Article

Dealing with Green Gentrification and Vertical Green-Related Urban Well-Being: A Contextual-Based Design Framework

Tzen-Ying Ling [1],* , **Wei-Kai Hung [1], Chun-Tsu Lin [2] and Michael Lu [3]**

[1] Department of Architecture, Tamkang University, New Taipei City 251301, Taiwan; 404360157@gms.tku.edu.tw
[2] Advertising Department of Communication Studies, FuJen Catholic University, New Taipei City 242062, Taiwan; 407070115@mail.fju.edu.tw
[3] The Information School, University of Washington, Seattle, WA 98195-2840, USA; mikelu@uw.edu
* Correspondence: 111221@mail.tku.edu.tw

Abstract: Urbanization and climate change have generated ever-increased pressure to the ecosystem, bringing critical resilience challenges to densely congested cities. The resulted displaced and encroached habitat in need of recuperation demands a comprehensive overhaul to the customary urban planning practices; further, the deteriorating public health state of urban residents calls for strategies in dealing with green deprivation and gentrification issues. Frequently, urban greening strategies are envisaged at a macro-scale on a dedicated horizontal track of land, rendering local implementation in a densely built neighborhood a challenged undertaking. Communities lacking green and land resources could promote vertical greening to enable and enhance social and psychological well-being. This study ascertains that vertical greenery closest to the inhabitants could be allocated on a building facade. It can contribute to a more sustainable ecology. The article presents the systemic design approach to urban vertical greening thinking and its role in well-being provision. We propose an interdisciplinary multicriteria contextual-based scalable framework to assess vertical green infrastructure; the prototype requires an innovative approach to balance architecture, human needs, and the local environment. The vertical greening application provides an alternative paradigm in the design implementation for urban green. We proposed the locality and place to be incorporated into the vertical greening design framework. The research concludes the three-tiered consideration framework resulted: (1) in line with the human-habitat ecosystem, the local environment-social dimension is explored; (2) the well-being criteria encourage the design practice's support for localized driven community vitality; (3) the design paradigm requires integration with the increasing demand for green space as well as taking into account the impact of severe climate; and (4) the framework should achieve the strengthening of health and well-being of the community.

Keywords: contextual-based design framework; vertical green; well-being; green gentrification

1. Introduction

In recent years, we have witnessed how climate change, green deprivation, or green gentrification incessantly affected the displaced urban inhabitants; this is exemplified by the surge in the poor physical and psychological health condition in urban dwellers [1–3]. Furthermore, the pandemic spread in 2020 revealed substantial gaps in public space accessibility, flexibility, design, management, maintenance, and connectivity [1]; the standstill has aggravated urban residents' physical and psychological health even further [4]. As these cities continue to exhaust enormous natural and

man-made resources at unprecedented paces, the growth inertia generated a spatial expanse vertically and horizontally [5]. The United Nations estimated that Asia and the Pacific became a majority of urban areas for the first time in history in 2019; with more than 50% of the region's population living in cities, the growth propelled acceleration on the consumption of the ecosystems [4]. Indeed, the progress in human development can no longer be sustained without addressing the environmental degradation, climate change, health crisis, and the overcrowded living habitat. While withstanding the impact of COVID-19, urban areas need to focus on how urbanization shapes impacts, responses and longer-term recovery [1]. If successive sprawl and urbanization persist, intensifying the urban environmental pressure, the continuous dilapidation of the living conditions requires an introduction of an alternative model of urban development. This transitional move must regenerate and reduce waste to result in cost savings as well as environmental benefits [1,6–9].

Empirical evidence affirms that urban planning and development practices must tenaciously amend the current densely populated landscapes bereft of formal greenspace [1,10–13]. Effort to alleviate the development impacts has been endeavored as early as during the rapid urbanization of the late 19th century [14]; the public park movement implemented formal planning measures at the macro-scale to allocate green areas like Central Park in New York City and other smaller urban parks. These "green capitals" have been touted as health incentive measures as well as a city's image-building tool; they attracted more companies and residents to gravitate toward the crowding urban core. The allocation of greenspaces is often set on a horizontal land parcel in a natural setting or restoring parks, gardens, greenways; or even open spaces apportioned for playgrounds or other mixed-use areas in specific locations, seldomly distributed uniformly across [15–20].

Due to distinctive development paths and approaches, densely built cities across the continents have adapted to their unique socioeconomic, historic, and demographic parameters [7,15]. Accessibility to green, however, is still a relentless, hard-to-reach goal. On one hand, an initiative may trigger probable property value fluctuation, fragmenting local neighborhood fabric and dislocating existing community citizens with the influx of wealthier residents [21–24]; on the other hand, shortage of green area deprives residents of proper access opportunity. The result is a so-called green gentrification or even deprivation [24,25]. The disproportionate shortage of, and the approachability issue related to, urban green has been recognized as a pivotal core in green gentrification [13,24,26,27]. Dealing with green gentrification or green deprivation, cities beckon for alternative solution.

Efforts to increase the exposure and interaction to promote re-greening congested cities could integrate vertical informal green spaces (VIGS) [9,22,24]. Sociospatially gentrified communities or neighborhoods lacking available land can build up greening opportunity with the vertical system [7,28–34]. It can be designed vertically on a building facade, functioning as an "anti-gentrification" urban greening strategy [29,35–37]. Benefits from green's interactions are manifested along multiple pathways [38,39]; a short five minutes of contact can improve one's health condition, stimulates increases in physical activity, encourages positive behaviors, and triggers a sense of well-being [15,40–46]. Other commonly benefits cited include improved stormwater management [47], improved water and air quality [48,49] (Sun et al. 2020; Davis et al. 2015), mitigation of the urban heat island [50,51], boost of physical and mental health [29,36,52–55], habitat improvements [56], and increased property values [57].

Current literature elucidates a definite knowledge gap, as the focus solely illustrates Western cities' perspective and is lacking a broader global consideration [40]. Though cities such as Adelaide, Melbourne, and Sydney, and Osaka and Tokyo, ranked top in livability ranking [7], other high-density and congested Asian cities should evaluate the impact of social equity and green capital enhancements at the forefront of the design consideration [6,7,27]; the stature of architecture needs to incorporate innovative ideas and experimentation that explore purposeful design through the incorporation and redefinition of traditional paradigm into sustainable urbanism [29]. This paper undertakes the local practice consideration of vertical greening on facade walls to enrich the urban habitat and promote the development of sustainable health and well-being. The composite assessment addresses the meso-micro scale, ranging from neighborhood to urban block distribution, allowing sensitive socioenvironmental

attributes to be cautiously weighed. It attempts enlisting design strategies as a restoration alternative to support environmental justice [15,24,28,58]. Studies focusing on such issues are limited in the Taiwanese region, given their absence in the existing literature. The Driver–Activity–Pressure–State changes–Impact–Response (DAPSIR) framework is used to align with the social and environmental agenda, while promoting mental health and well-being [29,59–61]. This paper proposed: (1) to present the multifold criteria for vertical greening elements sustaining toward well-being; (2) to identify the key design practices viable for vertical green; (3) to introduce the scalable factors toward urban vertical greenery and its causal impact to a well-being state as an active contributor for urban sustainability. Finally, the discussion and conclusion stand on the possible partaking of well-being as a contributor of urban resilience and a critical variable in the design process.

2. Material and Methods

2.1. Study Site: Location Consideration

Most Asian cities frequently exhibit informal and loosely formed morphology with a dynamic mix of land use and activities; this is a result of rapid dynamic organic growth prior to formal planning intervention [5,47,61–63]. Western cities have had a head start in urbanization, accommodating a series of challenges like pandemic events and overwhelming population convergence from the onset of industrialization [1]. The formal planning approach implemented since the late 19th century included the provision of green spaces to balance economic opportunities with the natural benefits of a rural setting. The framework implemented during physical planning and urban design has often been rooted in a complex social vision benefitting the urban dwellers [14]. This is reflected in the Western cities' morphologically finite form and regimented zoning ordinances [51].

Green spaces serve as a health-promoting setting for all members of the urban community. For urban areas lacking proper green spaces, it is important to allocate public open spaces and other common services provided by a city; they are key in reducing stress levels, improving mental health and well-being, contributing to well-being's development [1]. Asian cities are often plagued by high density in population and building masses, low green areas, as well as exhibiting a dynamic overlay of historic and modern neighborhoods [7,27,40,51,62,63]. In dealing with the blooming of the urban population, governmental efforts to combat deteriorating health conditions could consider vertical greening as an alternative measure for boosting physical or mental well-being [1,7,29,36,62–67]. Cities' leaders must consider the availability of urban land or alternative ways for greening [7,29,51].

For the study site selection, Taiwanese cities with high population density and below the minimum green coverage ratio should be considered [15,29]. The intervention logic lies in where causal links between actions and impacts should be tracked in pathways for a cohesive evaluation [29]. The driver or objectives of vertical green space planning, the probable public health and social benefits, the urban/local planning context, and the diversity of urban green space types must respond to diverse demands. Attention should be placed on the effect on extreme climate, coupled with high density and low green coverage, causing further aggravation to the urban heat island effect. Taking metropolitan Taipei as an example, it encountered 134 and 93 days above 31.5 °C and 33.4 °C, respectively, in 2017 [61], and the trend continues (Figure 1). If vertical greening strategies could be implemented, the air-conditioning loading per ton could be decreased; the electricity bill for 24 h a day is about NT $60. If the interior temperature could be naturally decreased, allowing the temperature sets to increase by 1 °C, the electricity bill will be reduced by about 6%, producing considerable savings [67,68].
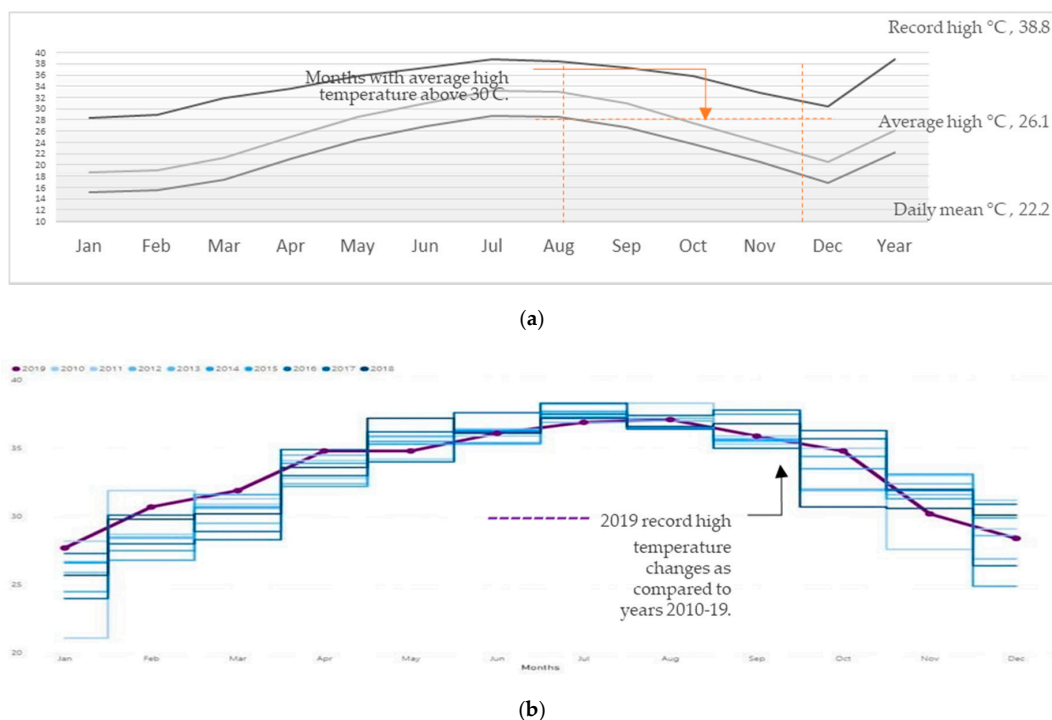
(**a**)

(**b**)

Figure 1. (**a**) Record high, average high, and daily mean temperature °C in northern Taiwan 1981–2010 (New Taipei City); (**b**) Record high temperature °C changes 2011–2019. Source: Central weather bureau https://opendata.cwb.gov.tw/fileapi/v1/opendataapi/C/ accessed on 20 March 2020.

2.2. Causal Consideration: The Human-Habitat Ecology State in Vertical Greening and Well-Being

Strategic integration of social and ecological benefits into vertical green infrastructure planning at the community scale have substantially been limited; deliverance of more practically oriented tools and concepts could provide the needed guideline for implementation [68–70]. The intervention logic, or "logic model", clearly defines what are the actions aimed at and how change will occur [51]; similar to evaluation tools like the Millennium Ecosystem Assessment or the C40 theory-based approach pathway [51,71]. They provide the public-sector ways to evaluate, integrate, and gauge green's effect on the well-being state, by focusing on a regional landscape level. Accommodating the demographic, economical, sociopolitical, and other drivers can benefit cities from the improved economic and social development policies and strategies [30,72]. However, the emphasis at the regional scale frequently dismisses most intricate neighborhood sociospatial features.

The intensified interaction of vertical green possibilities welcomes relationship build-up, and other positive behavioral changes contributing to the well-being effect [29,36,73–75]; the "Space" attribute is the critical bridging unit parameter since a vertical green system takes advantage of facade walls as a planning condition [29,76–81]. Aiming at the community's dynamic interchange and spatial traits, the systemic framework proposed aligns with the Driver–Activity–Pressure–State changes–Impact–Response (DAPSIR) framework (Figure 2), as a way to depict the causal cycle between human and society and the environment domain applied within the environmental impact research [29,82–84]. With a focus on the neighborhood level, the DAPSIR framework allows a thorough analysis at the meso-micro scale, ranging from neighborhood, urban block to singular building distribution; it allows sensitive socioenvironmental attributes to be cautiously weighed. It combines obtainable quantitative, semi-quantitative and qualitative information, and provides essential progressive analyses and information about diversity in activities, seizing the urban intervention pressures. The human-environment criteria generate the causal drivers versus pressure-based investigation; the response influences on the state of change in the environment assume

that drivers must engage in interventions to neutralize local pressures. We proposed the causal DAPSIR diagram below.
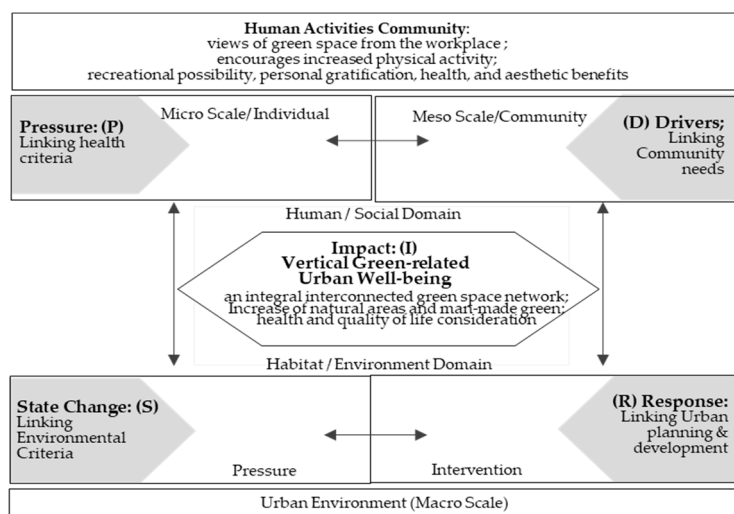

Figure 2. Vertical green-related urban well-being causal DAPSIR diagram. Source: compiled by this study.

The central inertia derives from the impacts (I) of vertical green-related well-being, attributed by the ecological, environmental, and social benefits of green systems on a roof or wall [28,29,31,58,68,85–87]. To contribute to the health and quality of life for communities, and people (impact), the greening strategy must come into being as an integral key green space network toward a healthy, livable habitat [29,36,65,66,88,89]. The meso-environment dimension (driver) acknowledges the extreme climate, frequent record-breaking temperatures worldwide [67,90], and the aggravated urban heat island effect. The aim is to allocate pressures within the human-habitat system. Vertical green space on building facades lowers exposure to air pollution and other environmental toxins [91]. The shading and cooling effects to ease the urban heat island effect (pressure) is incorporated, while reducing the energy required for cooling [65,78,92]. The thermal performance of exterior vertical green systems (VGSs) results in evaporation-transpiration and modification of the wind pattern. Further, greening plants can exert a sound-absorbing effect, sometimes even providing acoustic benefits by dampening noise pollution.

The application (response) can deliver benefits like enjoying the green amenities (state change) and creating a desirable attraction for residents. Environmentally, it is achieved by maximizing the green resources' ratio; vertical green seems suitable for a city under development pressure, while mitigating the urban heat island effect and temperature reductions [50]. Green canopy and plants can absorb or reflect 80% to 90% of the sun's long-wave radiation heat [91]. Interactions with urban green space leads to equity concerns determining the fairness of such interactions [93]. It enhances satisfaction with sighting or interaction with green (activities) [36,76,94,95]. Likewise, frequent visits contribute to physical and mental health through the promotion of physical pursuits [96].

2.3. The Health and Environmental Determinants and Criteria

To propose a context-based design framework based on the causal DAPSIR diagram detailed in Figure 3, the etiology examines the adaptive thinking criteria; allowing flexibility for the vertical green features to be incorporated onto a building's exterior or interior. The tri-tier framework allows for step-by-step consideration on the site context, pressure, impact, responses, and design attributes for the multifaceted functions generating the desired activities. Linkage measurement of the human and environmental dimensions is established.
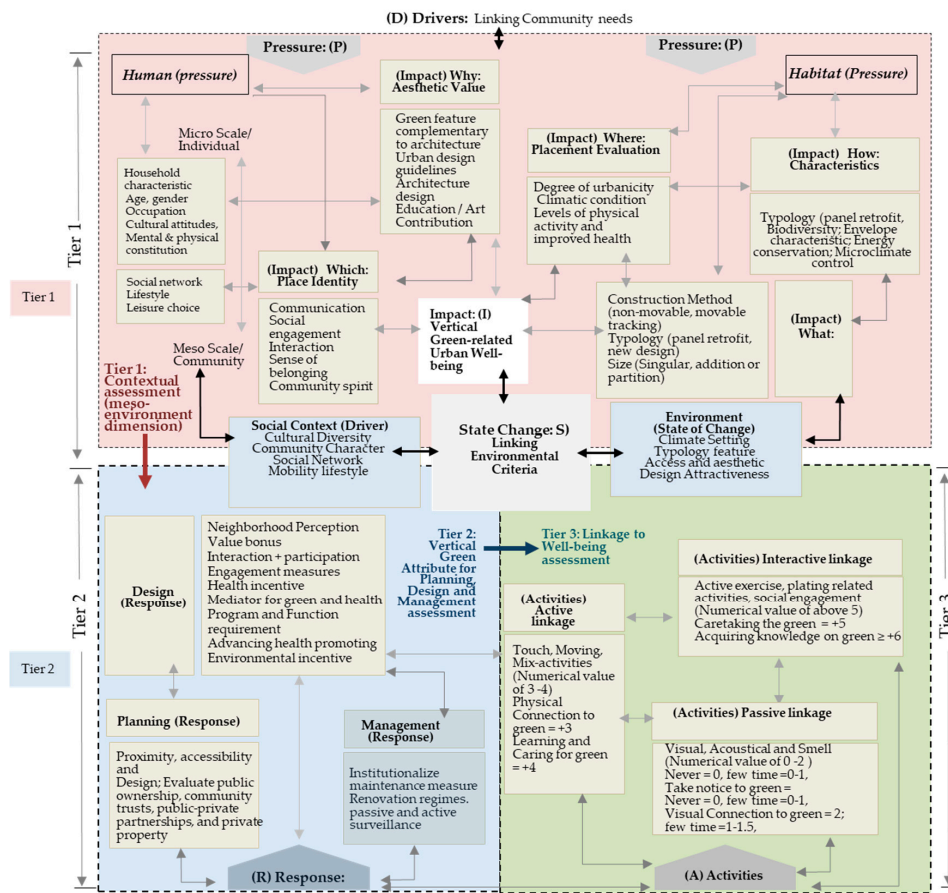
Figure 3. The determinants and criteria framework for vertical green-related urban well-being causal consideration. Source: compiled and drawn by this study.

The contextual tier (first tier) considers the habitat-human dimension (pressure), tackling the environment (state of change) and social context (driver) to access the linkage within the multitier evaluation of the vertical green. The human-habitat dimensional pressure (P) brings about beneficial impact (I) of the "What", "How", "Where", "Which", and "Why" factors.

Within the habitat dimension:

- The "What" category surveys options in vertical greening, as a manmade three-dimensional vertical surface covered in vegetation [92,94,95,97]; exterior living walls can be used as passive energy-savings systems. The material durability, recycling method, irrigation, and plant's life expectancy affect the total system efficiency and future management method [29,78].
- The "How" category emphasizes the implementation and economic effect it may have on the community [89].
- The "Where" category evaluates the placement location and position; placement in the south-facing green wall, for example, yields about 1.5–2 times higher cooling energy savings than in the west-facing wall [98,99], marking it as the ideal placement orientation.

Within the human dimension:

- The "Why" category assesses the appealing effect, degree of perceived restoration, and how the well-being state could be strengthened. Functions provided by the prototype in the viability, spatial, economic, and social dimensions contribute toward the greening design strategy [100].
- The "Which" category emphasizes the cultural or social relevance that the vertical greening may contribute to the community. The construction method considers the production and flexibility for installation onto building facades of diverse height and scale.

The process and criteria incorporate vertical greening into the urban architecture context to consider the practicality and implementation strategies (Figure 3 below).

The second tier considers the planning, design, and management attributes (response); the approach allows the state to shift from a "mechanistic" to an "ecological" or living system. As an effective response from design, the successful combination must demonstrate the design potential. In the third tier, linkage to well-being assessment, the degree of linkage that activities related to vertical green connects the users (activities), is evaluated. Whichever form the architectural solution may take, the connectivity, like passive linkage, evaluates how to be curious or try new things and could stimulate active linkage. Stronger interaction and sharing experiences stimulate interactive linkage; this allows for more substantial opportunity toward well-being, promoting a socially more agreeable mood and physical health, life satisfaction, and lessens a sense of loneliness and low support. Further, urban green space appears to lower possible rates in incivilities, even lower levels of crime [101]. The increasing physical activity, social interaction, and the provision of vertical green must meet the contextual constraints while satisfying the recreational needs [36,65,66]. Decisively, other consideration options include benefits from the energy aspects, acoustic protection material and support of biodiversity [29,95]. Finally, the multiple constituents of humans' well-being could be accrued through desired activities-driven responses, satisfying the fundamental aspiration for a better life, freedom and choice, health, active social relations, and security [36,65,102].

2.4. Activities (A) Involving Vertical Greening Related to Well-Being in the DAPSIR Framework

Residents increase social integration and interaction and gain social capital by arriving at a mutual understanding of green-related activities [103,104], even if there are other conflicts of interest among them [43,94,105]. The process of well-being as an activity *(A)* engagement toward greening results in positive behavior and a sense of well-being. The behaviors and activities involving vertical greening are shown below [71,106]; a 0–6 scoring system (passive-to-interactive engagement) provides a sensitive scales assessment of the design consideration related to the engagement of well-being state (Figure 4).

The focus attains an innate connection to avail for a sense of well-being. Emotional (perceive life satisfaction), psychological (self-acceptance, inspired personal growth), and social (sense of place, sense of community) well-being are all important indicators. Users are encouraged to engage in behavioral enticement such as curiosity and inquisition, sharing, and interacting with others, in keeping with a closer linkage with nature. To summarize, having daily contact with nature can promote a sense of happiness as well as being conducive for productive and meaningful lives.
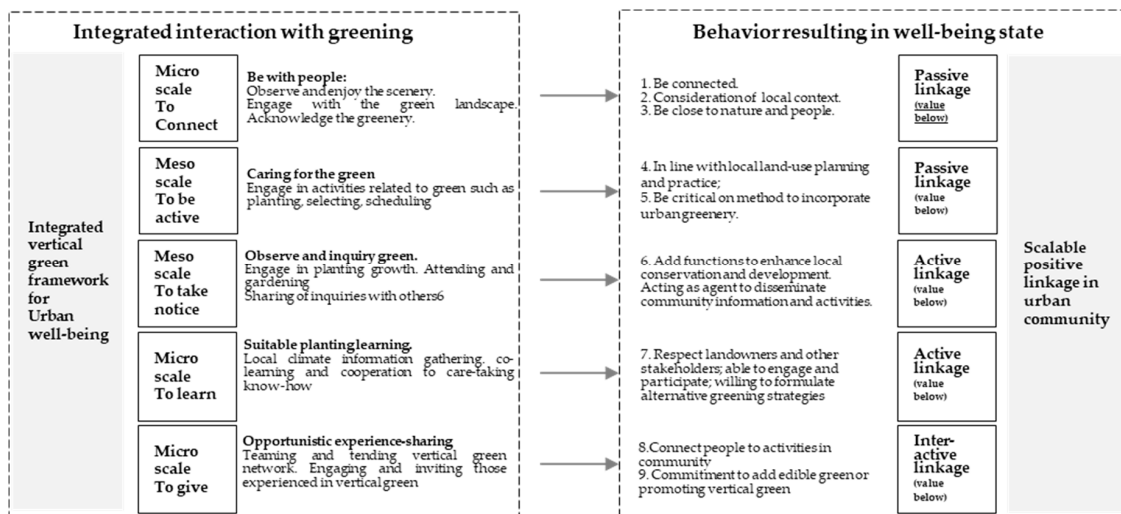

Figure 4. Activities (A) involving vertical greening related to well-being in the DAPSIR framework.

Source: adapted from [70] and the DAPSIR framework, (A) activities consideration is proposed and compiled for this study. Passive linkage: (Numerical value of 0–2); Never = 0, 1–2 times per week = 0–1; Take notice to green = Never = 0, 1–2 times per week = 0–1, Visual Connection to green = 2; 1–2 times per week = 1–1.5; Active linkage (Numerical value of 3–4); Physical Connection to green = +3; Learning and Caring for green = +4; Interactive linkage (Numerical value of above 5); Caretaking the green = +5; Acquiring knowledge on green = +6 and above.

2.5. DAPSIR Comprehensive Assessment Framework

For vertical greening to be added to a building exterior, one must accommodate the localized feature; the prototype planning should allow certain modularity in the unit design to be applied in scale to the building's envelope. The human-social and -habitat perspective is crucial for lifestyle benefits. The function response (R), activities (A), and state of change (S) are enumerated. The DAPSIR comprehensive assessment framework is shown in Table 1 below.

Table 1. DAPSIR assessment resulting in Function and Well-being Consideration.

(*Driver*)		Function (*Response*)	Well-being Consideration (*Activities*)
Habitat (*Pressure*)	What: *(Impact)* Construction method Environment Relevance Viability	Diversity	1. Take notice, Passive linkage; 2. Sense of satisfaction: Visual
		Building envelope incentive	1. connect; 2. be active; 3. take notice; 5. give Passive, active and interactive linkage
	How: *(Impact)* Characteristics Economic Relevance	Energy Conservation And Comfort	1. connect, 4. keep learning and Passive and active linkage
		Microclimate Control Urban heat island	1. connect, 4. keep learning and 5. give Passive, active and interactive linkage
	Where: *(Impact)* Placement Evaluation Spatial Relevance Composition & Configuration	Method of Vertical Greening	1. connect, 4. keep learning and Passive and active linkage
		Plant Species	2. be active, Active linkage
		Typology	1. connect, Passive linkage
		Area Size	1. connect, Passive linkage
Human (*Pressure*)	Which: *(Impact)* Place Identity Social Relevance Social Inclusion Quality of Life	Community Socialization	1. connect, 2. be active, 4. keep learning and 5. give
		Human Health Connection to nature (accessibility)	1. connect, 2. be active, 4. keep learning and 5. give
	Why: *(Impact)* Aesthetic Value Cultural Relevance Cultural Heritage Satisfaction Quality of Life	Locality based history	1. connect, 2. be active, 4. keep learning and 5. give
		Repeat visit and Education/Art contribution	1. connect; 2. be active; 4. keep learning; 5. give
		Visual enhancement	Passive linkage
		Place Identity	2. be active, 4. keep learning

3. Result

The empirical research aimed to take a Taiwanese city to conduct the DAPSIR contextual analysis and prototype design. This section is divided into four parts: 1. Selection of analysis site; 2. Contextual assessment; 3. Prototype Assessment; and 4. Well-being linkage. Each step allows broad consideration to the effect it has on the increase of the state of well-being.

3.1. NTC Building as the Analysis Site

For this study, we focused on the Banqiao District in New Taipei City, located within the Taipei Metropolitan area. Banqiao's diversified urban neighborhood composition is particularly suitable for studying measures dealing with green gentrification and vertical greening for several reasons; it satisfied the required high-density and low green area ratio condition; it is a mix of the urban–rural prototype for Taiwan, i.e., a typical urban developed area built in flood prone areas, an agricultural land transmuted for urban use [40,62,63]. Banqiao, as the central business district of New Taipei City and the location of the administrative center, is located in the western part of the Taipei Basin; surrounded by Taipei to the east, Sanchong to the north, Xinzhuang to the northwest, Shulin to the southwest, Tucheng to the south, and Zhonghe to the southeast. Banqiao is also bordered by two rivers, Xindian River to the northeast and Dahan River to the northwest (Figure 5).
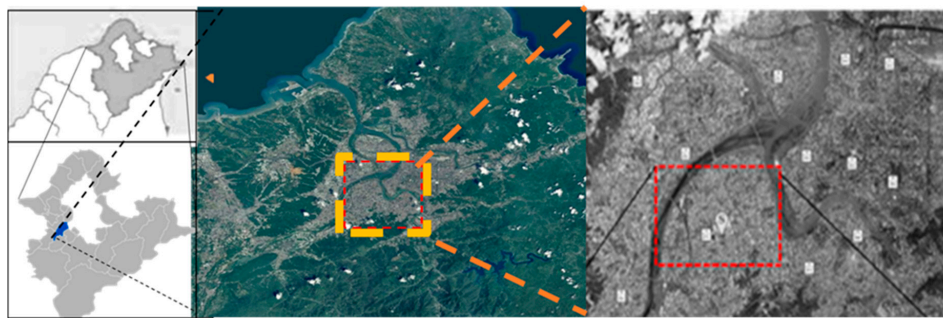

Figure 5. Location of Banqiao District, New Taipei City Source: [62] statistics and map compiled by this study. Source: compiled by this study.

It is one of the most populated zones within the urban planning area in Taiwan; these areas accommodate about 80% of Taiwan's total population to date [62]. Pockets of newly built dense multistory mixed-use buildings house residential and commercial activities; they are surrounded by early settlement communities characterized by the lower-story mixed-use communities dotted with temples and informal outdoor markets or eateries. Nowadays, the Banqiao District has the third-highest population density in Taiwan and the highest density in all of New Taipei City's districts, with a population of 550,000 persons and a population density over 24,000 people per km^2; green open space is a rare commodity.

The urban plan exhibits an inequality issue in the distribution of urban green space. Though the Great Taipei City Plan implemented during the Japanese occupation proposed a system of the green space, amidst the city for a service radius of 500 m with a width of 50, 70, and 100 m to meet the recreational demand [63], it was suspended during WWII. At the time, the open space ratio accounted for 10% of the urban area, which is roughly 8 m^2 per person. The rapid development in the Taipei Metropolitan Area has attracted the largest population and greatest number of industries, and these developments have taken place rapidly. Especially for New Taipei City, the rapid urbanization thereafter depleted available land for construction, reducing most accessible urban green spaces (Figure 6).
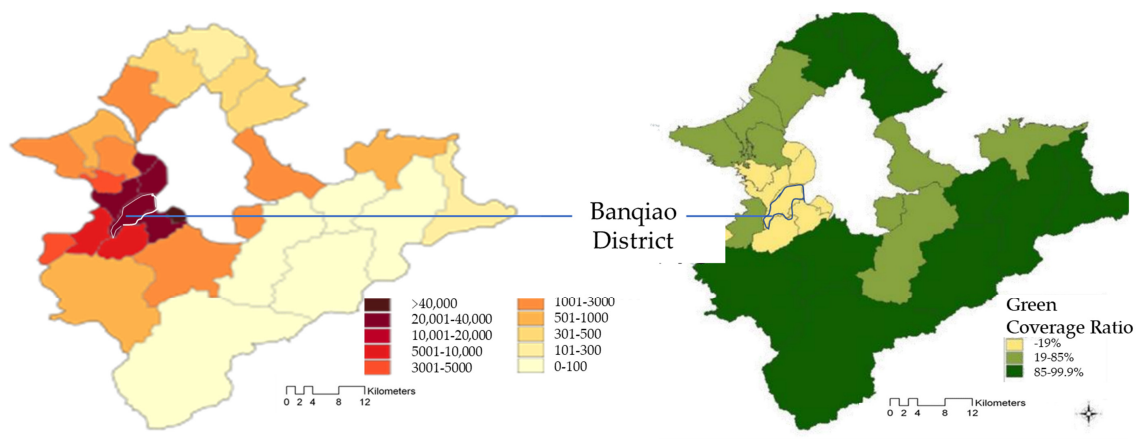
Figure 6. Banqiao District as New (**a**) Taipei City Population Density and (**b**) Green Coverage Ratio Plan. Source: compiled from the [62] statistic by this study.

From 1995 to 2007, green space area was reduced by 2339.5 hectares (occupies 1.19%), and 93.19% of the green space still retains its original use [62]. The dynamics of land density and demographic change are fully articulated in this region. The green cover rate is 7.96% and the per capita green space ratio is 3.15 m^2. It is still much lower than the standard of 8 m^2 per person set by WHO for urban areas. Moreover, Banqiao's green coverage ratio is 1.15 m^2 per person, much less than the overall ration for New Taipei City and still not to par with WHO's standard; hence, the area is in need of adding additional green resources. To alleviate the overcrowded neighborhood, the New Taipei City (NTC) government commenced the initiative and kicked-off a demonstrated greening concept as a supplemental effort to reduce the building thermal loading, through green roofs and walls, as well as attaining the well-being effect desired within the government building in 2019. The increase of urban greening cuts back the amount of heat absorption, effectively reducing the wall thermal loading, providing the comfort of the indoor environment; hence, the selection of the site location for the study.

3.2. Contextual Assessment

To demonstrate an alternative greening strategy or informal green space (IGS), the initiative supports the placement of urban vertical greens. The New Taipei City Municipal Government Building (NTC Building), located in the Banqiao District (Figure 1), measures a height of 140.5 m, with a total of 33 floors above ground, and 4 floors below grade. As an industry–academia collaboration with the New Taipei City Government, the research team conducted the DAPSIR framework assessment followed by the design prototype evaluation during 2019–2020; the NTC government-initiated effort to mitigate extreme weather shocks. The greening policy seizes the benefits of thermal cooling as a surface temperature of the green roof or wall can be about 19 °C lower than the average roof without covering, indicating a significant reduction in the urban heat island effect [67]. The evaluation focused on possible locations for the vertical green prototype on the exterior envelope of the New Taipei City Government building (NTC Building, Figure 7).

Upon completion of the DAPSIR analysis, the prototype design was simulated with 3D modelling and a full-scale prototype unit has been tested. The installment of one unit is planned as a demo site to investigate the effect and showcase the results for pedagogical purposes. To initiate the process, the "What" and "Where" factors assessed the size and placement possibility. The "How" and "Why" factors determined the "Which" effect in maximizing the well-being factor. In this context, the design thinking defines the vertical green as a movable and detachable unit applicable in diverse building exterior settings. The design thinking takes on the contextual assessment on the human-habitat dimension. The driver, pressure, state, and contextual attributes were carefully reviewed, emphasizing taking the well-being factor into consideration (Figure 8).
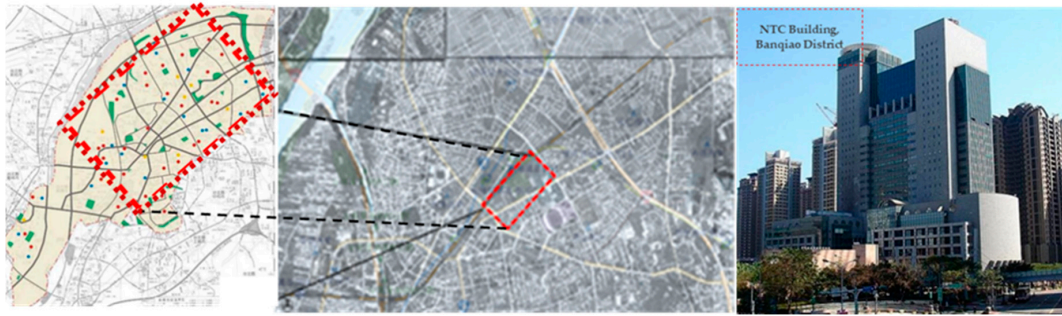
Figure 7. Location of NTC Building location. Source: [62] statistics and map compiled by this study. Source: photo by China News Agency and compiled by this study.
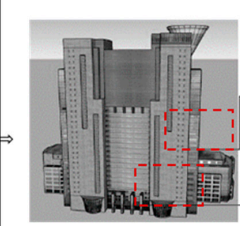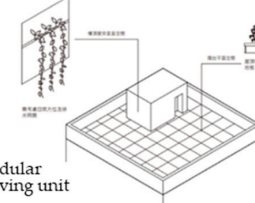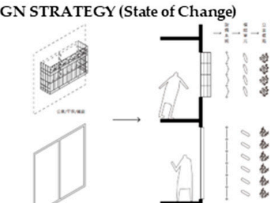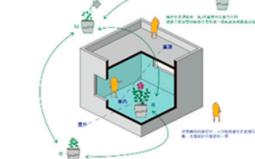

Figure 8. NTC Building Contextual evaluation. Source: drawn by AJL CReS Lab research studio and compiled by this study.

3.3. Vertical Green-Related Urban Well-Being Linkage

Our exploration of the design prototype offers a probable solution for the integration of vertical greening processes as an urban planning consideration. The undertaking encourages future green provision in urban systems to accommodate the sociodemographic differences for the place-based public health equity. Adequately placed vertical urban green encourages enhancement of their state of well-being. A predesign checklist allows the team to evaluate the criteria and solicit relevant opinions from the users. The process investigates and confirms the causal cycle from intervention to driver through to finally achieving well-being benefits and formulated a design solution to alleviate drivers within the human-habitat for the desired impact and response. A checklist was designed for easy assessment during the evaluation to design process. The cyclical process conducts the intervention to drivers as the steppingstone (Figure 9).
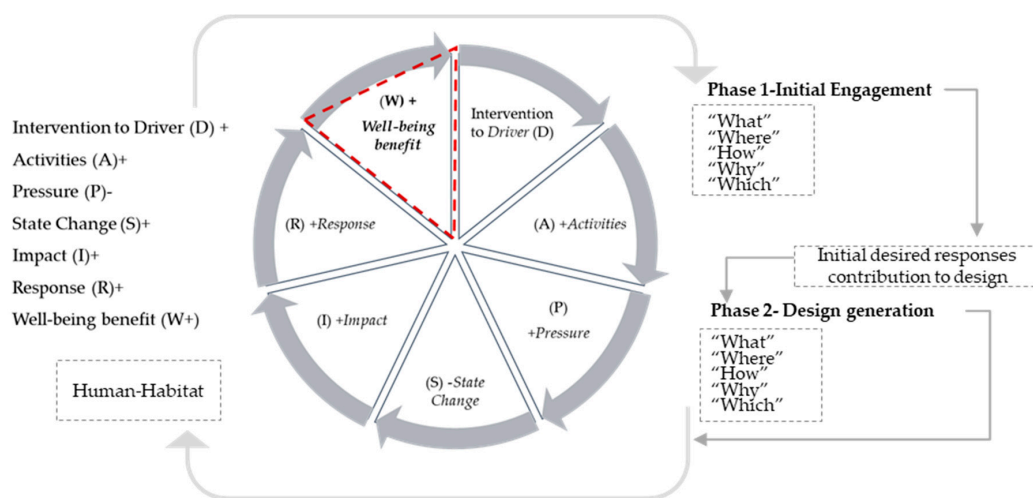
Figure 9. DAPSIR assessment framework process diagram. (+) denotes strengthening or reinforcing certain features; (−) denotes decreasing or lessening a certain state or scenario.

As the design assessment evaluated the linkage to well-being, we engaged in a causal appraisal for the probable reaction in behavior from each singular design. The intent is to look for a design that can entice fruitful behavior's linkage to well-being. To better understand behavior and related emotional state, the collection of first-hand data through participant observations during the workshop and semi-structured interviews conducted was analyzed. A group of 20 local participants, ranging from city workers to visitors, were included in the semi-structured interview, supplemented by the observations during the workshop. The checklist was used to gather initial responses from the respondents during the interview. The authors recorded the results on the checklist (Table 2). In each of the DAPSIR stages, the "what", "where", "how', "why", and "which" issues were explored. The intervention to driver was presented, followed by exploring possible activities generated from interventions. The pressure (P) affects the state of change (S) while making a significant impact (I) on the human-habitat. The assumed response (R) in the first workshop was used to generated design proposals. Most importantly, according to the evaluation results, three design renderings were shown to the study group during the second workshop. The appraisal study was conducted from October 2019 to March 2020. The initial workshop was conducted in November 2019, and the second workshop was conducted in March 2020 when the three renderings were presented (Figure 10).

Table 2. Prototype's vertical green-related urban well-being linkage checklist.

Integrated Vertical Green Framework Checklist for Well-being (DAPSIR Method)							
Intervention	*Driver (D)+*	*Activities (A)+*	*Pressure (P)−*	*State Change (S)+*	*Impact (I)+*	*Response (R)+*	*Well-Being Benefit*
What: Vertical Green Environment Relevance (Habitat)	**Design answers to:** alleviate climate condition.✓ urban heat island effect✓	**Design promotes:** green and encourages increased physical activity✓;	**Design lessen the impact of:** Displacement from nature✓.	Proximity rate increase ✓ Enhance the energy aspects✓ acoustic protection material, biodiversity✓; lessen exposure to air pollution and other environmental toxins✓;	an integral interconnected green space network✓; Increase of natural areas and man-made green✓ non-movable Singular partition✓	Application and installation of vertical green in high density zone✓	To take notice✓ **Passive linkage Numerical value = + 1**
Where: Placement Evaluation Spatial Relevance (Habitat)	**Design answers to:** meso-environment degradation✓	**Design promotes:** Increase in interaction with greens✓	**Design lessen the impact of:** lack of green✓ High density✓	Creating community desirability✓	Degree of urbanicity✓ Climatic condition✓ Levels of physical activity and improved health✓	interactions with nature✓Institutionalize maintenance measure ✓ Renovation passive surveillance; ✓Proximity, accessibility✓ public ownership✓	To be active✓ **Interactive linkage Acquiring knowledge on green Numerical value = +6**
How: Characteristics Economic Relevance (Habitat)	**Design answers to:** Property value increase✓	**Design promotes:** Health incentive activities✓,	**Design lessen the impact of:** Household friendliness✓ Personal characteristic✓ Age, gender Occupation✓	Real estate value and neighborhood improvement✓	non-movable✓ Typology (panel retrofit) ✓ Size (Singular) Biodiversity✓ Envelope characteristic✓ Microclimate control✓	Health incentive (decrease of obesogenic environment) Mediator for green and health Program and Function requirement	To give✓ **Active linkage Learning and Caring for green Numerical value = +4**
Why: Aesthetic Value Cultural Relevance (Human)	**Design answers to:** Green feature✓complement to architecture✓	**Design promotes:** health, and aesthetic benefits✓	**Design lessen the impact of:** community activity✓cultural attitudes✓ Mental & physical constitution✓	Architecture design Education / Art Contribution	Urban design guidelines; Green feature complementary to architecture Urban design guidelines Architecture design Education /Art Contribution	Neighborhood Perception✓ Social interaction + participation✓Advancing health✓promoting Environments, ✓	To learn✓ **Interactive Linkage Caretaking the green Numerical value = +5;**
Which: Place Identity Social Relevance (Human)	**Design answers to:** Identity✓ Communication Social engagement✓ Interaction✓ Sense of belonging Community spirit ✓	**Design promotes:** recreational possibility✓personal gratification✓	**Design lessen the impact of:** Distraction from satisfactory lifestyle✓Distraction from freedom and choice✓ Distraction from health, good social relations✓	better mood✓lower rates in incivilities✓ Positive measures of mental well-being✓	health and quality of life consideration; ✓Communication Social engagement Interaction✓ Sense of belonging Community spirit✓	Part-take in the process✓ promote system benefit ✓ promotion of activities✓ social support✓reducing stress✓.	To Connect✓ **Interactive linkage Acquiring knowledge on green Numerical value = +6**

(+) denotes strengthening or reinforcing certain features; (−) denotes decreasing or lessening a certain state or scenario.
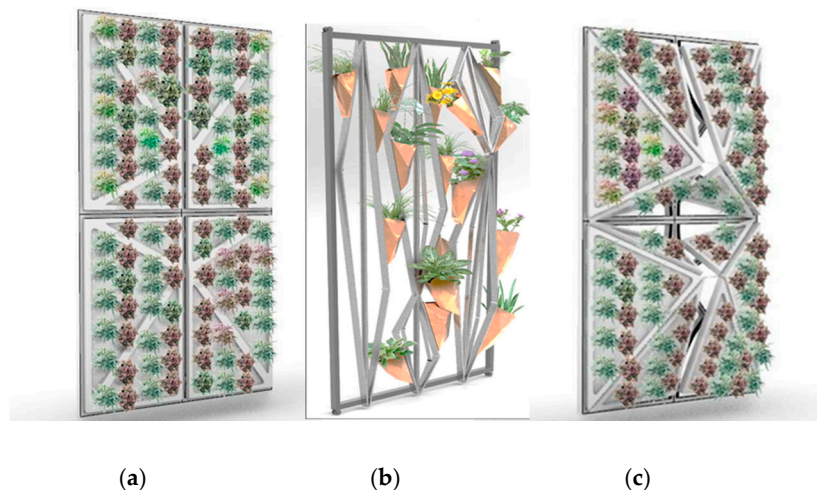
(**a**) (**b**) (**c**)

Figure 10. Proposed vertical greening unit renderings for 3 design proposals: (**a**) denotes a fixed panel; (**b**) denotes a free-form panel; and (**c**) denotes a movable panel design. Source: drawn by AJL CReS Lab research studio and compiled by this study

The architecture's programming could extend the scope by including vertical greening possibilities for a myriad of combinations. This demands a customized design solution to accommodate the ancillary activities. Coupled with the checklist shown in Table 2, it provides a comprehensive assessment for an informal vertical greening prototype.

In summary, the study recorded the results from the interview and observations as follows. The comprehensive results for the semi-structured interviews and participants' observations using the checklist are shown in Figure 11. As an assessment tool, the categories affecting the DAPSIR process are indicated as follows:

— Driver (D) stage, the "How" category scored the highest, followed by "Which" and "What". This reflects respondents' thinking that the vertical green placement is important; the design and how it blends in within the community are key issues as well.
— Activities (A) stage, the "What" category was ranked most important, followed by the "Why" and "Which" categories. The vertical green typology directly influences the activities generated; further, whether it is recreational or personal gratification and how it can attain health incentive are ranked as important criteria to be considered during design.
— Pressure (P) stage, the "Why" category was ranked highest, followed by "How" and "Which". Respondents felt strongly in determining the reason for vertical green; whether it is to foster community spirit or interaction should be clarified. The place-based contextual analysis in the "How" category clarifies the intent.
— State Change (S) stage, "What", "Where", and "How" were ranked equally importantly. Careful consideration on the desired changes, location, and method must be considered to provide a suitable design for the state of change.
— Impact (I) stage, "Where" is followed by the "What" and "How" categories. Respondents felt that vertical green can bring benefit to areas with an extensive degree of urbanity, urban heat island as well as level of interaction with green. Having the opportunity to form an integral vertical green belt and the logistics in caring for the system should be holistically considered.
— Response (R) stage, the "What', "Where", "How", and "Why" categories are considered equally crucial for the respondents for the final design. The installation process, interaction with the neighborhood, critical neighborhood, and health incentive should be coordinated.
— Well-being (W) result, "Where" and "Which" are considered foremost, followed by the "Why" category. Respondents felt that to be active and to connect are two components most crucial in

achieving well-being. These are both interactive linkages, demonstrating a desire for a design that could evoke interactive behavior and activities.
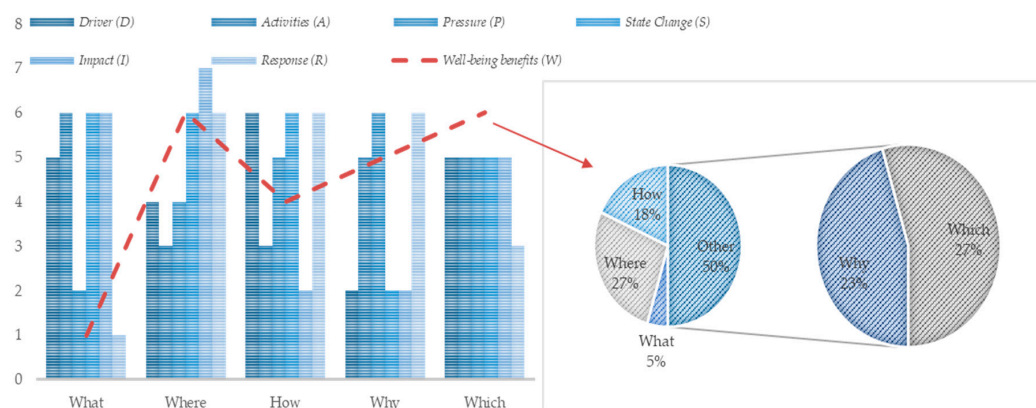

Figure 11. Integrated Result of Vertical Green Framework Checklist for Well-Being (DAPSIR Method).

Finally, the results for the well-being benefit-weighted criteria (Figure 10) show that, for the five categories of self-evaluations, the "Which (place identity)" and "Why (aesthetic value)" categories scored the highest, comprising 50% of the total well-being benefit. This is followed by "Where (placement evaluation)" and "How (characteristic)", with "What (environment relevance)" being the lowest with only 5% of the overall well-being benefit. Evidently, the place identity and aesthetic value scored the highest, reflecting that users indeed care how the vertical greening is introduced to the habitat. Significantly, the location is, in addition, a relevant criterion, as people tend to mind proximity of the added vertical green to one's location. Ultimately, the prototype characteristic is referred to as attachment or spatial feature may affect the habitat; the least critical factor is the environment relevance, as people tend to overlook conditions that may not be of direct consequence to oneself. Plus, users were inquisitive about edible planting and showed enthusiasm for recreational possibilities; most respondents reacted positively to the interactive activities The changing times, user needs, locality differences, and social form become the key determinants in the patterns and practices in the design of vertical green. Developing an interdisciplinary strategy at the onset of the design process is imperative for the result that best answers the design. The unit design should accommodate the functionality criteria and the planting selection diversification as well. Naturally, to increase the well-being state, the design must accentuate the interactive aspect of the interaction.

3.4. Vertical Green Unit Prototype Assessment

Consensus among the building owners and users is obtained through numerous meetings, workshops, and presentations; coordination with the facility management allows for the modularized design as an exterior wall prototype system. Spatially, it contributes to the urban environment and the building exterior. The unit's frame is settled in a measurable system module constituting a basic prototype that can be multiplied in a variety of patterns on the building exterior; significantly, the design includes: (1) a modular type could be attached to an existing wall; (2) integrated vertical green interactive movement function is added; and (3) a system to be integrated with the solid exterior wall or windows. "Space" as the bridging parameter in the design of the prototype allows for diversified application and design solution.

The prototype's scale, spatial feature, and activities could be incorporated, befitting to the locality and function required (Table 2). Functionality concern is integrated within the assessment process; from the composition and configuration criteria, the module supports dimensionally the average floor-to-ceiling height; the scale and measurement are taken from the set window opening in the NTC building as basic dimension parameters. From the attractiveness criteria, the study assumes that the

vertical greening unit can be used for multiple planting, including edible greens to attract users to engage in activities. The lifespan of living green walls is difficult to assess, but the structural panel and frame's lifespan varies according to the attachment method and material chosen. System adaptability is of utmost concern in the management assessment, performance, and durability strategy (Figure 12).

(**a**) (**b**)

Figure 12. Conceptual development of adding the vertical green system to existing building envelope. (**a**) full-scale planting cell prototype; (**b**) is the assembly diagram: A is the plating cell; B is the sub-framing grid; C is the attachment structure; D is the support subsystem; E is the unit frame, and F is the irrigation support. Source: AJL CReS lab Research Studio [106,107].

Prototype size adjusts to the building solid wall or opening; the bay proportion rhythm can be adapted according to the pattern's design. To allow maximum flexibility, the integrated method generated a design that bears higher initial construction costs, though it could adversely affect the promotion of such design. As an added-on or retrofit element into the building exterior, the green features are a positive catalyzer to the local community, encouraging interaction and engagement. The spatial attribute ranges from a micro unit that could be placed on the interior of the building and enlarged to a macro-scale outdoor. Considering the economic, construction, and cost factors, a rail system is proposed to be attached to the exterior of the building; it acts as a framing system installed between window openings, or as a greening scheme in front of gaping windows or terraces. The greening system can be positioned to the rail either through a sliding manner or permanent attachment to the wall. The research tested a prototype unit. The auxiliary unit can be part of the building wall surface; a dripping system and sensor can be added to the unit, providing the water and nutrients necessary for the plants. It can provide the required shading under the sun as well as a cooling mechanism to the radiant heat and urban heat island effect. The concept is incorporated as 3D rendering of the system prototype pattern (Figures 12 and 13).
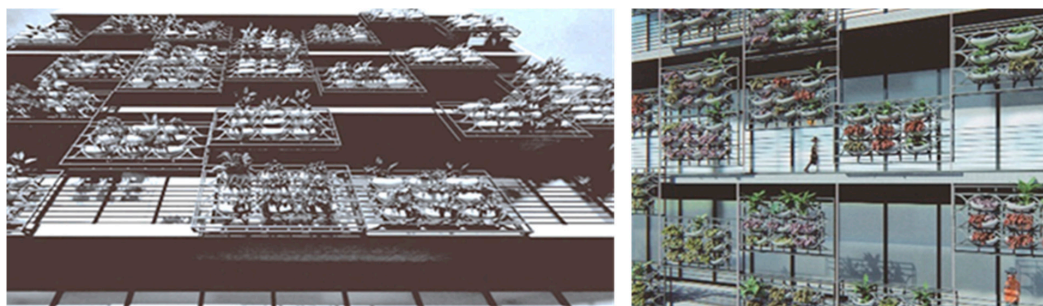

Figure 13. Conceptual development of adding the vertical green system to building envelope. Source: AJL Cres Research lab [106,107] and compiled for this study

4. Discussion

4.1. Urban Anthropocene at the Community Level

With the continuous increase in urbanization rate, the Urban Anthropogeny era has come to fulfill the realization; managing the balance of urban development versus preservation of green is customarily a trade-off and a conflict of interest. To mitigate the environmental drains and promote urban adaptability, vertical greening design and options can add on to an existing building facade or be integrated onto new construction during the design phase. From the physiological side, activities stimulate desired behavior; to exercise or engage in physical interaction could inspire one to feel good about oneself. Moreover, the provision of vertical green nearby from a daily circulation path can entice users to interact, meet others, and increase socialization opportunities.

Empirical studies demonstrated the diversity of complex social–ecological relations in the sustenance of ecosystem services. The social, economic, and environmental criteria regarding well-being are of concern regarding sustainability [6,15,29,102]; complying with the UN-HABITAT's Safer Cities Program approaches and sustainable goals, vertical green satisfies the proximity criteria on the accessibility to urban green to promote social inclusion. Historically, proposals like the Garden Cities exemplified the Western architectural solutions that include greenery elements either for the restoration of existing buildings or in the design of new ones, allowing enhancement of the aesthetic aspect of our cities. In Asian cities, the promotion of vertical greening is still at the preliminary stage, and in Taiwanese cities, only few sporadic designs included vertical green during the development stage; others added vertical green during the building renovation or addition, or simply by greening the construction fence to abide by relevant governmental incentives. Regardless of the initial motive, the vertical greening process can aid the inclusion of more willing residents and convey a sense of belonging; it promotes well-being and may result in a more active and livelier neighborhood. Lastly, it enhances a balance in the human-habitat resilience to achieve the urban adaptability within the community.

4.2. Vertical Green Incorporation—Coping with Green Gentrification, Health Equity, and Well-Being

This study asserts that the right to access green has been recognized as an equity and environmental justice issue. Neighborhood environments, both social and physical, affect health and well-being [30] (Cox et al. 2018). However, hierarchical practice in urban planning processes regards open spaces or green area as the residual area per FAR (floor area ratio) code requirement; unlike public schools that usually considered the access distance from residential areas, most public open space in Taiwan often overlooks the accessibility from those in need. Land value tends to override all factors and issues like income level, ethnic-racial characteristics, age, gender, and other traits of differentiation are inconsequential during the evaluation process. The less-well-to-do, tenants and those of multiethnic backgrounds have found themselves excluded from the benefits of these new environmental amenities and vulnerable to unintended, yet negative, consequences, such as residential, commercial, or industrial displacement [21].

The urbanization and gentrification in many cities have constrained both social and health well-being. Rising land costs, congestion, and deteriorated habitat heightens the state of green gentrification. This directly displaces residents who may lack the economical means to withstand such an increase in rent or housing costs. Equity-driven policy should consider access to nature as a fundamental human right for urban residents, attuning the attention on relevant incentives or support. Escalation of urban density obliges balancing the growth while attaining sustainability. Often, highly demanded real estate is frequently located near precious urban green; Central Park in New York City, East Garden in Chiyoda Tokyo City or Da-An Park in Taipei City represent a few examples. In such cities, policies tend to place economic growth-concerned interests at the forefront; while social-driven equities like environmental sustainability, health, and well-being become subservient disputes. In dealing with environmental injustice, neighborhoods with higher population density

house lower-income residents; however, the demand for better life quality and green resource is still present regardless of the existing density condition.

　　Green provides an aesthetically pleasing and more active habitat; however, it can also increase the housing costs, which further stimulates the gentrification of the neighborhood that may benefit from such a resource. The proposed assessment tool effectively employs vertical green as part of a local contingency measure. Dealing with morphologically dense neighborhoods lacking green areas, the strategic planning attests for methodologies for vertical green as an ecosystem service in the urban centers. It sustains the very ecological integrity and the public health of the inhabitants. Environmentally, the added vertical green infrastructure can reduce local pollutants, cool the temperature, and attenuate noise pollution; it becomes part of the edible green system and supports the ecological integrity of cities. It can equally safeguard the community health of urban populations. Access to green does have considerable implications on social and health policies, while enhancing the local equity with nature-based initiatives. It reduces social isolation and welcomes interaction among residents. This is a bonus to communities lacking green resources. Discounting vertical green further aggravates the existing urban habitat; as these spaces become congested, less friendly and hard to use, residents, then, could not secure active engagement with green/nature. As the demand increases, the pressure for the government to fulfill the plea from the displaced local land resources intensifies. Opportunity to arouse emotional, psychological, and social well-being is probable; the addition of vertical green could solidify the community comradery, and reinforcement of the local social capital. This could provide proliferation of health equity and minimize the effect of green gentrification. The resilient practice ultimately depends on the local community's stakeholders' will and the government's sensible planning and incentive strategies.

4.3. Vertical Green Prototype Assessment

　　The prototype criteria were analyzed using the DAPSIR model; the structured assessment model assists in evaluating vertical green design and well-being benefit. The main goal is to expand beyond the rhetorical function, articulating a community-based strategy toward implementation of vertical green. Architects and urban planners have long investigated co-existence with nature (Ling et al. 2018 [29]); this tool contributes a sustainable practice in interdisciplinary design thinking. The contextualization process focuses on the perception, demand, and practice within the human-environment domain. The process links multiple site-related circumstances leading to a significantly increased complexity within the design agenda. Aside from the conventional functionality and placement options, the model critically accounts for health incentives while incorporating re-usability options with modularity thinking. The interdisciplinary design program advocates readjustment in the mindset to evaluate beyond the customary domain. The goal is to increase healthy behaviors [29,36,87] and a stronger connection with nature.

　　The tri-tiers structure provides a step-by-step process to analyze the habitat (vertical green) and human (well-being) dimension, to increase the amenability of nature in the affected urban environment. As an effective urban green strategy, it utilizes the existing building wall or is integrated into the new building facade. Greening on facades stimulates neighborhood interaction where activities may be created; it addresses environmental justice and ecological sustainability. Willing participants could initiate active engagement with greenery while encouraging other residents to be active or engage in activities as well. Moreover, residential buildings with integrated vegetation, as seen in many older neighborhoods with mature planting and greening, were more preferred and considered more beautiful; the aesthetic effect typically brings a pleasing and restorative value compared to those neighborhoods without vegetation or green. The challenge, however, is identifying and holistically evaluating complex yet multiple layered issues. The increasing pressure to synthesize the interdisciplinary criteria toward creative solutions must transcend the conventional design paradigm. Simultaneously, we observe if the design is reasonably accessible to the people; it should encourage contact and interaction.

5. Conclusions and Further Research

The environment, health, and well-being of urban citizens reckon a re-examination of the long-established planning paradigm in Asian cities. Land-use priorities often wedge out indispensable greens for greater economical returns, and urban health equity and well-being seemed insignificant compared to the economic output. Further, the urban proliferation driven by socioeconomic targets has resulted in hastily formed neighborhoods of densely packed buildings lacking available green space. These cities must deal with green gentrification and deprivation. This study investigated the process of vertical-green design consideration as related to green gentrification and human activities' triggered sense of well-being. Understanding the current urban planning encompasses larger-scale regional attributes; the DAPSIR model proposed focuses on the community-based scale design strategy process, pertaining to site-based attributes. The model is used to evaluate the complex drivers affecting the human-habitat ranging from the neighborhood to building level; in this case, to evaluate the vertical greening-related contextual design framework for the NTC building. Relationships are typically complex, and the result is frequently a place-based product that is distinct to the geographic area and neighborhood characteristic. The process critically expands the attributes' evaluation to include not only the human condition but also the habitat context within the evaluation process. The framework assesses at the neighborhood scale, striving to include the place-based criteria for a best-fit design proposal.

Vertical green could be utilized for recreational, health and aesthetic purposes, providing the necessary green element to those deprived of such opportunity. Currently, the application of a vertical built surface for greening is generally overlooked. This study expanded the ongoing investigation of the NTC building, a considerable-scaled mixed-use government complex, to integrate the health-enhanced planning and design-led effort; the endeavor allows the environmental linkage to well-being through vertical greening. A holistic overview conducted during the design consideration could aid the well-being enhancement. To begin with, we defined the linkage by looking into the human-habitat dimensions and associated the design possibilities. Impact toward the spatial diversity as well as its contribution to the human-habitat value was assessed. The proactive focus identified the conditions and probable practices. Vertical greening, as a part of the landscape dimension, must incorporate the holistic planning, design, and management strategy. The building facades become the probable urban vertical green fabric and address the community's social and ecological need to restore the neighborhood environment.

The community in need should familiarize itself with the multiple greening strategies. Critical design thinking needs to encompass the divergent requirements among individuals and residents; their actions must be observed, gathering responses toward the environmental impacts. Government's support guarantees the execution means. Current mind-set focuses on the fact that horizontal greening should redirect toward novel thinking: placing vertical green incrementally in the built community. The addition could include long-awaited green to communities lacking horizontal land. Relevant policies and subsidies programs pertaining to such measures could be propositioned to encourage communities adapting appropriate strategies. The issue of equity associated with accessibility to urban green warrants further attention. Though the condition varies, it considers a lasting implication on the well-being of the inhabitants. We now turn to urban planning and landscaping interventions; therefore, planning authorities and other disciplines may apply to enhance the inclusion, equity, and ecology in urban centers. To promote well-being, this assessment model and well-being checklist could be applicable to other urban systems as the enumerated attributes are widely relevant. This critical observation affirms the effect of resilient practice, and the learning contributes otherwise.

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