Exploring the Role of UP Campus as a Living Lab for Sustainable and Resilient Transport

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Abstract: Studies in travel behaviors and patterns in universities show that it is constantly changing along with changes in views and attitudes, available services, and technology. As universities are institutions where knowledge is cultivated, it stands to reason that institutions of higher learning should be in the forefront in the pursuit of sustainable development goals and climate action. This is especially true as universities imbibe critical thinking and social consciousness that can impact the decision-making process in the entire society. Literature on living labs underscores the transformative potential of universities in leading by example and equipping future generations with the knowledge and tools to address global sustainability issues. This paper explores the role of UP campus as a living lab for sustainable mobility by evaluating mobility trends in UP Campus and pursuing avenues to demonstrate approaches and innovations toward sustainable and resilience transport.

Keywords: Campus Living Lab, Sustainable Mobility, Resilient Transport, Participatory Action Research (PAR)

1. INTRODUCTION

1.1 Background

In the context of innovation research, MIT's Professor William J. Mitchell together with Kent Larson, and Alex (Sandy) Pentland were the first who started to construct home-like labs at the end of the 1990s (Tötzer, et al., 2020). They led early initiatives at the MIT Media Lab, where real-world urban environments were used as testbeds for developing and evaluating new technologies. The idea was to move innovation out of controlled lab settings and into real-life environments, enabling users to co-create, test, and refine solutions in their actual living contexts. Living labs are defined as physical or virtual spaces that address societal challenges, particularly in urban settings, by fostering collaboration among diverse stakeholders. The study by Hossain, et al. (2019) indicates that living labs are inherently multidisciplinary, intersecting various research domains and often discussed within the frameworks of open and user innovation. The implementation of the living labs is based on the involvement of the user in the innovation process, thereby making the innovation system user-centric, as opposed to technology centric.

The European Network of Living Labs (ENoLL) defines living labs as "user-centred, open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real-life communities and settings." This definition underlines the importance of engaging end-users as co-creators rather than passive recipients,

ensuring that products, services, and policies developed within Living Labs are practical, relevant, and community driven. (ENoLL, 2025). According to ENoLL, living labs work as collaborative ecosystems built around the quadruple helix model of innovation whereby:

- Citizens and civil society contribute with their lived experiences and needs;
- Academia brings research and scientific evidence,
- The private sector offers market perspectives and the capacity to scale; and
- Public authorities ensure alignment with policy frameworks and societal priorities.

As universities are institutions where knowledge is cultivated, it stands to reason that institutions of higher learning should be in the forefront in the pursuit of sustainable development goals and climate action. This is especially true as universities imbibe critical thinking and social consciousness that can impact the decision-making process in the entire society. Nyborg, et al. (2023) highlights that living labs on campuses emerged largely in sustainability contexts, making universities "sites for social interaction and engagement in sustainability transitions." Universities realized that using the campus itself as a laboratory creates a natural platform where students learn through hands-on experimentation, researchers access real data and systems, and campus operations benefit from innovations. As such, this enables the integration of teaching, research, and operations.

1.2 Rationale

Universities are widely recognized in academic literature as effective microcosms for studying and implementing solutions to the broader societal challenge of sustainable transport. For example, Balsas (2003) argues that university campuses represent a microcosm of society where norms and behaviors are shaped, making them ideal settings for exploring policy initiatives aimed at reducing automobile dependence. Fernandes, et al. (2019) provides methodologies for evaluating sustainable transport strategies within a campus setting, framing universities as strategic starting points for wider urban benefits. It is also argued that universities can influence travel behavior and that students, who may later occupy influential roles in government and companies, can learn sustainable mobility practices that last into later life.

Travel behaviors in general and campus mobility are rapidly changing marked by the alarming increase in private modes. In the context of the University of the Philippines (UP) Diliman, considerations such as socio-demographic characteristics, safety and convenience perceptions, environmental awareness, and institutional support are critical. Based on person-trip surveys among students conducted in 2019 and 2024, it is found that the percentage of trips using cars in UP Diliman has increased from 11% to 21.6%. On the other hand, the share of walking trips has decreased from 39% to 27.3%. There is also a marked increase in the use of new private modes offered by Transport Network Companies (TNCs). Consequently, the share of public transport has decreased from 2.39% to 25.3% during the same period.

There is great need to generate sustainable development and sustainable transport knowledge and innovations. As such, the UP Campus provides a rich environment to explore and demonstrate sustainable mobility and resilience transport initiatives through a university campus living lab approach

1.3 Research Objectives

The objective of the Study is to explore the role of UP Campus as a Living Lab for sustainable and resilient transport.

2. LITERATURE REVIEW

Literature views living labs simultaneously as landscapes, real-life environments, and methodologies, emphasizing their versatility in application. The study highlights several challenges faced by living labs, such as temporality, governance complexities, efficiency issues, difficulties in user recruitment, sustainability concerns, scalability, and unpredictable outcomes. Despite these challenges, living labs offer significant benefits, including both tangible and intangible innovations and a broader diversity of innovation outcomes.

Gomez and Derr (2021) examine how university campuses utilize their physical landscapes as living laboratories to promote sustainability and enhance student learning. Through a scoping review of 28 scholarly articles, the authors explore the integration of biophysical campus environments into educational and sustainability initiatives.

Evans, et al. (2015) explores how university campuses can function as living laboratories to advance sustainability science through co-production. The authors examine the University Living Lab initiative launched in 2012 at the University of Manchester, which aims to transform the campus into a site for applied teaching and research around sustainability. The paper discusses the generation of living lab projects, the design of the campus as a living lab, and institutional visibility. It identifies key strengths of the living lab approach, such as fostering holistic and iterative frameworks for co-producing knowledge, and highlights challenges in applying this approach more broadly. The authors argue that living labs offer a real-world context for sustainability experiments, enabling stakeholders to work together to frame research that delivers more effective solutions.

Filho, et al. (2019) explores how universities can act as "living labs" to support and implement the Sustainable Development Goals (SDGs). It emphasizes the role of higher education institutions as innovation hubs where sustainability can be integrated not only into teaching and research but also in operations, governance, and community engagement. It underscores the transformative potential of universities in leading by example and equipping future generations with the knowledge and tools to address global sustainability issues.

Stuckrath, et al. (2025) presents a comprehensive examination of Campus Living Labs (CLLs) as instruments for driving sustainability transitions within higher education institutions (HEIs). By providing a shared understanding and framework for implementing and analyzing CLLs, the study offers valuable insights for HEIs seeking to catalyze sustainability transitions from within. The proposed models and definitions serve as tools for institutions to effectively design, implement, and evaluate CLLs, fostering a collaborative approach to sustainability

Verhoef et al. (2019) presents a comprehensive framework designed to transform university campuses into dynamic environments for sustainability experimentation and learning. Recognizing the significant environmental, social, and economic impacts of universities, the authors advocate for the 'Campus as Living Lab' approach. This methodology integrates sustainability into campus operations, education, research, and community engagement by fostering co-creation among diverse stakeholders.

Herth, et al. (2025) explores the factors that enable the success of campus-based living labs in fostering sustainable solutions. Through a systematic literature review, the authors identified sixteen key enabling factors, including stakeholder engagement, organizational coordination, a conducive work culture, co-creation and collaboration, and the use of suitable methods and practices. An expert panel further assessed the relevance of these factors across different development phases of living labs—initiation, operation, and dissemination. The study found that the initiation phase relies heavily on leadership, coordination, stakeholder engagement, a conducive work culture, and funding. In contrast, the operational phase is

supported by shared understanding, internal management, stakeholder collaboration, methodological appropriateness, and evaluation. The dissemination phase depends on transfer, scaling, evaluation, learning, and bridging stakeholders and contexts. These insights offer tailored guidance for stakeholders, emphasizing the need for adaptability to local contexts to effectively generate sustainable solutions for complex societal challenges.

Finally, Yañez, et al. (2019) presents a comprehensive carbon footprint (CF) assessment of a university campus, aiming to provide insights into emission sources, methodological challenges, and opportunities for mitigation. The study can guide universities in designing more effective climate strategies, emission reduction policies, and sustainability governance frameworks.

3. STUDY AREA

3.1 Location and Demographics

UP Campus is a barangay located in the Fourth District of Quezon City, Metro Manila. Most of its land area is occupied by the University of the Philippines Diliman (UPD). Its northern boundary is marked by the U.P. Compound and the boundary line of Barangay Culiat, Quezon City. The eastern boundary extends along Katipunan Avenue to the boundary line of Balara Filters. In the southeast, the barangay is bordered by the U.P. Compound and the boundary line of Barangay Loyola Heights, Quezon City. To the southwest, the boundaries include the U.P. Compound and the boundary lines of Barangay Krus na Ligas, U.P. Village, and San Vicente, extending towards Culiat Creek. An aerial map obtained through Google Map, showing these boundaries and the adjacent barangays, is shown in Figure 1.

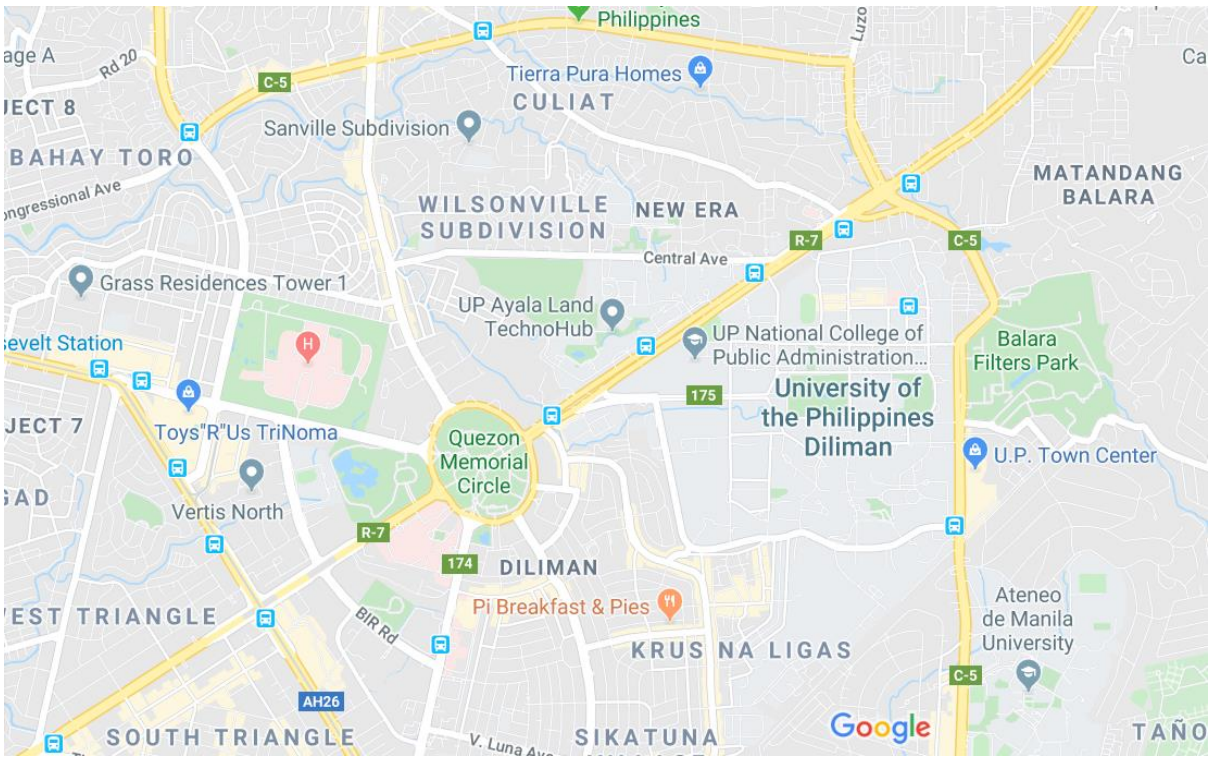


Figure 1. UP Diliman Campus Vicinity Map

According to Orbon, et al. (2019), outdoor open spaces are essential to the function of the university through provision of opportunities for social and recreational activities. The UP Diliman campus, highly regarded by Landscape Architect Paulo Alcazaren as an oasis of green open space in the Metropolitan Manila area, has greatly contributed to addressing the detrimental effects of Urban Heat Island (UHI). The balance between "green" open spaces and built environment such as buildings and structures is crucial in the development and planning of a campus so as to create a learning environment that is conducive to academic pursuits.

3.2 Student Population

For the year before the COVID-19 pandemic, Academic Year 2019-2020, the total number of enrolled students in U.P. Diliman, including elementary and high school students (U.P. Integrated School), amounted to 26,164 persons. For the Academic Year 2022-2023, the total number of enrolled students increased by a few thousand, reaching 28,828 persons. For both years, majority of the population were undergraduate students.

Tables 1 and 2 show the distribution of the student population by education level for 2019 and 2022. All of the data shown was obtained from the U.P. System Budget Office (UPSBO).

Table 1. Student Enrollment in U.P. Diliman by Education Level, 2019-2020

Education Level	Number of Students	Percent Share
Basic	1,499	5.70%
Undergraduate	14,039	53.70%
Graduate	10,626	40.60%
Total	26,164	100.00%

Source: UPSBO (2019)

Table 2. Student Enrollment in U.P. Diliman by Education Level, 2022-2023

Education Level	Number of Students	Percent Share
Basic	2,757	9.60%
Undergraduate	16,699	57.90%
Graduate	9,372	32.50%
Total	28,828	100.00%

Source: UPSBO (2019)

Another factor that can influence travel pattern and behavior is economic status. Looking through the data provided by UP School of Statistics, most qualifiers came from families with an income level of PhP500,000 and above, as reported by the applicants, which is true for both years. These figures can give a general picture of the economic status of the enrolled student population for that year. Table 3 and Table 4 show the reported income level and the corresponding applicants and qualifiers for that bracket.

Table 3. Number of Applicants and Qualifiers by Household Income, 2019

Reported Income Level	Number of Applicants			
	Applicant	Distribution	Qualifiers	Success Rate
Below 101,000	15,040	16.20%	1,278	8.50%
101,000 to 200,000	13,793	14.90%	1,678	12.20%
200,001 to 300,000	11,011	11.90%	1,563	14.20%
300,001 to 400,000	7,621	8.30%	1,130	14.80%
400,001 to 500,000	6,316	6.80%	978	15.50%
500,001 to 1,000,000	15,554	16.80%	2,594	16.70%
1,000,001 and above	13,675	14.80%	2,841	20.80%
No data	9,557	10.30%	740	7.70%
Total	92,567	100.00%	12,802	100.00%

Source: UPSBO (2019)

Table 4. Number of Applicants and Qualifiers by Household Income, 2022

Reported Income Level	Number of Applicants			
	Applicant	Distribution	Qualifiers	Success Rate
Below 101,000	24,610	22.10%	1,778	10.10%
101,000 to 200,000	16,195	14.60%	1,996	11.40%
200,001 to 300,000	12,703	11.40%	1,843	10.50%
300,001 to 400,000	9,553	8.60%	1,462	8.30%
400,001 to 500,000	7,443	6.70%	1,266	7.20%
500,001 to 1,000,000	17,922	16.10%	3,795	21.70%
1,000,001 and above	15,040	13.50%	4,804	27.40%
No data	7,662	6.90%	583	3.30%
Total	111,128	100.00%	17,527	100.00%

Source: UPSBO (2019)

3.3 Trip Diary Surveys

A trip diary survey in UP Diliman was conducted in 2018 by the Project 3 (Information Exchange Platform for the Public Sector) of the Data Analytics for Research and Education (DARE) Program of the Commission on Higher Education – Philippine California Advanced Research Institute (DARE-P3, 2019). The trip diary contains trips made by students in UP Diliman to and from the campus and within the campus, specifically from one building to another. Mode share, fare, and other demographic and socioeconomic data were also identified. It should also be noted that the total sample for the mentioned study is 542 students only as faculty, administrative staff, and REPS are excluded from this study.

A succeeding trip diary survey was conducted from November 18, 2024 to November 30, 2024 (Cunanan and Valzado, 2024). This survey was done after securing permits from the deans of each college, department, or institute of the university. The survey questionnaires that were used for this study consisted of two sections for the students; meanwhile, faculty, administrative staff, and REPS answered a three-section questionnaire. From the first page of the survey questionnaires, usage of data and assurance to the respondent that the data collected is within the guidelines of the Data Privacy Act of 2012 or RA 10173 and any

personal data that might be collected from the survey will be only used for research purposes. Additionally, the research objectives were also introduced on this page.

3.3 Campus Mobility Trends

To help ease the need for a more flexible personal mobility system, a free bikesharing system was first conceived by a group of students in 2015 and piloted as a first-generation bikeshare system within the University of the Philippines. Coined as the UP Bike Share, it first took a non-profit student entity advocating and aiming to provide the first fourth-generation bikesharing service in the Philippines. The first activity of the advocacy group was to develop a feasibility study and to determine the willingness of the students to ride the bikeshare bikes. Around 800 students participated in the survey. They were queried on their willingness to ride a bike, and their riding skills. Results showed that 83% of the sample size reported that they are willing to bike on the campus yet only 13% did so. Asked for the reason behind the difference between stated intent and actual riding behavior, they replied that these were due to bike and user safety, as well as the inconvenience to take care of their bike (Mateo-Babiano, et al., 2020).

A wide range of factors, such as social situations, environmental considerations, and personal preferences, influence university students' choice of transportation method. Public transportation was found to be the most common way for students to go to and from the University of the Philippines Diliman (UPD) campus. Age, household income, and opinions about comfort and COVID-19 safety are important factors that affect these perceptions (Tumamao-Guittap et al., 2024). These results are consistent with previous studies at Miriam College and Ateneo de Manila University that shown the importance of travel habits and the readiness to use alternate modes in influencing transportation decisions (De Guzman and Diaz, 2005).

Sociodemographic factors including age, gender, and financial status have a big influence on the modes of transportation that students choose. According to (Tumamao-Guittap et al., 2024), students who are younger and hail from lower-income families are more likely to take public transportation. Additionally, the ways that various demographic groups perceive convenience and safety change, which affects the modes that they choose. Results from other Metro Manila colleges that showed a strong correlation between students' socioeconomic origins and their travel habits support this (De Guzman and Diaz, 2005).

Students' opinions about convenience and safety play a major role in deciding which form of transportation they choose. Personal security concerns, particularly during the COVID-19 epidemic, have made these aspects even more crucial. Enhancing the comfort and convenience of public and non-motorized transportation options could promote students' increasing use of them, as based on the study by (Tumamao-Guittap et al., 2024). In a similar vein, studies on policies aimed at reducing the usage of private vehicles indicate that addressing issues of convenience and safety may affect students' inclination to switch to other modes of transportation (Peralta, 2024).

Environmental consciousness is increasingly influencing transportation choices among university students. University students' choices of mobility are becoming more and more influenced by environmental concerns. In academic communities, there is a growing movement to promote sustainable modes of transportation including walking and cycling. Research shows that students are more inclined to choose eco-friendly forms of transportation when they are informed of how their choices affect the environment. Several institutions have adopted programs to promote environmentally friendly transportation, demonstrating this trend (Peralta, 2024).

Furthermore, Peralta (2024) also stated that the transportation options that students use are greatly influenced by institutional policy and the state of the infrastructure. Reliable campus shuttle services, bike lanes, and pedestrian walkways can all have a big impact on how appealing other forms of transportation are. Research emphasizes that in order to encourage sustainable and effective mobility, institutions must match their transportation programs with students' abilities and preferences.

4. METHODOLOGY

4.1 Analytical Framework

Figure 2 presents the analytical framework of the Study. The study consists of five (5) distinct phases as follows:

- Phase 1: This covers the compilation of available mobility data covering trip-makers in UP Campus including the deployment of IoT sensors for tracking of Public Utility Jeepney (PUJ) units operating in and around the campus, cycling trips at specific locations as well as Bluetooth UUID observations for commuters waiting at the stops.
- Phase 2: This covers the development of a transport model covering the campus and surrounding areas. The target is to develop a agent-based travel demand model using the MATSim open-source software.
- Phase 3: This covers the conduct of transport model calibration and calibration using appropriate goodness-of-fit tests and AI/ML pipelines.
- Phase 4: This covers the conduct of scenario analysis and planning activities with concerned stakeholders including students, PUJ operators/ drivers, university administrators, student organizations and interested Civil Society Organizations (CSO)/NGOs.
- Phase 5: This covers the development of a Collaborative Governance Framework for sustainable mobility and resilient transport for UP Campus. Among others, this will involve the development of a Campus Mobility Planning and Decision Support System and community dashboard.

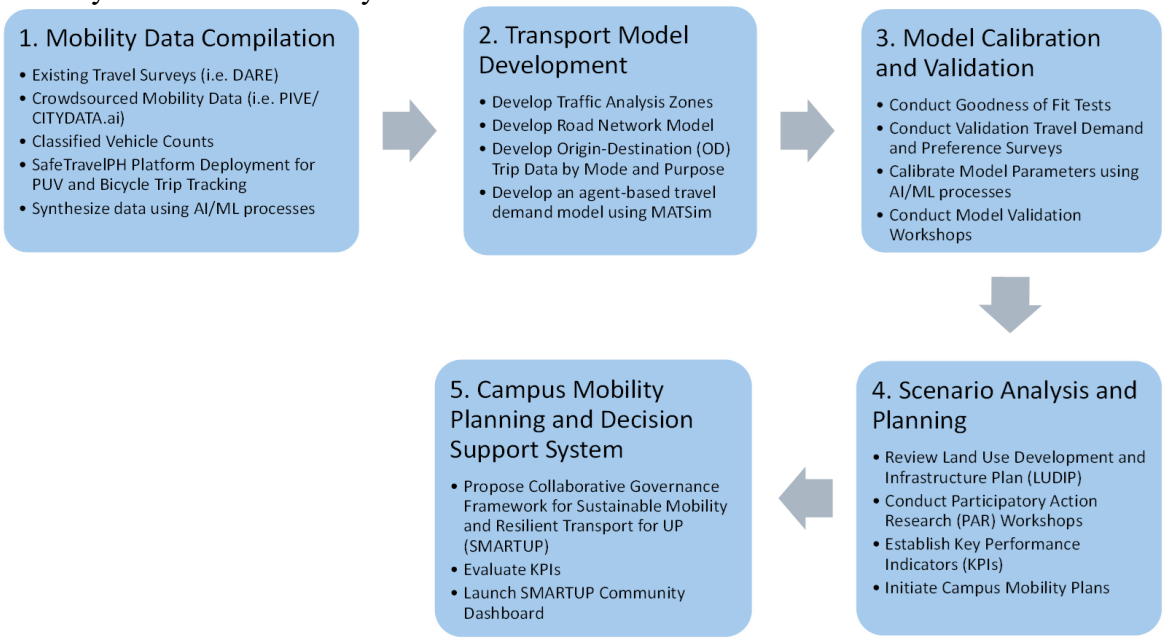


Figure 2. Analytical Framework

4.2 Data Capture

4.2.1 RFID Receiver

Several sensor systems were previously deployed in the UP Campus. Firstly, RFID receivers were installed at various locations and passive RFID tags were installed on selected UP Ikot/Toki units. The system can be re-deployed in order to provide near real-time location of PUJ units as well as Expected Time of Arrival (ETA) as stops. Figure 3 presents the previous setup of the RFID receivers. Figure 4 shows the actual RFID receiver installation.

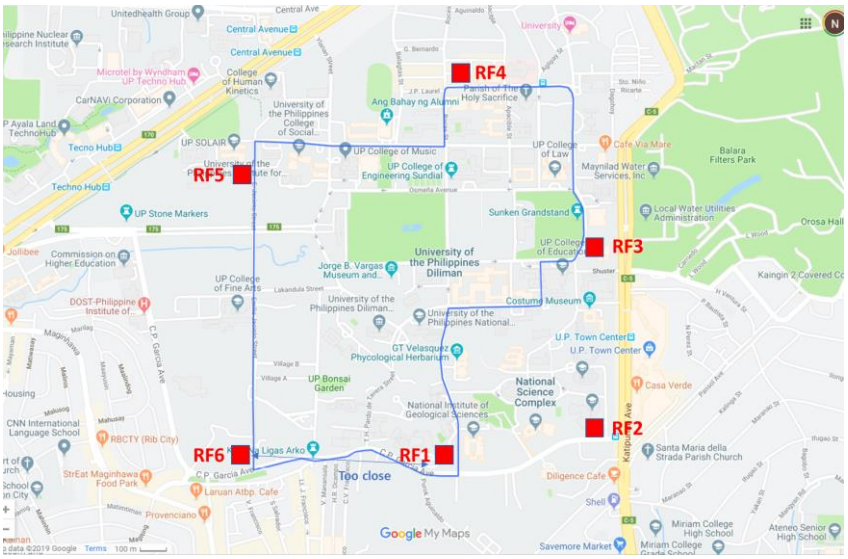


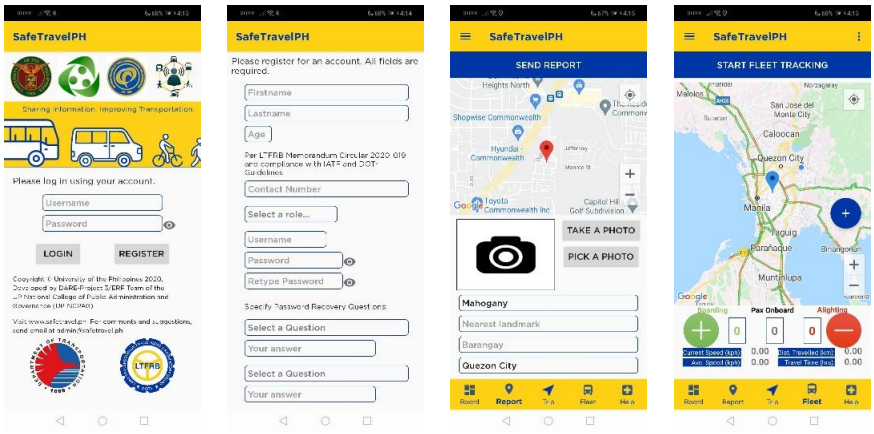
Figure 3. Location of RFID Receivers

Figure 4. Actual RFID Receiver Installation

4.2.2 Mobile Application

SafeTravelPH app is a public transport crowdsourcing and information exchange platform that actively engages government, transport industry providers, and passengers in sharing

transformative information to improve the quality, reliability, safety, energy-efficiency, and sustainability of public transport operations and services (Tiglao, et al., 2023). This app can be promoted for us by commuters in/out of the campus. Figure 5 presents the selected screens of the SafeTravelPH mobile application.



Login page *Registration page* *Reporting page* *Fleet tracking*

Figure 5. SafeTravelPH Mobile App

4.2.3 Camera IoT

Camera IoT devices are deployed at various portal gates of UP campus. These cameras IoT are comprised on Raspberry Pi 4 Single Board Computer (SBC) with Wifi dongle and web camera with an attached Intel Neural Compute Stick for vision processing. These are used to detect bicyclists but can also be trained to classify and count vehicles.

Figure 6. SafeTravelPH Mobile App

4.3 Transport Model Development

An initial Transport Model for UP Diliman was created using the Bentley CUBE

transportation modeling software during the CHED-PCARI DARE Program. The transport model consists of ninety (90) Traffic Analysis Zone where Zones 1 to 64 are internal zones and Zone 65 to 90 are external zones. The model system has several applications including OD Matrix Preparation, Network Preparation, Initial Traffic Assignment, Subarea Extraction, OD Matrix Calibration, Highway Assignment, and PT Assignment. Figure 7 shows the zoning system. Figure 8 shows the road network and Figure 9 shows the transit lines.

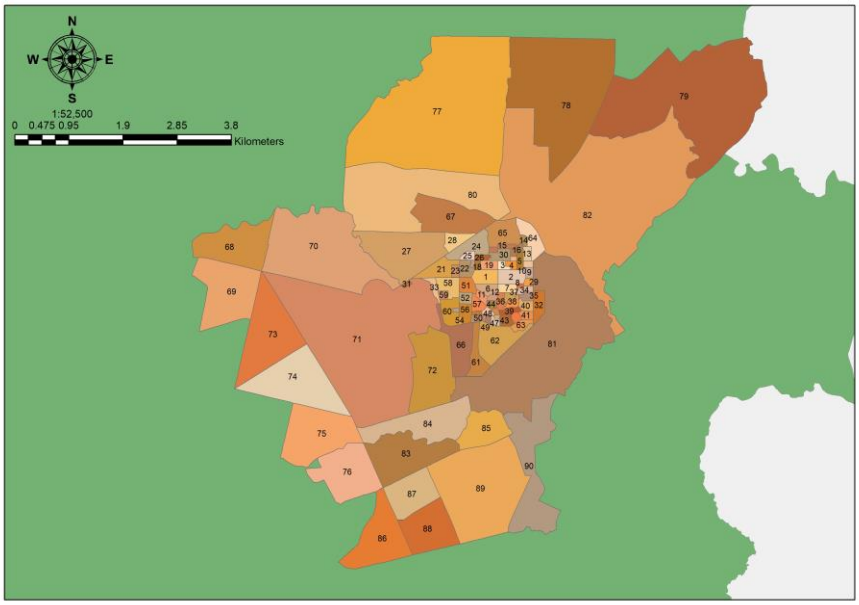


Figure 7. Traffic Analysis Zones

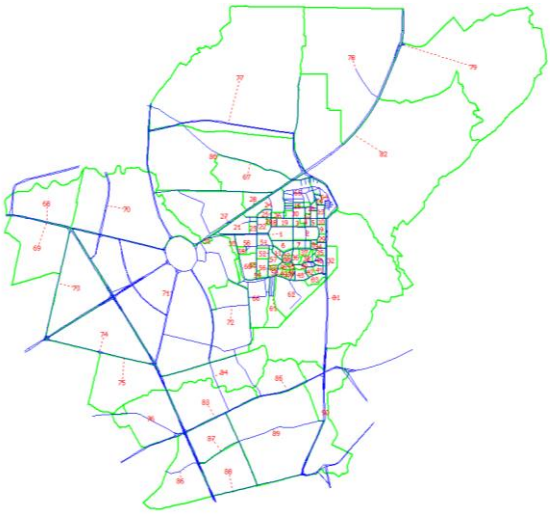


Figure 8. Road Network

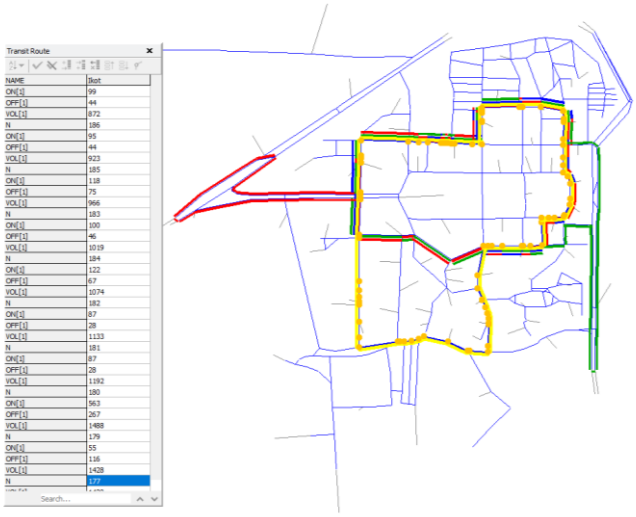


Figure 9. Transit Lines

5. UP CAMPUS TRIP CHARACTERISTICS

5.1 All Trips

Figure 10 shows the trip distribution by mode for all trips in 2019. From this, it can be seen that the highest percentage of modes of transportation used is Walking, followed by Jeepney,

then Own Car with a percentage of 39%, 29%, and 11%, respectively. Based on Figure 11, the trip distribution by mode for all trips in 2024 is shown. It can be seen that the highest percentage of modes of transportation used is Walking, followed by Jeepney, then Own Car with a percentage of 27.3%, 25.3%, and 21.6%, respectively.

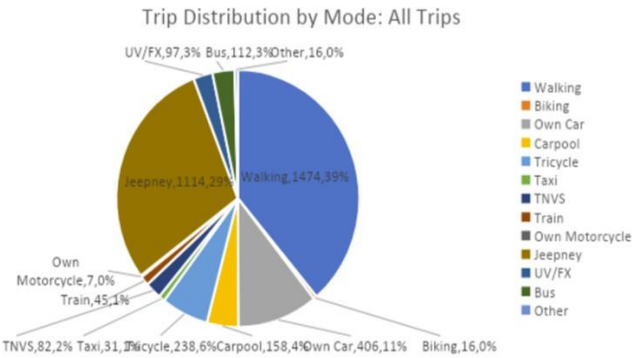


Figure 10. Trip Distribution by Mode-All Trips, 2019

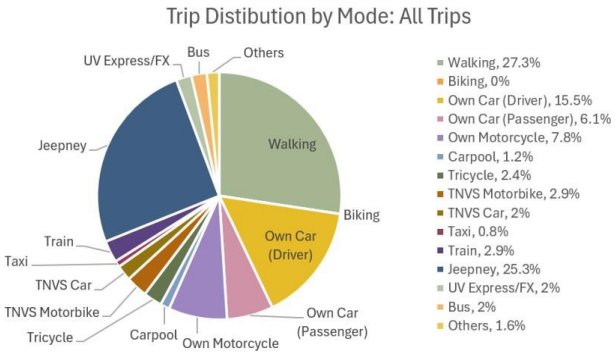


Figure 11. Trip Distribution by Mode-All Trips, 2024

Illustrated in Figure 12 is the trip distribution by the purpose for 2019. First on the list is the Transfer (34%) purpose, which indicates that many trips made in the trip diary are made to transfer from one route or mode to another route or mode. This is followed by Go to School and Go Home, accumulating 26% and 17%, respectively. Meanwhile, in Figure 13, the trip distribution by the purpose for 2024 can be seen. Topping the list are Go to School and Go to Home, both tallying 24.5%. This is shortly followed by Transfer (23.3%).

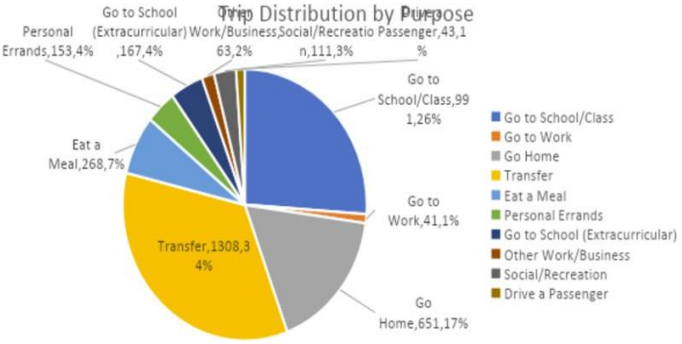


Figure 12. Trip Distribution by Purpose-All Trips, 2019

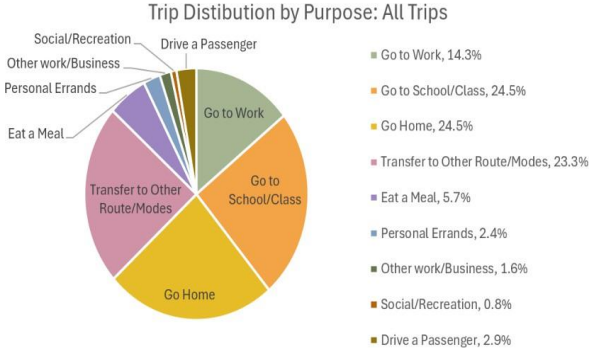


Figure 13. Trip Distribution by Purpose-All Trips, 2024

5.2 Internal Trips

Figure 14 depicts the trip distribution by mode in internal trips for 2019. The majority of the trips inside the campus are done by Walking (62%). Also, the next largest trip mode inside is Jeepney (27%), followed by Own Car (6%). On the other hand, Figure 15 shows the trip distribution by mode in internal trips for 2024. The majority of the trips inside the campus are done by Walking (60.9%). Also, the next largest trip mode inside is Own Car (18.8%), followed by Jeepney (12.5%).

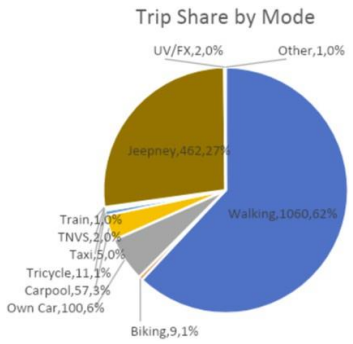


Figure 14. Trip Distribution by Mode-Internal Trips, 2019

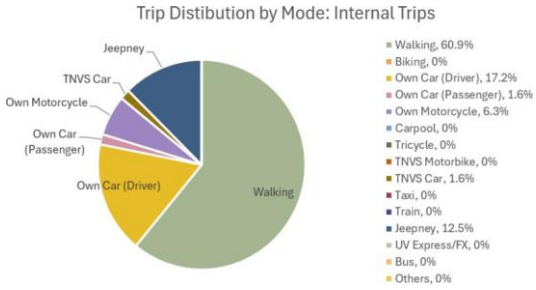


Figure 15. Trip Distribution by Mode-Internal Trips, 2024

It can be seen from Figure 16 that the highest percentage from the trip distribution by the purpose for internal trips in 2019 is Go to School (40%), next is Transfer (21%), then Eat a Meal (11%). For Figure 17, the 2024 trip distribution by purpose in internal trips is shown. It can be referred to in this figure that the highest percentage comes from Go to School (35.9%), followed by Go to Work (23.4%), then Go Home (12.5%).

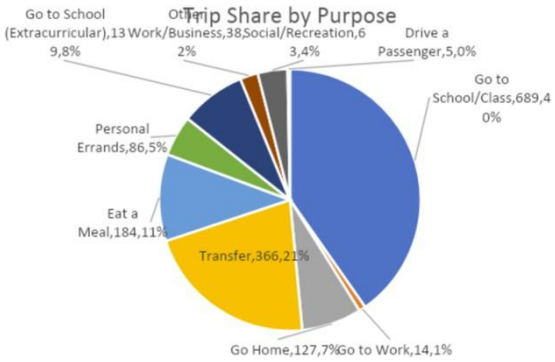


Figure 16. Trip Distribution by Purpose-Internal Trips, 2019

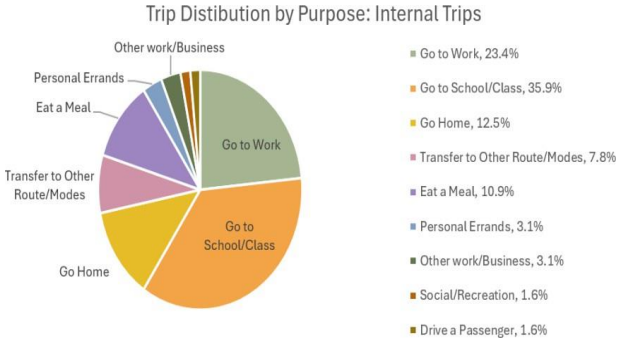


Figure 17. Trip Distribution by Purpose-Internal Trips, 2024

5.3 Inbound Trips

Illustrated in Figure 18 is the trip distribution by mode for inbound trips in 2019. For inbound trips, Jeepney is the most commonly used mode of transportation (33%), followed by Own Car (18%) and Motorcycle (8%). Other modes of transportation are more widely dispersed than jeepneys. Many jeepney routes, as well as national highways such as Commonwealth Avenue and Katipunan Avenue, provide access to UP Diliman. Presented in Figure 19 is the trip distribution by mode for inbound trips in 2024. For inbound trips, Own Car is the most commonly used mode of transportation (30.5%), followed by Jeepney (30.5%) and Walking (15.3%).

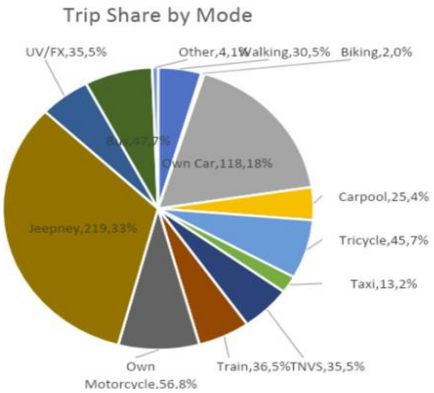


Figure 18. Trip Distribution by Mode-Inbound Trips, 2019

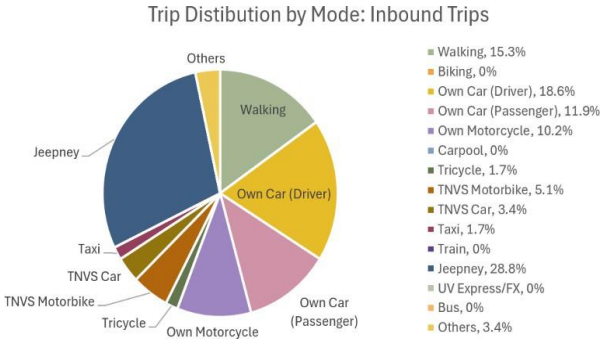


Figure 19. Trip Distribution by Mode-Inbound Trips, 2024

Figure 20 highlights the distribution of trips by purpose in 2019, showing that 48% of trips are for going to school or class, making it the dominant trip purpose. The second-largest category, transfers, accounts for 35%, indicating a significant portion of travel is intermodal or intermediary trips. Other purposes, such as going home (4%), eating a meal (3%), and personal errands (3%), have smaller shares. Based on Figure 21, the distribution of inbound trips based on their purpose in 2024 is illustrated. The largest proportion of trips (54.2%) is for going to school or class, indicating that education-related travel is the primary reason for inbound trips. The second-largest category is trips for work, accounting for 30.5%, suggesting that commuting to work is another significant purpose. The data shows a strong skew towards trips for education and work, emphasizing their importance in travel demand planning.

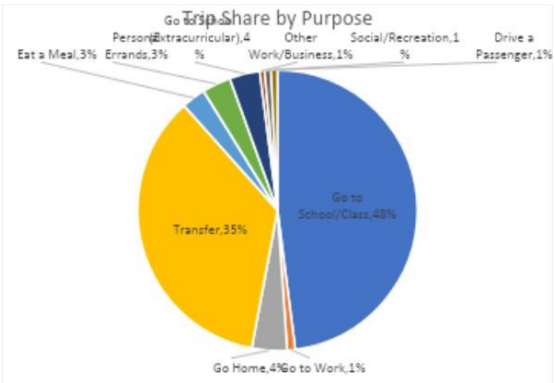


Figure 20. Trip Distribution by Purpose-Inbound Trips, 2019

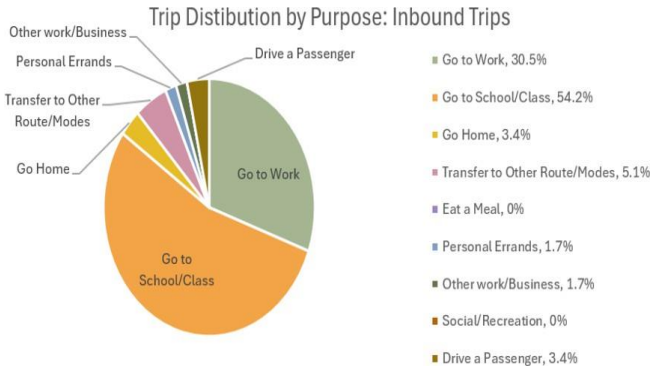


Figure 21. Trip Distribution by Purpose-Inbound Trips, 2019

5.4 Outbound Trips

Figure 22 depicts the distribution of trips by mode of transportation. Jeepneys emerge as the dominant mode, accounting for 39% of trips, underscoring their critical role in the transportation system. Private cars (21%) and carpooling (10%) are also significant, highlighting the reliance on personal and shared vehicles. Presented in Figure 23 is the distribution of outbound trips by mode of transportation in 2024. Jeepneys dominate the mode share, accounting for 31.6% of trips, indicating their critical role in public transportation. Own cars are the second most common mode at 22.8%, highlighting the prevalence of car usage. Then, walking accounts for 21.1%, suggesting significant reliance on pedestrian mobility for short-distance travel. This data underscores the importance of jeepneys and walking in outbound trips, while also indicating the significant role of private vehicles and the

relatively lower reliance on other transport modes.

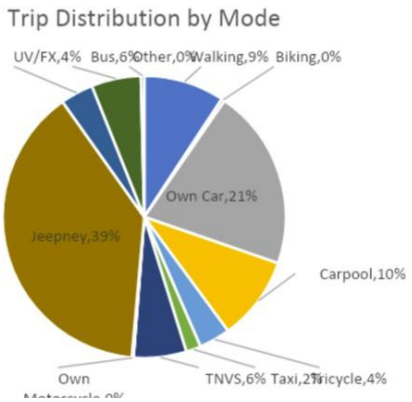


Figure 22. Trip Distribution by Mode-Outbound Trips, 2019

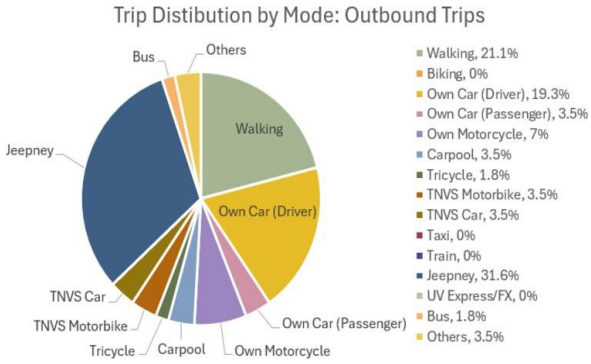


Figure 23. Trip Distribution by Mode-Outbound Trips, 2024

Shown in Figure 24 is the distribution of outbound trips by purpose in 2019. The most common reason for the outbound trips is “Go Home” (44%). This is followed by approximately a third of all trips (33%) which are made for the purpose of "Transfer to Other Route/Modes." It can also be noted that the remaining purposes represent smaller shares. The distribution of outbound trips by purpose in 2024 is shown in Figure 25. Nearly half of all trips (49.1%) are made for the purpose of going home, making it the most common reason for outbound travel. The second-largest category is "Transfer to Other Route/Modes," accounting for 28.1%, which highlights the importance of connectivity in travel behavior. The remaining purposes represent smaller shares. This data emphasizes that a significant portion of outbound trips relates to essential activities, such as returning home and completing multi-modal transfers, while leisure and work-related travel play a relatively minor role.

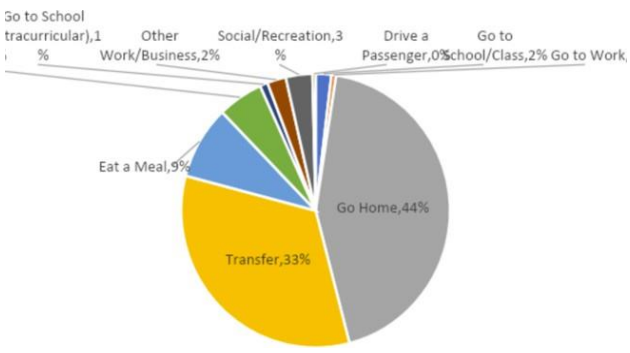


Figure 24. Trip Distribution by Purpose-Outbound Trips, 2019

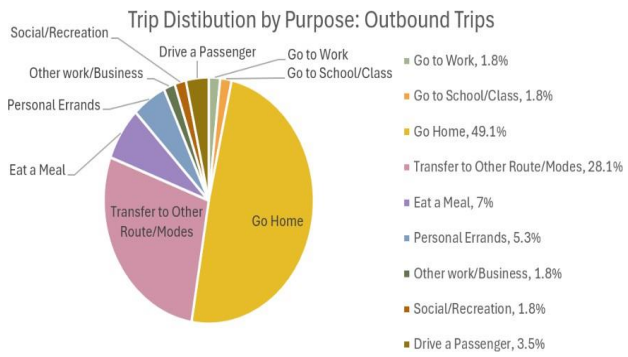


Figure 25. Trip Distribution by Purpose-Outbound Trips, 2024

5. PRELIMINARY DESIGN

The implementation of a University Campus Living Lab for UP Diliman is posited to revolve around the development of a Collaborative Digital Twin (CDT) as a collaboration platform and Participatory Action Research (PAR) as an engagement strategy. The fundamental objective of the CDT platform is to promote sustainable mobility and resilient transport for UP Campus. Figure 26 shows the structure of the Collaborative Digital Twin (CDT). Along the lines of Tiglao, et al. (2025), the CDT for UP Diliman can consist of the following:

- Policy Actors refer to key internal actors involved in the planning and operation of mobility systems in the campus;
- Partners refer to external actors who can support efforts to pursue sustainable development including SDGs to include representatives from civil society and the private sector;
- Performance Indicators refer to insightful data encompassing the strategic, tactical and operational levels harnessing the power of various ICT and IoT technologies;
- Policies (or Programs) related to achieving sustainable mobility and resilient transport; and
- Participatory Governance which puts emphasis on democratic engagement through deliberative practices and seeks to deepen community participation in policy and decision-making

Participatory Action Research is a collaborative and iterative approach that involves researchers and participants working together to identify problems, generate knowledge, and implement change. Participatory Action Research (PAR) has four central components, namely:

- Participation – stakeholders act as co-researchers.
- Action – implementing solutions and interventions.
- Reflection – collectively analyzing outcomes and learning.
- Cyclical inquiry – iterative cycles of planning, acting, observing, and refining.

Figure 26 presents the envisioned PAR engagement strategy which embeds the digital twin tool or platform as part of the evaluative phase.

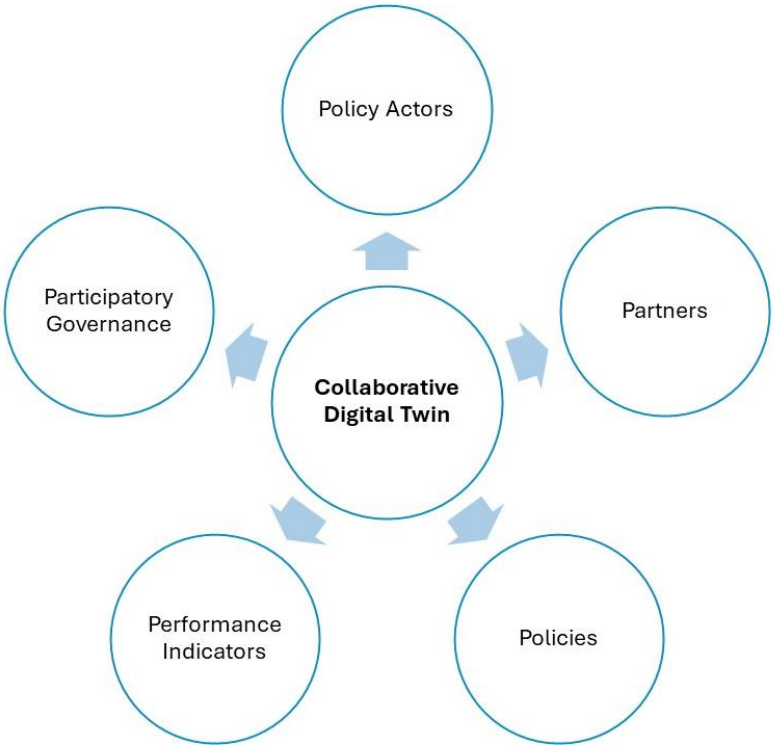


Figure 25. Collaborative Digital Twin (CDT)

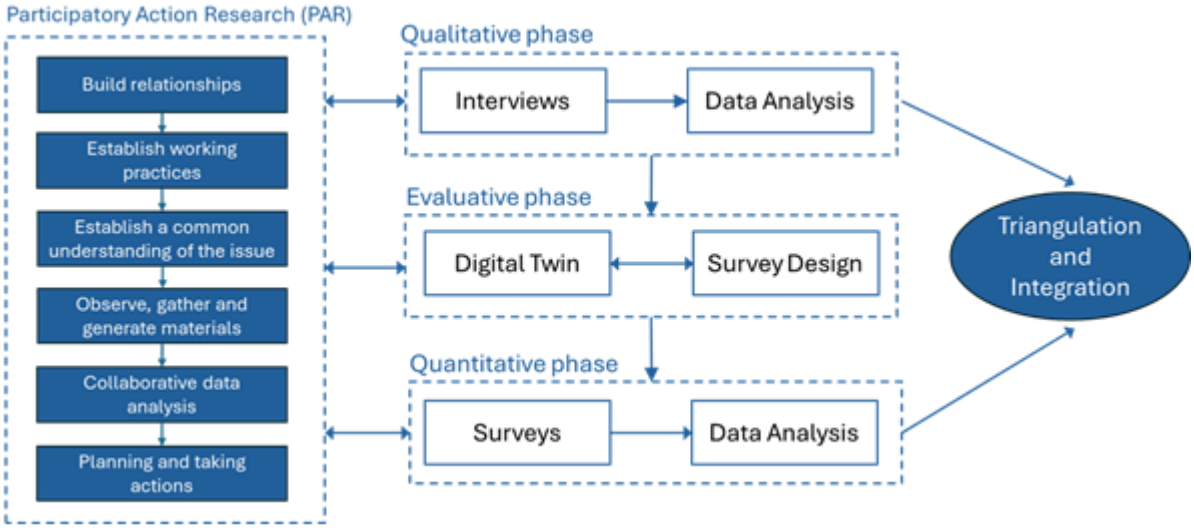


Figure 26. Participatory Action Research (PAR) Engagement Strategy

6. CONCLUDING REMARKS

The UP Campus provides a rich environment to explore and demonstrate approaches and innovations toward sustainable mobility and resilience transport. The campus can be designated as a Campus Living Lab in order to promote co-creation and co-production of sustainable transportation initiatives.

This study presents a comparison of travel characteristics and transportation energy demand and emissions in UP Diliman before and after the COVID-19 pandemic. The findings reveal a notable decline in travel for social and recreational purposes, alongside an increase in trips related to essential activities such as commuting home. This shift reflects broader behavioral adaptations due to health safety concerns, remote learning/work policies, and changes in mobility preferences. However, this shift has been followed by a greater reliance on private vehicle use, which is probably due to health concerns and the desire to reduce exposure to public or shared transportation. Despite the decrease in overall trip frequencies, this increased reliance on private vehicles such as cars has led to higher energy demand and emissions associated with transportation. The results show a post-pandemic trade-off between sustainability and safety, as initiatives to lessen the carbon footprint within the campus are interfered with by the desire for individual mobility. In addition, the rise in multimodal travel indicates that improved transportation system integration is required to maximize energy consumption and emissions reduction.

Strategies to promote sustainable transportation should be pursued including promotion of active transportation choices like bicycling and walking. Improving public transportation services in order to reduce the number of private vehicles entering the campus should be key. Furthermore, there is a need to evaluate policies that support remote or hybrid study and work setups.

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