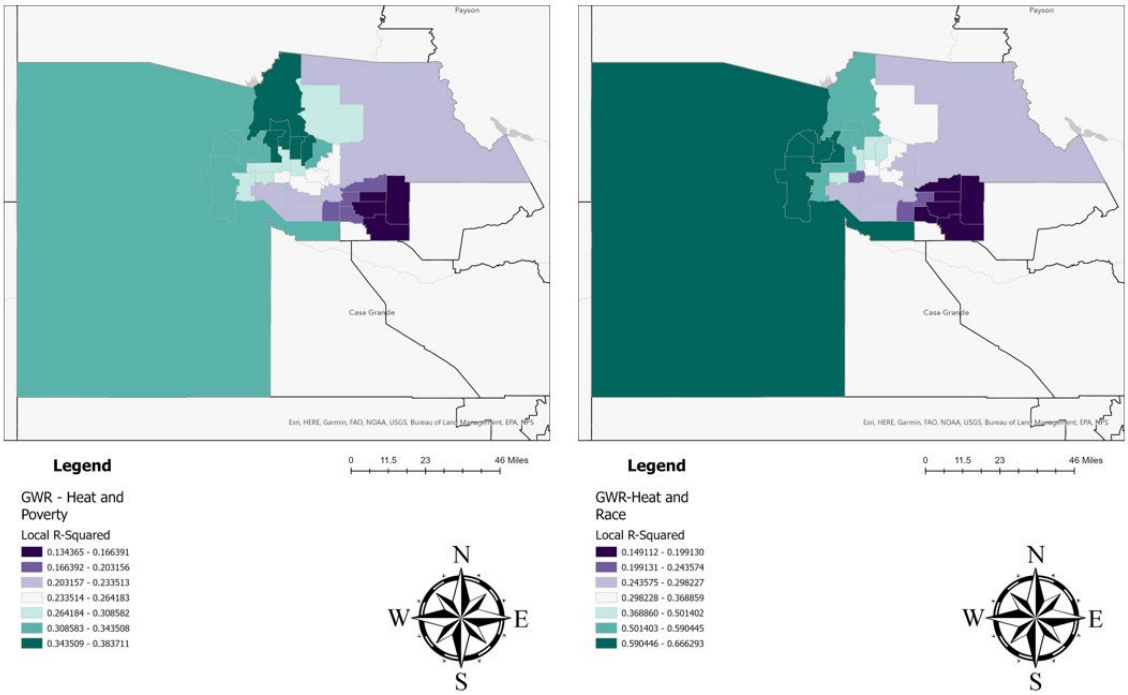

Figure 5: This map shows the spatial distribution between heat and social vulnerability (Hispanic race includes 2 adults and 1 child), heat and poverty, or household cost (adaptive capacity) vulnerability indexes of GWR analysis based on local R squared.

5. DISCUSSION

This study illustrates the variety of socio-economic indicators that impact people's sensitivity in Phoenix Metro areas due to the varied social economic and heat indexes. In scholarly literature, our study is the first to use the HEIGHT tool to estimate the poverty in Maricopa County. Cases acquired using the systematic mapping technique revealed disproportionate effects on people's income and cost vulnerability. Our findings have long-term policy implications due to the major determinants of increasing population concentration and a higher fraction of household poverty and income. It is widely recognized in the literature that the population of Maricopa County is distinguished by a wide range of cost of living and income levels. Few research found that the consequences on people's social-economic vulnerability were unclear. Some studies found disparities in outcomes for various social groups, indicating how social and economic processes determine who benefits from attempts to minimize vulnerability by applying nature-based solutions to create a better community for the future's people (Seddon, 2022). The SEVI assessment framework can be utilized to illustrate the vulnerability of hot spots in the metropolitan area with socio-economic susceptibility to heat risk at the local level. Furthermore, high sensitivity spatial clusters in the urban environment of Maricopa County were identified to assist decision makers in developing specific mitigation solutions.

While the Geographically Weighted Regression (GWR) provides a tool to demonstrate spatial variation, the method overlooks possible relationships among the local regression coefficients associated with distinct exogenous factors. We can see from the residuals map that the model fits well to show the percentage of the people struggling to meet their average living costs in Maricopa County (Northeast) and Scottsdale areas but poorly in the other districts. It shows that they still have large spatial relationships. It implies that leaving sections of the spatial organization unaccounted for leaves lots of room for improving the anticipated values. As a result, we propose that GWR models should be used as tools for exploratory and descriptive data analysis, rather than making conclusions. While scholars have previously emphasized the importance of spatial econometric models and autocorrelation, few research studies have taken into account geographical lag, spatial error, and GWR at the same time. Furthermore, geographic studies are

scarce on how pre-existing poverty circumstances influence heat outcomes in the Maricopa County region. We recognize that elevated heat incidences in Metro Phoenix areas are associated with larger population and their economic and social conditions. Our analysis (see Figures 4 and 5) shows that several districts are most vulnerable. Also, the demographic and household factors may have changed significantly since the last Census (2022), and hence the variables may have interacted differently with the heat based on the most current census dataset. The variation in our model fit highlights the model's complexity in estimating poverty. Aside from the variables we looked at, a variety of additional factors (such as social behavior, household occupation, meteorological conditions, and government policies) all have an impact on heat outcomes in large and diverse geographies. To formally represent the consequences of these limitations, a new class of GWR models would be necessary, and developing approaches to give a way out in the study area. A thorough implementation of the approach, as well as the use of diagnostic tools such as those used in this study, scatter plots of the local parameter estimates, and maps of the local parameter correlation, can address potential dependency issues in GWR research.

6. CONCLUSION

This study characterized the metropolitan social-economic vulnerability to heat in Phoenix Metropolitan Area, Arizona. We developed a Socio-economic Vulnerability Index (SEVI) considering three vulnerability components (i.e., sensitivity, exposure, and adaptive capability). We compared the adaptive capacity measuring tool between the poverty data defined by the US Census versus the HEIGHT poverty tool that considers living cost estimation in detail. Climate justice often intersects with other social and environmental issues, such as racial justice. The HEIGHT tool can support intersectional analyses, helping planners and designers address multiple dimensions of injustice simultaneously. This tool provides essential data for identifying vulnerabilities, promoting equity, allocating resources, engaging with communities to marginalize them, developing policies, and monitoring the disparities in income, education, and access to resources. As a result, the HEIGHT tool is better used to represent precise economic vulnerability and adaptive capacity whether the household can predict each expenditure to control and manage their budget about the extra costs even those related to electricity consumption, that affect cooling their living environments. By integrating this tool into the process, planners and designers can work towards creating climate-resilient communities that prioritize the needs of marginalized populations. In addition, by correlating the vulnerability indexes, the results showed how people of color and low-income individuals based on their household level economic capacity adapt to urban-induced heat hazards. The study demonstrated high significance in spatial clusters in the urban environment, which has implications in community design to assist decision makers in developing specific mitigation solutions to address climate justice in minority neighborhoods exposed to the high heat index. The method can be widely applied by landscape and urban planners when identifying priorities to invest in heat mitigation and adaptation strategies. This method helps to emphasize the importance of multidisciplinary methods and understand the development processes to cope with climate change, which will be appropriate for co-designing nature-based solutions with communities in the future (Schipper et al., 2016).

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LEARNING TO PREVENT: DEVELOPMENT OF A SET OF PEDAGOGICAL TOOLS FOR ARCHITECTS, LANDSCAPE ARCHITECTS AND ENVIRONMENTAL DESIGNERS TO ASSESS SITES' SUSCEPTIBILITY TO MASS MOVEMENTS

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ABSTRACT
With climate change increasingly driving extreme weather events and heightened natural hazard risks, landscape architects must enhance their ability to identify site vulnerabilities effectively. Currently, a notable gap exists in resources available to sensitize landscape architects and related design professionals to site-specific hazards, impeding informed decision-making during early site analysis stages. This paper presents a comprehensive natural hazard toolkit tailored for landscape architects, specifically designed for evaluating susceptibility to mass movements such as landslides. Developed and adapted in the Canadian context, the toolkit utilizes open-access, geographically adaptable data, ensuring its scalability and fostering trans-disciplinary collaboration, thereby enhancing climate resiliency. This toolkit combines remote site analysis techniques (using accessible GIS software and data) with multisensorial, in situ protocols for the evaluation of the site's susceptibility to mass movements. This toolkit may assist the landscape architect in the earlier phases of the design process, allowing for a nuanced and context-sensitive approach when dealing with landslide-prone environments.
We discuss the pedagogical and educational opportunities and benefits linked to the development of such tools, while interrogating their place within a pedagogical framework which aims to question or challenge conventional approaches of providing straightforward, fixed solutions to complex issues. This non-prescriptive framework, which we refer to as "non-solutionist", is gaining increasing relevance within the field of landscape architecture. In addition to the pedagogical value for newly trained designers, we argue that the presented toolkit encourages a more rigorous and holistic site analysis process and advocates for improved design interventions in areas susceptible to landslides.

Keywords: Landslides, mass movements, site analysis, landscape architecture, pedagogy

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1 INTRODUCTION

In Canada, terrestrial landslides account for an estimated $200 to 400 million in direct and indirect costs annually and present significant threats to infrastructures, natural systems/resources, and human safety (Government of Canada, 2017). Though fatalities related to mass movement events have decreased in recent decades, the number of landslides in Canada have increased and are expected to become more frequent from landslide triggering climatic events, such as heavy rainfall, due to climate change (Blais-Stevens, 2019; Sobie, 2020). This has been made apparent through the series of floods and landslides that occurred in November, 2021 throughout southeast British Columbia and northeast Washington State caused by a prolonged atmospheric river. The landslides, occurring in several locations in the region, led to destruction of highways and railroad tracks, causing massive supply chain issues, and the fatalities of five people (Parfitt, 2022). While the atmospheric event was unprecedented in British Columbia, it is likely that similar events will occur as precipitation frequency and intensity increases due to climate change (Sobie, 2020). The increasing risk of mass movements must be accounted in more rigorous ways and engage more professions to provide novel methods for mitigation.

Within the discipline of landscape architecture, where the shaping of landforms is intrinsic to the profession, there exists a notable scarcity of resources tailored specifically to sensitize landscape architects to the complexities of mass movements. A comprehensive review of 43 peer-reviewed articles, books chapter, and government documents revealed that only two among them explicitly addressed the role of landscape architects in managing landslide risk (Melsom, Girot & Hurkxkens, 2015; Claghorn & Werthman, 2015). Beyond these, the majority of available resources pertaining to landslides are characterized by their technical depth and extensive length, rendering them less accessible to the average landscape architect.

In light of this deficiency, the profession necessitates more accessible resources and tools to advance its capacity to spearhead climate-resilient projects. Such resources would not only enhance the effectiveness of design solutions but also empower landscape architects to critically assess relevant projects and identify potential landscape instabilities within their work, fostering collaboration with engineers and geologists.

To address this critical gap, the authors have conceived an open-access, user-friendly, and geographically adaptable toolkit hosted on the University of British Columbia's blog platform. In pursuit of a comprehensive approach that melds digital tools for large-scale analysis with immersive site assessments, two distinct tools have been developed the comprise the final toolkit. The first tool entails an ArchGIS workflow facilitating the creation of interactive susceptibility maps for preliminary site analysis. These maps draw upon publicly available data that can be readily customized based on the geographic context of the designer. The second tool is a multisensory, in-situ field questionnaire engineered to evaluate a site's susceptibility to mass movements.

These complementary tools not only hold value for the profession as a whole but also possess significant pedagogical utility for novice designers. They provide a robust yet accessible resource for comprehending the intricacies of landforms, thus augmenting the knowledge base of newly trained designers.

This project inscribes itself within a larger discussion on the teaching of site analysis and planning in landscape architecture curricula. The analysis, planning and representation of a site is a fundamental component of the design process, particularly within the discipline of Landscape Architecture, which lends itself to self-criticism, reflection, and deconstruction.

In this paper, the research objectives guiding the development of the toolkit are initially outlined. The creation process of both the blog and the toolkit is explained, highlighting the significance of each component and their collective contribution to a comprehensive approach to site analysis. Subsequently, the discussion pivots to situating this project within the broader landscape of site analysis and planning instruction within landscape architecture curricula. The utility of the toolkit is emphasized, alongside the acknowledgment of its inherent limitations as a pedagogical instrument.

We argue for the necessity of additional tools dedicated to the investigation and comprehension of natural hazards, despite their limitations. Finally, consideration is given to the project's future trajectory, indicating ongoing efforts to enhance and expand the toolkit beyond the scope of this paper.

2 RESEARCH OBJECTIVES

The toolkit summarized in this paper has several objectives. The overarching goal of the project has been to provide design professionals with an intuitive, accessible, and easy-to-use site analysis toolkit that delivers a basic understanding of earth and soil science in the context of the prevention and mitigation

of mass movements. The tools must be accessible in order for them to be available for anyone to use, regardless of profession or background, allowing them to be adaptable and replicable in different geographical contexts. They need to be intuitive and easy to use since they are targeted at design professionals who may not have a basic knowledge and formal training in soil science, which is fundamental to address slope instability.

Second, we aim to provide design professionals and the general public with an online educational platform that hosts a series of resources for learning about mass movements. Through this extensive online resource, we present information and resources through the form of a bibliography matrix, a literature review, external resources, and our toolkit. As an educational platform, we seek to deliver information through a variety of media to engage different learning styles. This includes diagrams, sketches, and a video tutorial that supplement written explanations.

Third, we hope to bridge the existing gap between specialized, specific, and technical knowledge on mass movements phenomena, typically directed toward engineers, geologists and geophysicists, and elementary information directed toward the general public. In other words, the goal for these landslide analysis tools is to reach a middle ground by targeting a group between these extremes, such as design professionals, who might need more in-depth knowledge on mass movements than what is currently available for the general public, but who would not possess the necessary in-depth knowledge to understand the more technically oriented material.

3 METHODS

The development of the toolkit occurred in multiple phases. The first phase involved an extensive review of existing scientific literature on landslide prevention, initially within the field of landscape architecture, and subsequently expanding into other domains such as soil science. This literature review was subsequently transformed into a blog, addressing the broader topic of landslide prevention in landscape architecture. The blog encompassed sections covering the classification of mass movements, the geomorphology of landslides, and related subjects.

The literature review underscored the imperative need to create assessment tools tailored for landscape architects and other designers. Initially, we devised a cartographic tool for site susceptibility assessment to landslides. This tool employs an intuitive protocol and utilizes readily accessible geospatial data. The cartographic assessment tool was seamlessly integrated into the blog and accompanied by a usage tutorial.

Furthermore, the literature review shed light on the relative absence of in-situ prevention tools that could facilitate a more intimate and multisensory analysis during on-site visits, a need especially pertinent for landscape architects. Consequently, a second tool was developed: a multi-sensorial, in-situ field questionnaire to assess the site's susceptibility to mass movements. These complementary tools, in addition to their pedagogical value for newly trained designers, allows for a more rigorous and holistic site analysis process that utilizes digital tools along with site immersion assessments. In doing so, the pedagogical aspects of the toolkit should lead to more adequate design interventions in susceptible areas through a deeper understanding of mass movement risk.

3.1 Blog

The blog originated as an online repository for a comprehensive review of literature focused on the intersection of mass movement hazards and architectural remediation strategies. In pursuit of this objective, a bibliographic matrix was constructed, encompassing 43 peer-reviewed articles, books, and government documents. This matrix facilitated the assignment of technicality and relevance indices to each entry, thereby providing a concise overview of influential works within the realm of mass movements.

A comprehensive bibliography matrix—a table cataloging articles and assigning them technicality and relevance indices—was constructed to provide landscape architecture students with an overview of influential works in the field of mass movements. This matrix encompasses articles of varying technical complexity and audience focus, comprising predominantly peer-reviewed journal articles but also encompassing book chapters, conference proceedings, and government publications.

In addition to the bibliography matrix, an annotated bibliography was compiled, featuring concise summaries of each article's content and editorial notes on their applicability to landscape architecture. This supplementary resource offers succinct summaries of each article's content and incorporates editorial notes assessing their applicability in the field of landscape architecture. Notably, this exhaustive literature review yielded a limited number of resources (two in total) addressing the convergence of landslides and landscape

architecture. Of these two, only one delineated a specific workflow tailored for landscape architects, outlining a method for developing a Rapid Mass Movement Simulation utilizing GIS and Rhinoceros 3D (Claghorn & Werthman, 2015).

Following this literature review, a dedicated section centered on mass movement mitigation was incorporated into the blog. This section was informed by an exploration of architectural precedents featuring components designed for mass movement prevention. Additionally, it encompassed a comprehensive listing of engineering and architectural techniques that could be integrated into broader design frameworks. Each of these illustrated methods and technologies was categorized according to its applicability in preventing specific types of mass movements, thereby facilitating quick reference and accessibility.

An educational section on the basic concepts associated with mass movement was also added. This includes three main sections: landslide morphology, mass movement classification (based on the original method of Varnes, 1978 and adapted by Hungr, 2014), and the different mechanisms involved in the initiation of different mass movements, including geological, biological, and hydrological causes. Added to these concepts is an individual review of each major type of mass movement, including the prevalence and specific triggering mechanisms, as well as mitigation measures adapted for each of them. Schematics by the authors populate the entire section and allow for a more visual learning process for the users of the site (see Figure 1). This aids in establishing an engaging educational interface, helping to foster different learning styles through an array of communication methods. Much of the illustrated portion of the blog is composed of diagrams, drawings, and photographs that supplement the written information. With the more technical sections, as with the GIS tool discussed in the subsequent section, learning-by-doing is highly encouraged through resources, such as an audio-visual tutorial in the case of the GIS tool.

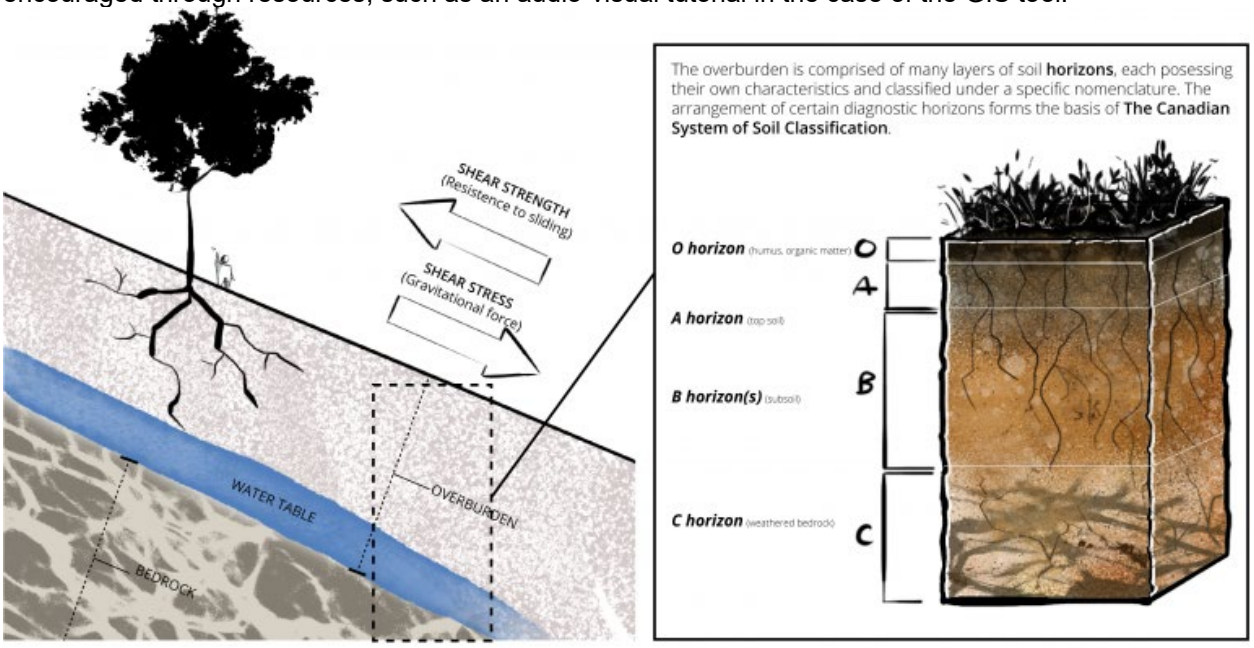


Figure 1. Diagram explaining the forces acting on a vegetated slope that cause landslides, from *What Causes Landslides* section under 'Basic Concepts'.

3.2 GIS tool

The GIS susceptibility analysis tool was created using ArcGIS to provide a quantitative analysis of slope stability for a given site and its surroundings, using the openly accessible data shown in Table 1. The tutorial featured on the blog used a case study site based in British Columbia, Canada, thus allowing for the use of publicly available data through government databases. Multispectral satellite imagery used to calculate the Normalized Difference Vegetation Index (NDVI) was downloaded through ESA's Copernicus Open Data HUB, LiDAR imagery was obtained from LiDAR BC, and stream network information was obtained from BC Data Catalogue (see Table 1).

Table 1. List of data used for the GIS tool exemplified through a site in British Columbia.

Data	Source	Format	Date

Level-2 Sentinel 2 Multispectral Satellite Imagery	Copernicus Access Open Hub	Raster - .tiff	2022
Study Area LiDAR	LiDAR BC	.laz	2017
Fresh Atlas Stream Network	BC Data Catalogue	Vector - .shp	2011

In order to evaluate slope stability, a multi-Criteria Evaluation was conducted using the Suitability Modeler in ArcGIS Pro. In this method, each layer is assigned a weight (in percentage) representing the parameter's influence on slope stability, with all weights combining to a total of 100%. The four layers used for the analysis were (1) Elevation, (2) Slope, (3) Vegetation density and (4) Proximity to streams. The final output can be seen on Figure 2.

The determination of relative weights assigned to each layer was achieved through the utilization of the Analytical Hierarchy Process (AHP), a widely employed method in the domain of Landslide susceptibility mapping (Leonardi et al., 2022). In this method, the weights are ascribed based on a hierarchical order of importance. While a general hierarchy of importance regarding landslide-controlling factors does exist, practical considerations, such as data availability and the tool's desire for simplicity and accuracy, necessitate users to discern the most pertinent factors specific to their site, contingent upon its location. Consequently, the calculated weights may vary in response to the relative importance of these variables.

Since higher elevations often receive increased rainfall due to increased condensation through adiabatic cooling, elevation is used as a proxy for rainfall (Song, 2019; Smith, 2008). With additional shear stress, along with other factors, areas with steeper slopes are more likely to fail (Bobrowsky & Highland, 2013). Vegetation density also affects slope stability since root systems act as anchors that stabilize soil, as well as absorb water limiting additional shear stress. This can be calculated within ArcGIS Pro using the NDVI, which uses spectral bands to evaluate vegetation density and health (Angers & Caron, 1998; Ford, 2016). Proximity to streams is also important to include as streams erode and reshape the landscape, increasing slope angle and potentially undercutting hillsides making them likely to fail (Fox, 2010; Bobrowsky & Highland, 2013).

Within each individual layer, values are assigned different weights, amounting to 100%, using Transformation Functions in the suitability modeler. Weights were assigned using the Analytical Hierarchy Process (AHP) that has been used by previous researchers to assign weights to different variables (Jazouli, 2019; Leonardi, 2022). AHP is a mathematical decision-making matrix that assigns weights based on the order of importance. In the case of landslide susceptibility mapping, this process is useful as different variables should be assigned different weights based on the area of study where, as shown in the tutorial, slope carries the highest value and distance to streams carries the lowest weight (Cleveland, 2004).

Figure 2: Final output of the GIS-based tutorial on determining slope stability through a cartographic quantitative analysis.

The study site used for the simulation is situated in the Deep Cove Area of North Vancouver, British Columbia, a region profoundly influenced by glaciation processes. Consequently, the area features steep slopes characterized by a substratum of bedrock overlaid with glacial sediments (BGC, 2009). The variability in the permeability of these sediments assumes a pivotal role in soil stability. This geological configuration is a prevalent characteristic of North Vancouver.

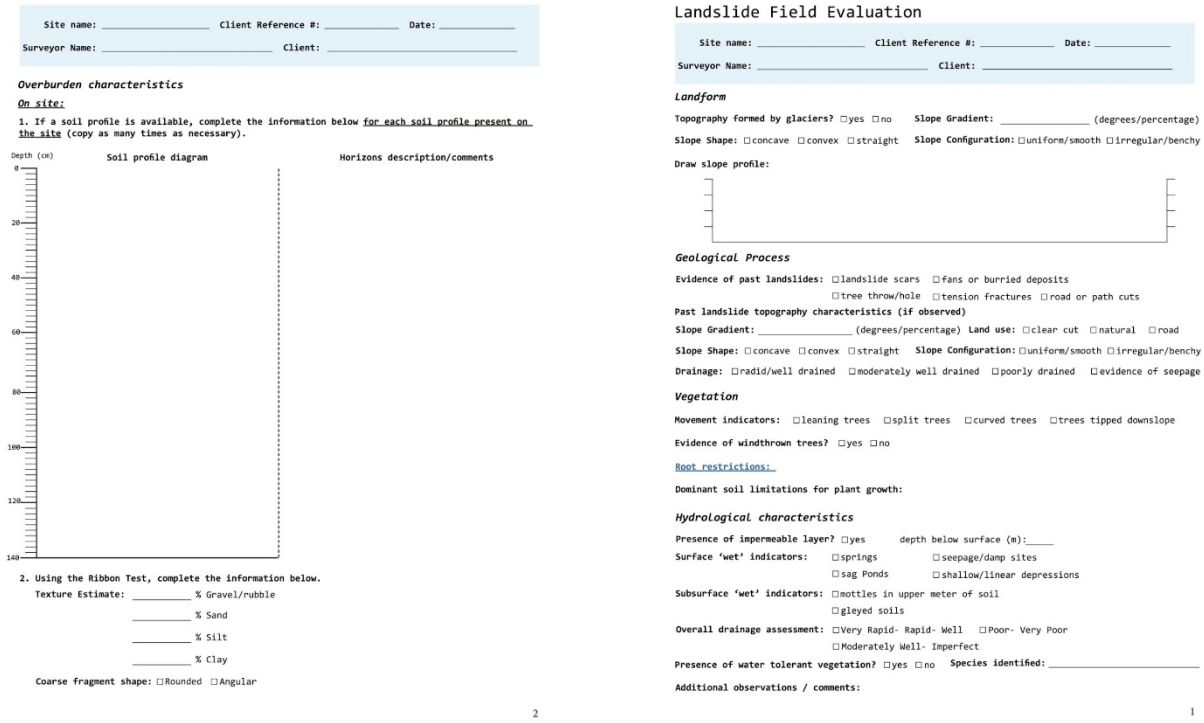
Climatically, North Vancouver experiences substantial annual precipitation, often exceeding the quantities observed in the neighboring Vancouver area by a considerable margin, primarily attributable to the orographic effect. Consequently, soils in this region are subjected to higher volumes of water, a factor that can significantly impact their cohesion.

Historically, North Vancouver, including Deep Cove, was covered by dense temperate rainforests, which underwent extensive clear-cutting, subsequently elevating the susceptibility to landslides (Saito et al., 2017). While reforestation efforts have been undertaken in many areas, certain regions have transitioned into residential neighborhoods, devoid of the intricate soil stabilization mechanisms offered by forests. North Vancouver exhibits a history of smaller-scale mass movements, characteristic of its topographically complex terrain. However, given the escalating intensity of rainfall events, an increase in the frequency of mass movements is anticipated (Jakob & Owen, 2021).

3.3 Field questionnaire and companion document

The GIS tool involves a quantitative preliminary site analysis through a cartographic-based approach, providing a better understanding of mass movement risk near a given study site. While this is a useful starting point for landslide assessments, there are limitations due to the availability and resolution of data. For example, contrary to elevation, slope or proximity to streams, data related to soil composition is either incomplete or unavailable in high-resolution, requiring an alternate approach to evaluate this component. In order to circumvent these limitations, an *in-situ* questionnaire was developed to supplement the GIS tool, along with a “companion document” which provides the theoretical explanations behind the criteria found in the questionnaire. The questionnaire (divided into 2 forms) was adapted from *A Guide for Management of Landslide-Prone Terrain in the Pacific Northwest* (Chatwin et al., 1994), a document published by the Ministry of Forest of British Columbia, providing an updated and simplified version that is specifically created for landscape architects.

Five assessment groups were defined according to their degree of influence on the susceptibility of a site to mass movement: (1) landform, (2) overburden, (3) geological processes, (4) hydrological characteristics, and (5) vegetation. For each theme group, a series of observable factors and items were listed according to their ease of interpretation by design professionals, their multisensorial aspect, as well as their relevance for a qualitative assessment of a site's sensitivity to mass movements. In addition to the methodological approach adapted from Chatwin et al. (1994), concepts and procedures related to soil analysis and pedology were integrated into the document following the standards of the *Canadian Soil Classification 3rd edition* (Soil Classification Working Group, 1998) and using the *British Columbia Soil Information Finder Tool (SIFT)* (Provincial Soils Working Group, 2018).


Site name: _____ Client Reference #: _____ Date: _____

Surveyor Name: _____ Client: _____

Overburden characteristics

On site:

1. If a soil profile is available, complete the information below for each soil profile present on the site (copy as many times as necessary).

Depth (cm) | Soil profile diagram | Horizons description/comments

0 20 40 60 80 100 120 140

2. Using the Ribbon Test, complete the information below.

Texture Estimate: _____ % Gravel/rubble

_____ % Sand

_____ % Silt

_____ % Clay

Coarse fragment shape: ☐Rounded ☐Angular

2

Landslide Field Evaluation

Site name: _____ Client Reference #: _____ Date: _____

Surveyor Name: _____ Client: _____

Landform

Topography formed by glaciers? ☐yes ☐no Slope Gradient: _____ (degrees/percentage)

Slope Shape: ☐concave ☐convex ☐straight Slope Configuration: ☐uniform/smooth ☐irregular/benchy

Draw slope profile:

Geological Process

Evidence of past landslides: ☐landslide scars ☐fans or burried deposits ☐tree throw/hole ☐tension fractures ☐road or path cuts

Past landslide topography characteristics (if observed)

Slope Gradient: _____ (degrees/percentage) Land use: ☐clear cut ☐natural ☐road

Slope Shape: ☐concave ☐convex ☐straight Slope Configuration: ☐uniform/smooth ☐irregular/benchy

Drainage: ☐radid/well drained ☐moderately well drained ☐poorly drained ☐evidence of seepage

Vegetation

Movement indicators: ☐leaning trees ☐split trees ☐curved trees ☐trees tipped downslope

Evidence of windthrown trees? ☐yes ☐no

Root restrictions:

Dominant soil limitations for plant growth:

Hydrological characteristics

Presence of impermeable layer? ☐yes depth below surface (m):____

Surface 'wet' indicators: ☐springs ☐seepage/damp sites ☐sag Ponds ☐shallow/linear depressions

Subsurface 'wet' indicators: ☐mottles in upper meter of soil ☐gleyed soils

Overall drainage assessment: ☐Very Rapid- Rapid- Well ☐Poor- Very Poor ☐Moderately Well- Imperfect

Presence of water tolerant vegetation? ☐yes ☐no Species identified: _____

Additional observations / comments:

1

Figure 3: *In-situ* questionnaire developed by authors.

A companion document was written to complement the questionnaire and to guide the designer in filling the forms that comprise it (see Figure 3). It contains the required theoretical notions to complete both forms and serves both as an instructional document, explaining the importance of each factor and outlining specific steps to complete *in-situ* tests indicated in the forms. This component can additionally act as an educational resource on the topic of soil science and classification, pedology, plant identification and topography. Similar to the blog, the companion document is thoroughly populated with tables, diagrams, schemas, and illustrations to assist the learning and visualization processes.

4 RESULTS

The GIS susceptibility assessment tool, site questionnaire, and companion document are accessible online at https://blogs.ubc.ca/landslides/. Hosted by the University of British Columbia, this platform provides open access to the tools for a diverse audience, encompassing students, professionals, and other interested individuals. The blog functions as an extensive online resource, offering essential knowledge concerning mass movements, adaptable and replicable to suit various geographic contexts.

In conjunction with the other sections within the blog, the toolkit equips design professionals with intuitive, accessible, and user-friendly site analysis resources. It encourages professionals to consider the risk factors associated with mass movements comprehensively. Notably, the blog and toolkit are designed to be accessible to a broad audience, bridging the gap between specialized technical knowledge and its practical application by landscape architects and related professionals.

To enhance the toolkit's effectiveness and ease of use, ongoing evaluations are being conducted by master-level landscape architecture students at the University of British Columbia. These assessments seek to refine the tools and optimize their utility.

5 DISCUSSION

We are confident that the toolkit developed holds substantial potential for adoption by landscape architects, offering a tangible method for assessing the susceptibility of a given site to mass movements. However, it is essential to acknowledge the limitations inherent in the workflow. The dynamic nature of technology and information means that even minor updates to software or websites can lead to issues such as broken links, missing data, or the relocation of tools within software platforms. While some individuals may possess the expertise to address these challenges, navigating software can prove daunting for others, compounded by uncertainties surrounding the selection of relevant data. While the possibility of regular updates to the workflow may help mitigate some of these limitations, it may not present a fully practical solution in the long run.

To simplify the use of the site questionnaire, we have opted not to assign parametric values to each of the risk factors considered in the questionnaire. A parametric analysis would guide the users toward a quantitative and tangible risk index for site assessment. However, we believe that the questionnaire should be part of a human-scale, multisensory site observation process, with the precise quantification of mass movement risk conducted collaboratively with relevant professionals. The toolkit's role is to provide landscape architects with a preliminary understanding of various site-scale mass movement risk factors, rather than replacing the work of qualified professionals in the field of geology.

This project inscribes itself within a larger discussion on the teaching of site analysis and planning in landscape architecture curricula. The analysis, planning and representation of a site is a fundamental component of the design process, particularly within the discipline of Landscape Architecture, which lends itself to self-criticism, reflection, and deconstruction. There is a trending effort to teach architecture students, especially at the graduate level, to uncover underlying ideologies and biases of common tools and methodologies used in site analysis in order to understand their limitations. Among the objectives of this approach is to consider site analysis as a recursive process that does not endeavor to produce objectivity, but instead to develop a deeper understanding of the complexities of site and aid in development of design interventions that are more socially and environmentally just (Karim, 2021). ‘McHargian’ approaches to site analysis using traditional cartography and mapping have been rightly criticized in academia (See, among others, Treib, 1999; Herrington, 2010) and are taught to students with the preamble that they are inadequate when used alone for site analysis. “Solutionist" approaches, a term raised and eloquently described in *The Problem with Solutions* by Rob Holmes (2020), are presented to students as ultimately the source of further problems with landscapes, and are often touted to exclude processes like globalization, rapid urbanization, climate change, systemic racism, increasing wealth disparities, and systematized inequities in site planning and analysis.

In developing a set of tools whose framework is rather prescriptive, such as the one presented here, we are thus faced with a dilemma. Are we contributing to the reinforcement of a solutionist method of site analysis that continues to be problematic in the field of landscape architecture today? Are we reducing an eminently complex phenomenon - that of mass movements - to a simple technical problem requiring pragmatic and technocratic approaches to be "solved"? Are we transposing, through the tools we have designed, any cognitive biases that may ultimately be more damaging than useful in addressing the phenomena of mass movements?

We must weigh these arguments with the fact that this project, despite the critique it may raise, has proven to be highly formative and relevant to our learning experience. First, notwithstanding the theoretical limitations of the “solutionist” dynamic in design, it is reasonable to assert that the phenomenon of mass movement is, in itself, a real problem in populated areas: it damages infrastructure and takes lives. It is also a phenomenon that is being exacerbated by climate change, and one that design professionals are currently ill-equipped to understand and address. To lead to greater resilience in the face of these changes, there is therefore clear value in developing accessible, freely available, intuitive, and practical diagnostic tools (Roehr, 2023).

We also believe that there is a tangible added value in more prescriptive and ‘technical’ site analysis tools in an educational context. Presenting mass movements as an unambiguously problematic phenomenon that needs to be addressed professionally greatly simplified our task at the beginning of this

project. It gave us an intuitive starting point and a logical goal to pursue; how we pursue and achieve that goal could subsequently be as complex and abstract as we wished.

Building the toolkit also led us to understand scientific concepts related to site analysis that we felt were fundamental yet had not been taught in our courses: concepts related to soil science, hydrology, pedology, mapping methods, recognition, and identification of water sensitive plants, among others. In this sense, the "prescriptive" and "solutionist" side of our project framework - mass movements are a problem, and it needs to be fixed as soon as possible - was a precursor to holistic thinking and appreciation of site complexity rather than a detriment.

The primary objective of our toolkit is pedagogical: it aims to provide design professionals interested in intervening in mass movement issues with a set of basic knowledge that they acquire through multisensory site analysis (Roehr, 2022). It thus encourages trans-disciplinarity, as it allows design professionals to communicate more effectively with other professionals involved in land use, such as geoscience specialists. Although our questionnaire has directed questions and relies on rather "prescriptive" observation criteria (e.g., description of the soil profile according to recognized classification standards), our hope is that it will encourage the designer to engage more deeply with the site beyond the confines of the questionnaire. The simplified and prescriptive purpose of the in-situ questionnaire is a pretext, a precursor to deeper site exploration, providing a more accessible starting point for students who are unfamiliar with such immersions. Through soil profile analysis and the ribbon test, the designer learns to touch the soil; to smell it, to feel it, to perceive its textural qualities. Identifying the characteristics of slopes present on the site can lead to an appreciation of their formal qualities. Assessing the drainage of the site can reveal its latent characteristics and provide inspiration for future design interventions.

How do we ensure, then, that such tools do not lead to the same problems associated with so-called "prescriptive" solutions as those raised by Holmes and others in the design field? We believe that part of the answer lies in the pedagogical approach surrounding the development of this tool, along with other similar tools, and its use. For this learning process to "work," that is, for the rigid and prescriptive framework of problem solving to lead to an analysis of a depth expected of today's designers, mentorship and adequate retrospection are required. Following the prescriptive and directed site analysis protocol, students should be advised, as we were, to analyze their analysis or, as Holmes puts it, “frame the problem before attempting to solve it” (2020, p.12).

6 CONCLUSION

Despite the substantial advancements in technical and theoretical knowledge concerning mass movement prevention and mitigation, landscape architects and other design professionals currently lack comprehensive tools to propose design interventions that adequately address these hazards. The development of accessible, user-friendly, and geographically adaptable tools, as proposed in this paper, including accessible mapping methods and in-situ analysis protocols, holds the potential to enhance resilience against climate change. We recommend the integration of these tools within a multi-sensory field immersion approach that extends beyond the confines of the questionnaires outlined in this study.

It is our contention that the development of such tools carries tangible educational value, affording students involved in their creation the opportunity to cultivate trans-disciplinary awareness. The compatibility of protocol-based and prescriptive analysis tools within a "non-solutionist" approach to site analysis warrants discussion and consideration, given the pedagogical research opportunities inherent in these tools. Similar methodologies, akin to the one employed in this project, can be replicated to investigate various natural hazards (e.g., avalanches, forest fires, floods) or to broaden design professionals' awareness of mass movements.

To enhance the toolkit's assessment, master-level landscape architecture students at the University of British Columbia are presently conducting a case study to gauge the effectiveness of these tools. Their insights and feedback will be instrumental in refining the toolkit, making it better suited for educational environments. Subsequently, based on their final report, we intend to further enhance the toolkit and collaborate with them on a research paper elucidating their findings.

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In addition to the references used for the present paper, the reader is invited to consult the Annotated Bibliography and Bibliography Matrix sections on the UBC Landslide Mitigation Blog (https://blogs.ubc.ca/landslides/), which contains additional resources and references used for the creation of the aforementioned toolkit.

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SERVICE LEARNING AND COMMUNITY ENGAGEMENT

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UNUSED OUTDOOR SPACE UPDATE: IMPROVING NEIGHBORHOODS IN HIGH-DENSITY URBAN COMMUNITIES WITH A FOOD-CORED ENVIRONMENTAL SCIENCE COURSE

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ABSTRACT
As urbanization accelerates year by year, China's urban public spaces are shrinking exponentially. The serious lack of outdoor space has led to the gradual degradation of urban blocks in Nanjing, a city with a population of 9 million, and the loss of space reuse potential in high-density urban buildings.
The research case is a sunken space on the south side of the main building of the Children's Palace in Jianye District, Nanjing. The design team used its educational resources to position the site as an outdoor base for nature education for children in surrounding communities. The garden uses food education as a medium to correspond to the 24 solar terms (traditional crop planting calendar in the Yangtze River Basin of China), forming a year-round planting plan for more than 60 kinds of fruits and vegetables and formulating more than 20 phenology courses. The course content is formulated according to the diet and planting customs corresponding to the solar terms, including farming operations and traditional food production.
Chinese urban residents are still keen on agricultural practices, and planting crops as a medium increases the site's readability and explores new possibilities for utilizing abandoned community spaces. In this garden, locally sourced plant materials enhance the site's resilience; the total cost is less than $1.5w. While the courses are free of charge to families in the surrounding communities, collective events promote widespread participation from the surrounding communities, and the initially loose neighborhood relationships are strengthened.

Keywords
Environmental science course, Edible Garden, Twenty-four Solar Terms, China

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1 INTRODUCTION

Urban micro-renewal advocates changing some small-scale urban public spaces slightly and gradually to solve some of the social problems brought about by the rapid incremental development of cities, and at the same time, make up for the traditional large-scale urban renewal that is difficult to penetrate trivial and negative urban corners (Lieflnder A K et al., 1986). Urban micro-renewal has not been used as a globally popular concept in academic research in various countries. However, its basic meaning has been widely used in various urban studies since Jane Jacobs. Since the 1960s, it has been practiced in many cities worldwide for nearly 60 years, and thus has accumulated a considerable theoretical system and practical methods (Jan Gehl, 2016; William H. Whyte, 2016). Urban vitality requires incremental renewal from the bottom up (Jane Jacobs, 1961). "Urban micro-renewal" is closer to the concept of "Urban Acupuncture" (Urban Acupuncture) commonly used in urban development around the world. Urban Acupuncture advocates the use of small-scale precise interventions to improve the overall urban environment on a larger level (Bai Xueyan et al., 2020). Separation of living, working and leisure in metropolitan areas is a major cause of urban inactivation, and urban acupuncture can mix incompatible functions in cities using low-cost precise interventions without large-scale changes and improvement to improve the overall urban environment (Lerner, 2014).

China's cities have experienced rapid expansion in recent decades, and construction land tends to be saturated. "Urban micro-renewal" considers the development of urban space stock, based on public participation, and targets community public spaces and public facilities. The local incremental renewal method aims to stimulate urban vitality, increase community cohesion, optimize neighborhood relations, and promote community co-governance (Shan Ruiqi, 2017). A highly dynamic public space should have diverse functions and spatial characteristics, and be able to meet the diverse needs of citizens (Dong Hexuan et al., 2018; Mehta, 2006). This is a practical strategy that combines top-down public governance and bottom-up public participation (He Xiaohan, 2022). However, on the whole, urban micro-renewal based on public activities is still in its infancy.

Urban public space has meaning because of human activities (Franklin C et al., 2003), and micro-spaces are no exception. Factors affecting the site design of micro-spaces include fitness facilities, children’s activity facilities, and lawns for rest (Han Xili, 2020). Accessibility, environmental quality, and place atmosphere are essential aspects that affect vitality (Li Qing et al., 2014), so vitality improvement strategies need to be classified based on the usage of the population (Wang Lijun et al., 2018).

Based on research at home and abroad, it can be seen that under the impact of global sustainable development, cities are facing multiple and complex issues such as resource allocation, social equity, environmental pollution, and social isolation (Liao Qingqing et al., 2020). The power of self-renewal is the key to sustainable development. It can be made clear that public participation is the internal requirement and mechanism of space micro-renewal, and micro-renewal provides a practical platform for public participation, and its core goal is to promote the sustainable development of negative space. However, the micro-renewal practice based on public participation has strong local characteristics and diversity, and is still in the rising stage in China. The current research basically focuses on the summary and enlightenment of foreign experience, the development process and current situation of domestic public participation, and community participation in a few developed regions. Practical exploration, there is a lack of research that uses educational landscapes and activities as a means to promote social participation to realize the reuse of idle space. This paper aims to fill this gap.

After more than 30 years of rapid urban construction, with the high degree of urbanization and disorderly expansion, China's urban public space is shrinking exponentially. In 2016, the first batch of 11 micro-renewal pilot projects in Shanghai were fully launched. Urban renewal has gradually shifted from extensive construction dominated by urban land redevelopment to refined governance that focuses on improving the quality of micro-spaces and revitalizing functions. As the ancient capital of the Six Dynasties, Nanjing is developing rapidly. A variety of settlement patterns have emerged in the center of Nanjing, coupled with the lack of public natural facilities, resulting in uneven distribution of residents' public spaces. Compared with large-scale public spaces, these gradually formed micro-spaces present typical characteristics such as large number, diverse sources of land use, scattered layout, and strong accessibility. Micro-spaces are closely related to and interdependent with all urban life trajectories and production resources such as communities, transportation, and commerce. They are usually derived near the boundaries of plots of different functional divisions in the city, partly due to the natural change of urban planning and design models in different eras, partly due to changes in the social behavior of some public groups, people subconsciously choose to stay away from such The place.

At the same time, the per capita activity area of students in primary and secondary schools in Nanjing is extremely limited, resulting in the lack of nature, activity areas and nature courses for children. With the onset of the new crown epidemic, the time and scope of children's activities are also limited to the community in a small area, regular teaching courses are also affected. Before September 2020, the land where the project is located is a typical "negative land" type. (Figure 1) The sunken site covers an area of less than 1614 sq ft and is located on the south side of a two-story glass curtain wall building with an area of about 129,167 sq ft. The user is the Children's Education Club in Jianye District, Nanjing. The minimum winter sunshine time at the site is less than three hours. Many children come to our school every weekend. "The teachers of the Children's Education Club said, "We hope to take the children outside sometimes, but there is neither a suitable venue nor a suitable course at present. "A tidy but barren environment does not provide opportunities to help build positive connections between children, nature and social groups. Even already in the Nanjing Greenery Theme Park, a large urban green space, the teachers feel that the surrounding area lacks an ideal place , can provide a convincing basis for action for year-round "activity" outside the building.

In this paper, we conduct a research investigation on Edible Garden, which aims to improve the reuse of urban micro-spaces by constructing a natural environment that supports sensory experience and inspiring learning, aiming to study whether landscape practice driven by educational concepts It can provide an ideal place for children, parents and the community to participate widely and integrate them into the development plan of this special site. China is a large agricultural country, so it is essential to know when to plant crops. So for thousands of years, working people have created the "twenty-four solar terms" according to the climate and weather patterns of the year, as a calendar to guide farming during the year, most of the traditional Chinese festivals are set according to the "twenty-four solar terms". Some of these festivals have both natural and humanistic connotations, and are both natural seasonal points and traditional festivals. Today, Chinese urban residents are still keen on agricultural practices. The "twenty-four solar terms" contain a body of knowledge (such as astronomy, physics, calendar, geography, biology, art, and other disciplines) that goes far beyond basic traditional cultures such as agriculture and food. The close connection between the 24 solar terms and crop cultivation, using edible crops as a medium for cultivation, increases the readability of the site and new possibilities for using abandoned community spaces (Figure 1).

Figure 1. Before site development, design plans and after garden completion. Photo by the Qi,Shaomin and Shi, Yihui.

Considering the lost potential of space reuse in high-density urban buildings and the general perception of traditional Chinese farming culture, the teachers finally reached an agreement with the design team: " Using food education as a medium, this sunken space is designed to be an outdoor classroom. Children who come to the Children's Palace to study and play can carry out various observation, experiment and interactive cooperation environmental education courses here, which provides them with opportunities to participate in natural experiments, artistic perception and group activities." These relatively independent "accidental" "Space has natural advantages to support educational functions—flexibility in physical space and connectedness in social space. We hope to develop and utilize idle community public spaces, build outdoor gardens that allow children to move freely and learn, and introduce systematic, food-related natural courses, so that children can get in touch with nature, understand nature, and learn and grow in nature vision, and then provide an effective way for the development and utilization of idle micro-spaces. The annual garden planting plan of the Children's Education Club selects the required fruit and vegetable materials according to the traditional Chinese 24 solar terms. It formulates the annual natural course plan according to the diet and planting customs corresponding to each solar term. Each course includes farming operations, traditional diet made part. A year and a half later, when the landscape infrastructure driven by the educational concept was completed on this vacant lot, it could support regular and creative outdoor science courses and create many extraordinary places through extensive participatory renewal—formal social cognitive experience.

2 RESEARCH OBJECTIVES

Taking the Edible Garden of Nanjing Children's Palace as a case study, we aim to study the reuse of idle space with potential for redevelopment, thereby ensuring that the updated place occupies a local cultural and social node in the complex external urban structure in which it is located vital position in. To this end, this study addresses the following research questions:

1. Explore the existence of key elements in the design site and the mechanism of action in stimulating the participation of a wide range of social groups.
2. Evaluate the resiliency of the design site and its path to continuous vitality.

3 METHODS

3.1 Study area

The research object of this paper is a sunken small garden, which was initially a vacant lot on the edge of a car park that no one cares about. The floor-to-ceiling windows of a large meeting room in the building frame this long and empty space. The owner of the meeting room is the Children's Education Club in Jianye District, Nanjing. Various small classrooms surround the meeting room. The teachers there wanted to provide a small outdoor garden for the children taking classes in the building, and to have outdoor lessons related to nature education, in addition to science, music and art and craft lessons.

In this study, to prove that the educational landscape can positively affect the activation of micro-spaces in the city and transform them into places with a real sense of self-identity, we collected Edible Garden by sorting photos and tracking records throughout the course. Evidence of the use case, the following is a detailed description of the method.

3.2 Semi-structured interviews and ethnographic observations

Methodologically, our research at this site focuses on the impact of scientific planting programs on-site participant resilience and social attractiveness. We conducted a series of unstructured and semi-structured interviews with participating actors entering the site, as well as ethnographic observations. Interestingly, the twenty-four solar terms originated from the cultural laws and activities that ancient Chinese residents summed up the laws of local nature and crops within a year. Therefore, the researchers conducted a year-long interview and observation near the field based on the time nodes of the 24 solar terms. (5 of them were forced to stop due to the temporary control of the epidemic). Finally, the text was finally generated through interview records, field notes, activity scene descriptions, and activity records (Table 1). Then we conducted a thematic analysis of the text, and finally identified three themes: sustainable construction, extensive community participation, and self-expression of user space. Specifically, different texts were thematically categorized through iterative feedback between twenty-four solar terms concept learning, empirical observation, and broader literature analysis. Finally, we conducted a second automated search to ensure that all relevant content was noticed.

In terms of the research process, it is essential to compare and analyze the snapshots and processes of this kind of life ritual. Because it is impossible to be in the garden at every moment, we took many photos and video recordings of the site at the beginning of the design and the construction stage to ensure that we could intuitively observe the subtle changes in the site (Figure 2). We collected photos with three main themes, including activities, environment, and portraits (a photo can be stored in multiple subject categories), stored them, and sorted these photos according to the time development. After a survey, the content of the photos will be supplemented. The different categories of photos collected according to the timeline reflect some imperfections in the design and the corresponding adjustments in the actual use process. In addition, some users' behavioral logic clues are hidden in the details of the screen, providing the core content for subsequent interviews.

Figure 2. Scenario-based courses around the twenty-four solar terms. Photo by the Qi,Shaomin and Shi, Yihui.

Table 1. Types and quantity of research data. Diagram by the authors.

Theme	Quantity	Unit
Number of visits to the site for research	19	Time
Number of photos taken at the venue	1548	Piece
Number of people involved in the interview	98	Person
Total interview time	20	Hour

4 RESULTS

We conducted a comparative study by sorting the photos according to the timeline, conducted analysis and research based on the interview results to form the research results, and discussed whether the design goals were achieved, and whether the strategy should be adjusted in the future.

4.1 Sustainable creation

According to the photo records and the description of the design team, it can be known that the research and design phase of the project began in September 2020, and the construction was completed from January to April 2021. Educational literacy runs through every link, and such a vibrant environment obviously cannot be built overnight (Figure 3). From the completion of the project to the first phenology course that started in October, the site has not interrupted the process of self-adjustment within half a year.

Thanks to the same team for construction and maintenance, when the first batch of small pumpkin and chayote seeds were sown in the planter box, the galvanized steel shelf that was too wide in the initial design was climbed by hemp rope in time Net filling. From late spring to midsummer, leafy vegetables such as water spinach, coriander, and milk cabbage mature earlier, and the teachers of the Children's Education Club became the earliest high-frequency users. In the original design plan, due to limited funds, the unreplaced anti-corrosion wood floor was overwhelmed, and damage began to appear one after another. In mid-July, the anti-corrosion wood pavement of the light steel keel replaced the original wooden keel structure. Moreover, a month ago in June, the custom-stepped wooden shelves and outdoor tool cabinets in the greenhouse classrooms were also completed one after another. Sunflowers and corn grow quickly to over 5 feet, and the leaves of the elephant ear taro grow superimposed on the vines of the sweet potatoes, covering the bare soil on the surface of the planting box. Considering that the garden is located in the Nanjing Greenery Theme Park, and Chinese people have the habit of walking at night, at the end of August, in the evening of midsummer, the teachers of the Children's Education Club installed a lighting system according to the completed external landscape environment, which made the night have a similar atmosphere, a completely different landscape effect during the day. In addition, plants also provide materials for sustainable construction. During the interview, the garden maintenance staff once said that the crops planted regularly in the Edible Garden and the annual castor plant at the garden entrance are more than 3 meters high, which can provide rich and highly plastic ecological materials for various courses of the Children's Education Club.

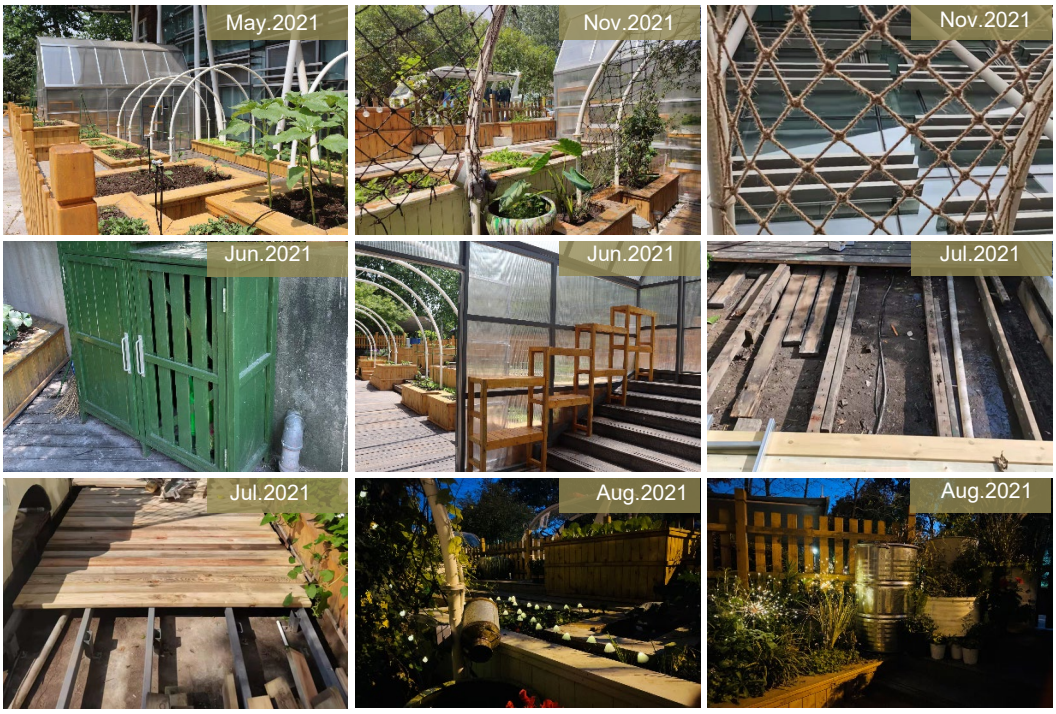

Figure 3. The garden is continuously updated within six months of completion. Photo by the Qi,Shaomin and Shi, Yihui.

4.2 Extensive social participation

Even at the school-scale scale, support for creative play continues to decline. Children need more freedom of movement to create a "creative mess," but in many schools and neighborhoods in today's cities, such behaviors that disrupt "tidiness" are severely restricted. From the beginning of the design, adults' aesthetic preference for a clean and orderly landscape has not been considered as one of the updated values of this micro-spaces. Uncluttered, relaxed, and unconstrained garden forms create more prosperous, more diverse learning spaces. Including modifying the daily maintenance plan combining simple gardening and agricultural maintenance with environmental science course, such as collecting fallen branches and leaves for compost and remaining branches after harvesting, the purpose is to use them as

handmade materials for courses in nature education classes, while saving costs, children's classroom behavior is matched with natural cognition.

The landscape of the Edible Garden not only encourages children to participate, but its design also sincerely invites all adult community residents, including the teachers of the Children's Education Club. The garden is not only a place for teachers to conduct environmental science course, but also a place for them to conduct social activities. According to the Chinese lunar calendar, the second day of the autumnal equinox is the Mid-Autumn Festival, a traditional Chinese festival that symbolizes reunion. On the day of the Mid-Autumn Festival, September 21, 2021, the teachers of the Children's Education Club held the first Mid-Autumn Festival outdoor dinner here. The positive sense of ceremony conveyed their identity to the existing venue, and the old tires, tin buckets and water tanks scattered on the side stated their work plan for the next stage. Before the Frost Festival, the teachers will complete the planting of tires and flowers on the fence, graffiti ecological water tanks and other support uncertainties landscape elements for teaching objectives (Figure 4) . After the dinner, a teacher shared on the social platform: "I am very lucky to work with everyone in Edible Garden, and I can experience the natural after work."

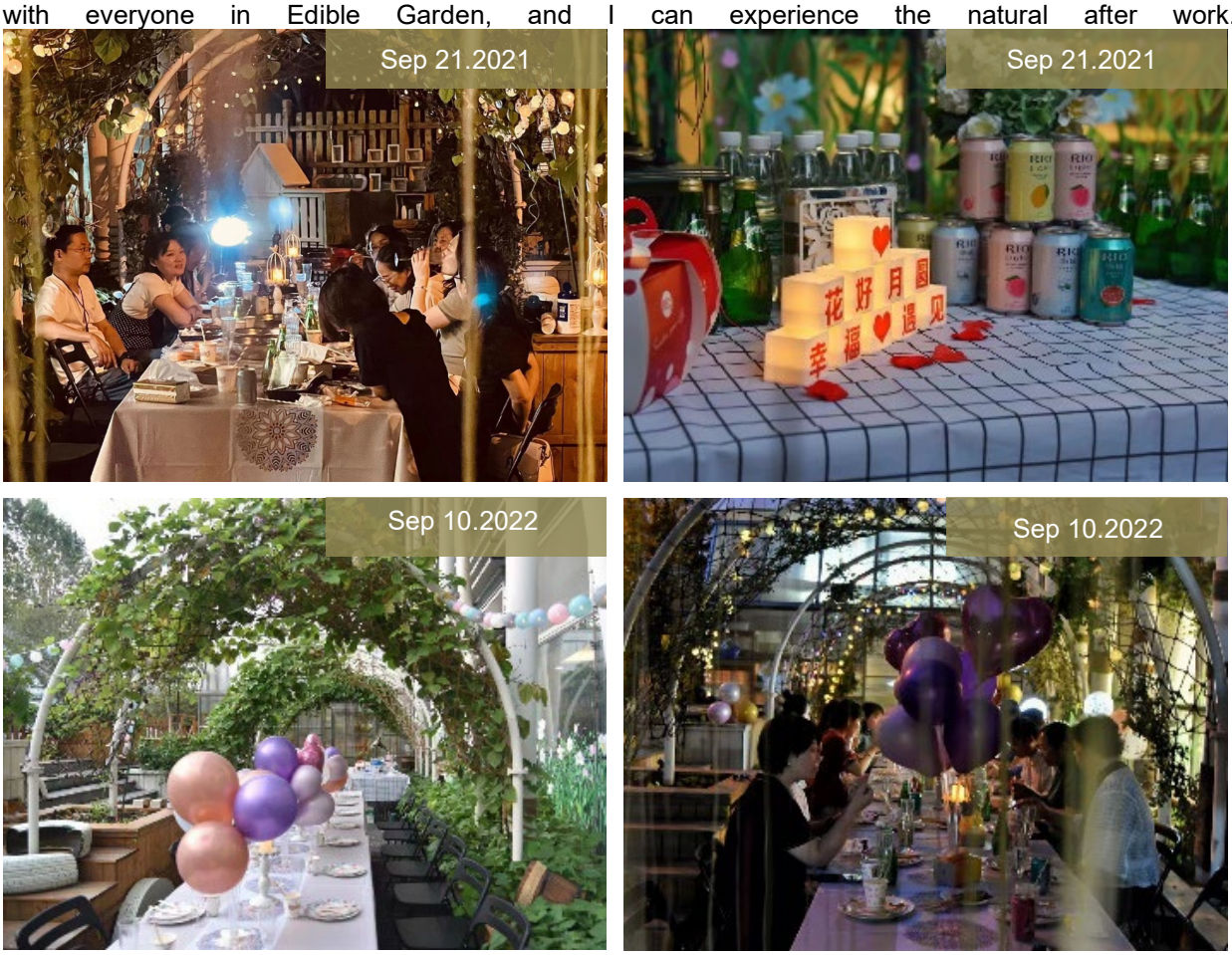

Figure 4. Mid-Autumn Festival in the Garden for two consecutive years. Photo by the Qi,Shaomin and Shi, Yihui.

During the pavement renewal construction stage in July 2021, the crops in the planting tanks at that time were already incredibly lush after a three-month growing season. During the cleaning process, the security guards of the Nanjing Greenery Theme Park went from silently watching outside the railings to stepping in to participate in the harvesting, and the interval was only a few words of conversation. (Picture 5) "When I was young, I lived in a farm and often helped my parents with farm work. Now I can participate in farming activities in the city. This reminds me of my childhood." The security guard expressed the joy of harvesting to us. Since then, the patrol cars of the Security Center of the Nanjing Greenery Theme Park have also parked on the outer edge of the garden from time to time, and the number of passers-by who stop and watch in their leisure time has gradually increased. The interview results show that most of these

stays are irrational and unexpected visitors, and their random travel plans are temporarily changed when they perceive the situation in this public space. Moreover, sudden accidents can even promote the occurrence of different forms of well-intentioned social behaviors. At the end of June 2021, there was a typhoon overnight, and the climbing fruits such as corn and sunflowers in the garden all fell to varying degrees. While cleaning up the site, teachers, maintenance staff and strangers randomly shared a messy but fun public space. Thanks to this process, all random participants get an opportunity for an environment that fosters cooperation, belonging, respect, and responsibility.

Figure 5. Fallen castor and site cleaning. Photo by the Qi,Shaomin and Shi, Yihui.

4.3 The user's self-expression of the space

As the landscape development level of Edible Garden becomes more and more stable, the continuous unfolding of the landscape and space within the site creates an objective complexity, with the details in the landscape elements constantly changing, there are entirely different environmental experiences in different seasons. The complexity of this environmental change combines the participants' individual needs and aesthetic expressions, and the resultant force acts on the site, resulting in a random and open design, which is entirely unpredictable and imaginable by the designers. The ever-changing and ever-derived landscape space provides children with more real environmental revelations (such as living and non-living, biodiversity, life cycle, food chain and carbon cycle). The security guard of the Nanjing Greenery Theme Park mentioned in the interview that the customized toolbox in 2021 was originally green, but it was repainted white half a year after completion. In addition, three sets of planting boxes in the natural color of pine at intervals, and even the gasoline barrels used as compost barrels, were painted white at different times. No matter where the motivation for such changes comes from, the behavior of change itself is the most apparent positive feedback provided by participants to environmental maintenance, and it is also an aesthetic expression to meet their own needs.

5 CONCLUSIONS

Inspired by the "Twenty-Four Solar Terms", the scientific curriculum system proposed by the team guides the continuous construction activities of the site (sowing, composting, harvesting, agricultural festivals, traditional food production), in addition, the daily maintenance and management of users, the growth of plants Provides a steady stream of nature education materials. All of these form an ongoing connection between humans and nature, contributing to the flexibility and dynamism of the site. The open façade along the street is like a stage play, showing the connection between users and nature, closely watched by passers-by, children and parents. Collective emergencies have further promoted the extensive participation of community members.

In addition, its research connotation also has a higher level of inspiration for landscape research. Engaging the design with local parks departments, other open space agency managers, community streets and non-profit organizations creates a sustainable partnership between the community's children, parents, and local ecosystems. Specifically, users' self-expression and professional consulting support are not contradictory in actual operation; on the contrary, they complement each other. The spontaneous design in the garden is not only derived from the direct users of the site, but the space is gradually out of the control of the design and more random events begin to occur. Subtle changes are slowly superimposed to generate the unique physical characteristics of the site. After the garden is completed, although the design team will conduct research and return visits regularly, due to the large number of teams, the follow-up personnel are not fixed, and the instability of personnel has not established a relatively stable communication and cooperation relationship between the two parties. In addition, regular financial support is also missing in this cooperation. Based on the above reasons, various stakeholders did not establish a necessary and clear communication and care mechanism at first. The owner gradually developed a different design concept for the garden from the design team, so they began to repair the garden and plant it by themselves. The result is that the food materials for some courses come from white lies: the property owners buy them in the market in advance and bury them in the soil for the students to harvest. Such problems stem from the owner's lack of guidance and consultation on planting laws. Therefore, we recommend clear, necessary communication mechanisms as an important factor influencing garden resilience. This helps various stakeholders express their own situations more naturally. This is beneficial for all stakeholders to express their situation and ask for help more naturally.

"Edible Garden" is a practical project as well as a research project. The design team has been participating in the project's design, construction and operation for more than two years, exploring a kind of differentiated design mode for urban micro-spaces renewal. The project illustrates how to design better and utilize "educational landscapes" to improve public participation in urban micro-spaces. This study is of great significance when the urban core area is facing a stock development stage of space shortage and resource saturation, and the public's increasing material and spiritual demands on the daily social life of the city.

6 DISCUSSION

Recognizing the pedagogical possibilities of landscape resources, the renewal mission of urban micro-spaces acquires a whole new dimension. If the learning environment accepted by the city is not only the concept of buildings, new alternative spaces will also be added to the public's concept collection of educational scenes.

In the joint construction of the garden, the local characteristics of the micro-spaces are combined with the natural education process. Through empowerment and cultivation, the endogenous force of the site is used to complete the spontaneous renewal of the space environment.

Substantial and complex issues are involved at various stages in the research process. In the preliminary planning and design stage, the participants' power resources, influence, and activity will lead to unequal participation status. How to avoid the planning stage being affected by personal interest struggles? When professional knowledge and local participation conflict, how should they be reconciled? Therefore, we encourage designers to consider the design quality and use function of each space, whether it is to improve the activation effect of the space or to improve the educational performance of the space. In addition, the communication between the design team and the site owner before the design is also a condition for the garden to develop positively. Many design projects in China usually focus on the design and construction stages of the site, ignoring the subsequent use, operation and maintenance, resulting in a decline in the sense of experience, which in turn leads to the secondary idleness of the site. Therefore, after the operation of the space, the designer should keep in touch with the owner, but conflicts and differences in different design concepts may exist. However, we encourage the owner to propose different

design concepts actively. In this case, the design team can choose to continue to communicate, or delegate power to the owner, and withdraw from the operation and maintenance cycle of the garden.

Edible garden is a new type of community renewal project born in the late stage of China's rapid urbanization process. This project provides a new idea for the frequent small-scale community renovation projects in big cities in recent years. By increasing the content of regular activities in the garden, stimulates the regular and substantive connection between the garden and the surrounding people. With the help of this continuously strengthened link achieves a stable frequency of use and maintains the landscape effect of the garden. It provides a brand-new design and long-term maintenance and management strategy for many similar urban community renewal projects that are abandoned 1-2 years after completion.

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