RESILIENCE SYMPOSIUM
2025

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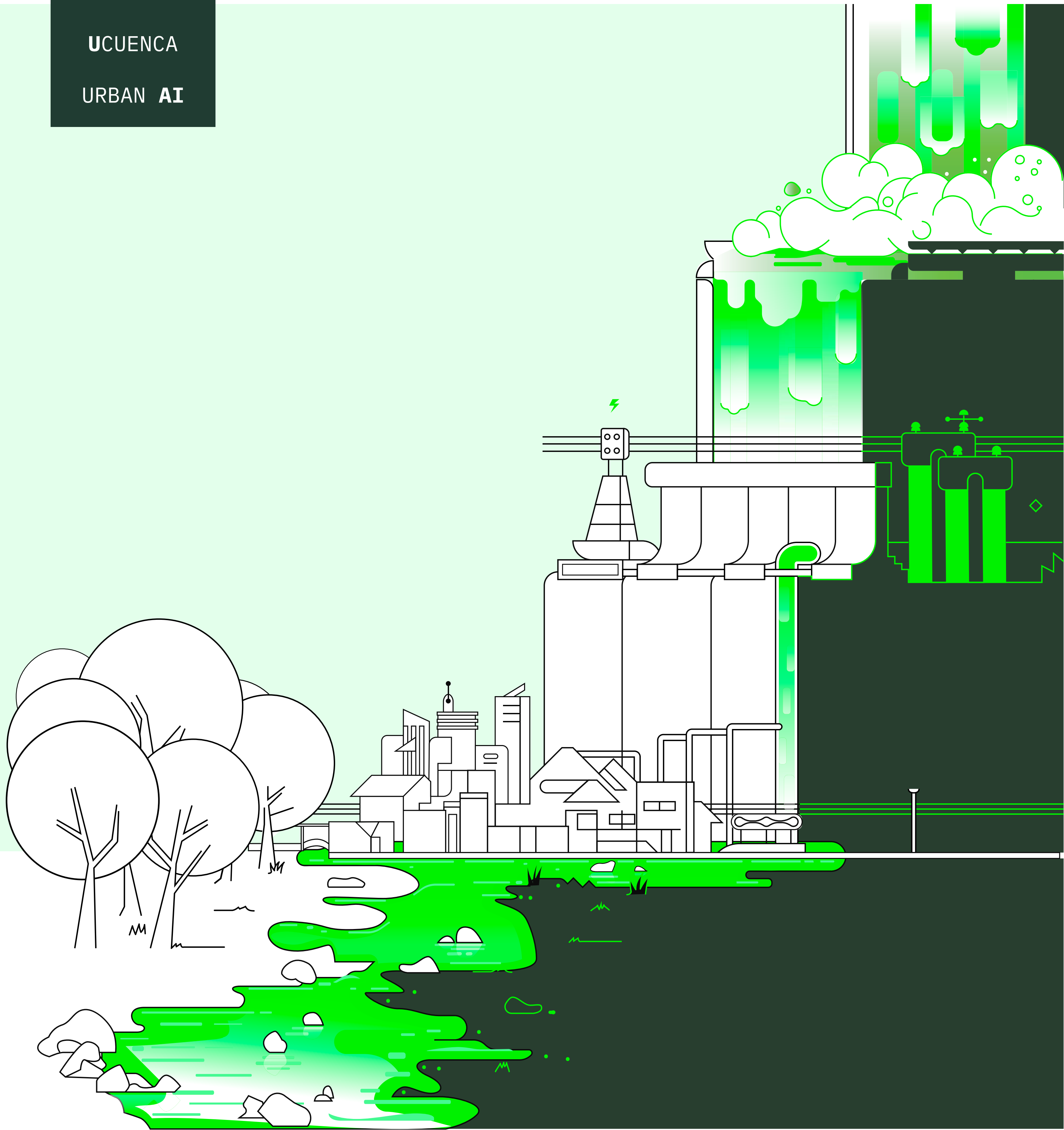
RESILIENCE

In urban environments toward
SDG sustainable cities



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URBAN **AI**

UF College of Design, Construction and Planning

UF Florida Institute for Built Environment Resilience
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BACKGROUND AND SIGNIFICANCE

In June 2022, a successful International Symposium titled “Resilience in the Built Environment” was held in Cuenca, Ecuador, as part of a memorandum of understanding signed between the University of Florida (UF) and Universidad de Cuenca (U. Cuenca). This symposium was a significant milestone. It marked the first meeting between research groups from both institutions: SHARE-Lab and FIBER at UF and Virtualtec Llacta Lab, and City Preservation Management at U. Cuenca. The symposium served as a platform for exchanging knowledge and experiences on resilience in urban environments.

In line with UF’s international mission, this project aims to strengthen global collaboration by promoting research collaboration and conference planning on resilience in urban environments. Resilience has become an essential concept in disaster risk management and sustainability science, presenting an opportunity for knowledge exchange between countries facing similar urban development challenges. These challenges include creating resilient and healthy urban environments, disaster risk reduction, environmental management, and community engagement in fostering resilience.

This proposal includes follow-up activities to strengthen international collaboration in resilience research. As the SDG of sustainable cities emphasizes, improving city resilience is crucial for creating livable, safe, and sustainable cities that promote innovation, development, and community well-being. To achieve this goal, we propose organizing an international workshop at UF and an international conference at U. Cuenca to explore ways to create more resilient built environments and promote sustainable cities. The events will focus on urban resilience, aligned with the targets set by the SDG of sustainable cities, especially Goal 11, Making cities and human settlements inclusive, safe, resilient, and sustainable. By taking a comprehensive approach that considers sustainable urban planning, resilient infrastructure, and social cohesion, we aim to foster global collaboration toward a more resilient future.

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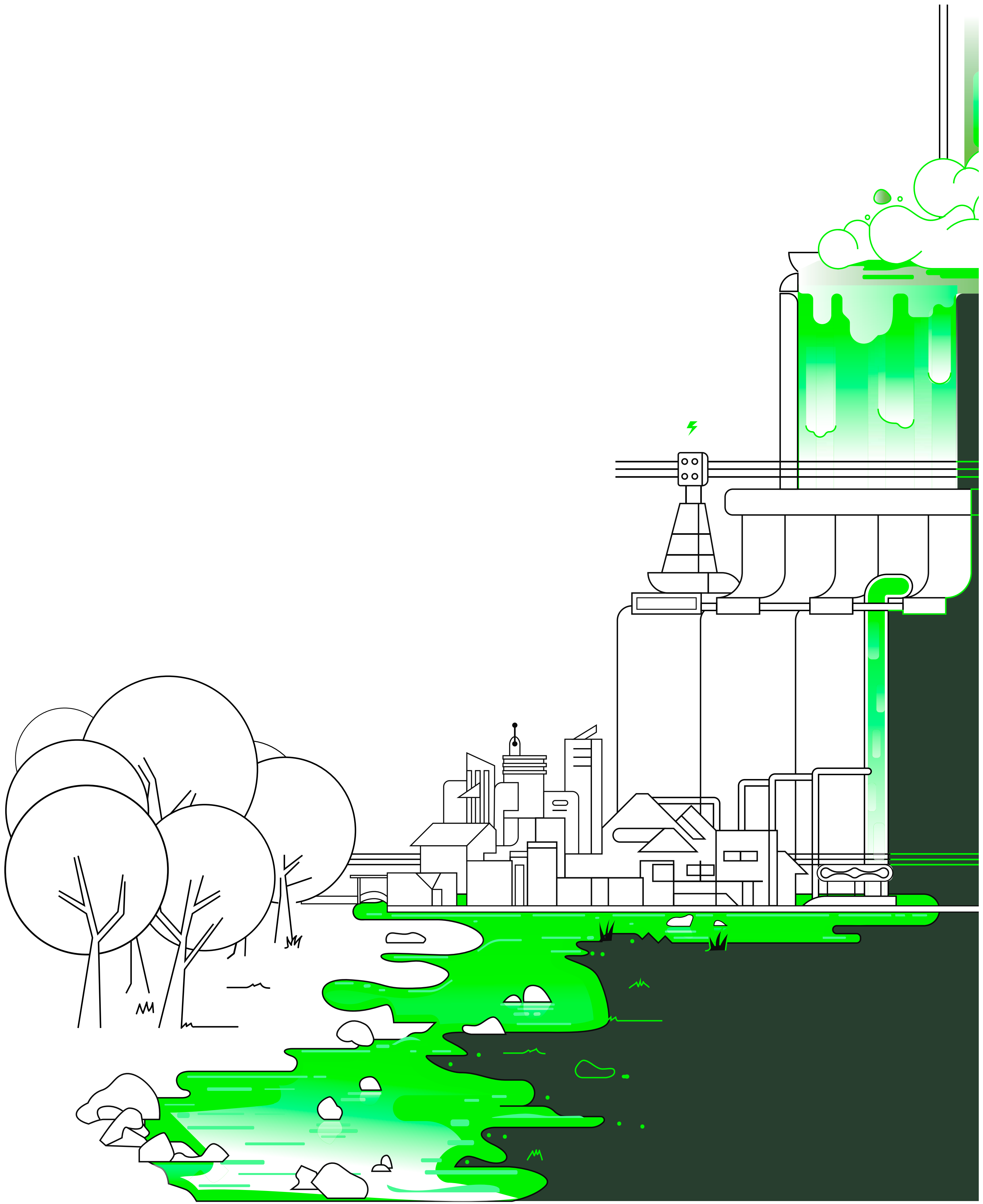
CONTENTS



TRACK 1

AI and Data Science for Disaster Resilience, Public Space, and Mobility

OPTIMIZACIÓN METAHEURÍSTICA PARA LA SELECCIÓN ESPACIAL DE INTERVENCIONES EN LA CIUDAD DE QUITO ANTE RIESGOS CLIMÁTICOS

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Resumen

La intensificación de fenómenos climáticos extremos relacionados con el cambio climático plantea retos críticos para las ciudades contemporáneas. Quito, debido a su posición geográfica, alta densidad poblacional y expansión urbana acelerada, enfrenta crecientes amenazas como inundaciones, movimientos de masas, incendios forestales, cambios micro climáticos y recesión de áreas verdes. Esta investigación desarrolla una metodología computacional avanzada que integra análisis geoespacial, simulaciones urbanas y algoritmos metaheurísticos Bioinspiradas, para identificar y priorizar espacialmente zonas urbanas vulnerables y optimizar la distribución de recursos para mitigación. Este enfoque combina predicción basada en datos históricos, simulación de amenazas naturales y modelos optimizados de intervención territorial, integrando criterios de gobernanza multinivel y resiliencia climática, en coherencia con el Plan Metropolitano de Desarrollo y Ordenamiento Territorial del Distrito Metropolitano de Quito 2024 - 2033, la Ordenanza Metropolitana N°.060-2023 y la Guía de Soluciones basadas en la Naturaleza de Quito.

Palabras clave: metaheurísticas, planificación urbana, diseño computacional, cambio climático, metabolismo urbano, gobernanza multinivel digital.

Introducción

Las ciudades enfrentan crecientes desafíos debido a la intensificación de eventos climáticos extremos como sequías, olas de calor, lluvias intensas y deslizamientos. En Ecuador, estas amenazas han afectado significativamente la calidad de vida urbana y la estabilidad de los sistemas urbanos. Quito, como ciudad capital, combina alta densidad poblacional, urbanización acelerada e infraestructura vulnerable, lo cual incrementa su exposición al riesgo climático.

Frente a este contexto, el objetivo principal busca desarrollar un modelo computacional que permita optimizar espacialmente decisiones de planificación urbana, para aumentar la resiliencia territorial, identificando zonas urbanas de alta vulnerabilidad climática, priorizando intervenciones con base en evidencia espacial y predictiva; e, introduciendo enfoques de gobernanza multinivel que investigan facilitar la toma de decisiones coordinadas y colaborativas frente al cambio climático. Este enfoque permite observar la ciudad como un sistema de flujos interrelacionados cuyo balance es fundamental para la sostenibilidad y resiliencia territorial (Aghaloo & Sharifi, 2024; Bahers et al., 2022).

Este estudio se enmarca en el proyecto "Big Data e Inteligencia Artificial para la planificación urbana de ciudades intermedias", impulsado por el Grupo de Investigación Estudios del Territorio y Hábitat - TERRHAB de la Pontificia Universidad Católica del Ecuador - Ibarra. El objetivo final de este proyecto es desarrollar una aplicación web open source que funcione como una plataforma de análisis territorial para la toma de decisiones urbanas basadas en evidencia, combinando minería de datos, algoritmos de aprendizaje automático y metaheurísticas para generar soluciones óptimas y replicables en diferentes contextos urbanos.

En este marco, el presente estudio se enfoca en Quito, abordando fenómenos como inundaciones, movimientos de masa, sequías, olas de calor, incendios forestales y recesión de áreas verdes. A partir del análisis de estos datos, se realizarán simulaciones para evaluar su impacto en el entorno urbano y clasificar zonas por nivel de vulnerabilidad. Posteriormente, se aplicarán algoritmos metaheurísticos bioinspirados como CrocOA y BFOA para optimizar la localización de intervenciones y recursos de emergencia. Finalmente, el modelo integra análisis espacial avanzado y técnicas de predicción para apoyar planes municipales de mitigación climática bajo una gobernanza informada por datos.

1. Marco conceptual

1.1 Metabolismo urbano

El metabolismo urbano, concebido como la analogía entre el funcionamiento de las ciudades y los sistemas vivos, permite visualizar los flujos materiales, energéticos e informacionales como procesos dinámicos que atraviesan múltiples escalas espaciales y temporales (Bahers et al. 2022, p. 3). Esta perspectiva es fundamental para estructurar estrategias de resiliencia que se adapten a cambios en el entorno físico y social. El uso de tecnologías digitales en el estudio del metabolismo permite, además, modelar patrones de flujo y pérdida de eficiencia urbana (D'amico et al. 2021, p. 5)

1.2 Resiliencia climática urbana

La resiliencia ante el cambio climático en el entorno construido no puede entenderse únicamente como resistencia a eventos extremos, sino como la capacidad del sistema urbano de reorganizarse y evolucionar tras el impacto (Wang et al. 2024, p. 2). Esta resiliencia se apoya en infraestructuras verdes, gobernanza colaborativa y herramientas digitales que permiten anticipar escenarios de riesgo. Ragazou et. al (2024) enfatiza que la resiliencia urbana no solo debe ser ecológica y estructural, sino también institucional y tecnológica, una dimensión crítica que abordamos en esta investigación mediante modelos predictivos y sistemas de apoyo computacional.

1.3 Metaheurísticas aplicadas al diseño y planificación territorial

Diversas investigaciones recientes demuestran el potencial de los algoritmos metaheurísticos en la toma de decisiones espaciales complejas: desde planificación del uso de suelo hasta optimización de redes urbanas y predicción de emisiones (Moayedi et al. 2024, p. 8) (Pan et al. 2021, p, 3.) Los algoritmos PSO, CrocOA y BFOA presentan ventajas particulares: tolerancia a restricciones, adaptabilidad a dominios multiobjetivo y eficiencia en entornos de alta dispersión topológica. Su aplicación en planificación urbana permite identificar óptimos de intervención territorial donde múltiples variables confluyan (riesgo, accesibilidad, cobertura vegetal, densidad poblacional) como se observa en la Tabla 1.

Algoritmo	Exploración/ Explotación	Adaptabilidad Espacial	Soporte Multiobjetivo (MOO)	Datos No Estructurados	Justificación de No Uso / Selección
Genetic Algorithm (GA)	Alta exploración, limitada explotación sin elitismo	Media (depende de codificación)	Sí, con extensiones	Baja	Alta tasa de convergencia prematura en dominios de soluciones con múltiples restricciones espaciales y no lineales. Limitada eficiencia en entornos con alta dispensación topológica. (Pan et al., 2021)
Particle Swarm Optimization (PSO)	Alta explotación, rápida convergencia	Media-alta	Sí, versiones adaptadas	Media-Alta	Ampliamente utilizado en planificación urbana por su simplicidad (Pan et al., 2021) pero propenso a caer en óptimos locales en entornos con alta dispersión topológica y restricciones múltiples. (Zhang et al., 2014)
Ant Colony Optimization (ACO)	Búsqueda guiada por refuerzo positivo	Alta (uso de grafos espaciales)	Parcial – requiere extensión	Media	Sobrecoste computacional significativo en escenarios continuos. Frágil cuando la dimensión de decisiones no es discreta ni secuencial. (Gallo et al., 2012)
Simulated Annealing (SA)	Excelente escape de óptimos locales; convergencia lenta	Nula	No nativo	Baja	Ineficiente para problemas distribuidos espacialmente. Difícil de parametrizar para condiciones urbanas dinámicas. (Sommese, 2024)
Tabu Search (TS)	Búsqueda local intensiva con memoria adaptativa	Nula	No nativo	Muy baja	Rígido para modelado espacial o distribución territorial con datos reales continuos. (Zhang et al., 2014)
Cuckoo Search (CS)	Salto largo tipo Lévy (alta exploración global)	Media	Sí (con ajustes)	Baja	Precisión limitada en problemas de asignación territorial con restricciones múltiples. (Pan et al., 2021)
Artificial Bee Colony (ABC)	Equilibrada (busca buena diversidad)	Baja	No nativo	Baja	Lento para convergencia fina. No se adapta bien a flujos metabólicos no lineales en redes urbanas. (Bahers et al., 2022)
Firefly Algorithm (FA)	Atracción decreciente – búsqueda local adaptativa	Media	No nativo	Media	Bajo desempeño en paisajes de solución con múltiples óptimos disjuntos y relaciones topológicas complejas.(Moayedi et al., 2024)
Whale Optimization Algorithm (WOA)	Alterna búsqueda en espiral con exploración global	Media-alta	Sí	Media	Menor precisión en problemas con dependencia espacial contextual. Necesita adaptación para escenarios urbanos específicos. (Bahers et al., 2022)
Biogeography-Based Optimization (BBO)	Migración adaptativa, buena diversidad	Media	Sí	Media	Poco robusto ante restricciones duras y cambios topológicos. Sin capacidad explícita de clustering espacial. (Pan et al., 2021)
Crocodile Optimization Algorithm (CrocOA)	Exploración-explotación adaptativa dependiente del contexto	Alta	Sí	Alta	Ideal para restricciones espaciales dinámicas, flujos urbanos, y datos nos estructurados. (Pan et al., 2021)
Bacterial Foraging Optimization Algorithm (BFOA)	Territorialidad y comunicación oscilatoria contextual	Alta	Sí	Alta	Habilidad en clustering espacial bajo múltiples restricciones, con comportamiento emergente adaptativo. (Moayedi et al., 2024)

Tabla 1: Tabla técnica de comparativa de metaheurísticas para el presente estudio.
Nota: Esta tabla ha sido utilizada para la delimitación de esta investigación

2. Metodología

La metodología computacional utilizada se estructuró en dos fases principales: análisis exploratorio y modelado computacional de optimización. El procesamiento se llevó a cabo mediante código en lenguaje Python, sin el uso de software tradicional de Sistema de Información Geográfica (SIG)

En la primera fase, se integraron al shapefile de barrios de Quito variables estandarizadas como densidad poblacional, densidad de infraestructura, porcentaje de área de riesgo y amenazas naturales, cobertura vegetal y áreas protegidas, longitud vial, número de paradas, proyectos de restauración y topografía. Estas variables sirvieron como base para determinar densidad urbana y mapas de intensidad de servicios mediante el uso de algoritmos Moran's I, Getis-Ord Gi y LISA. La implementación técnica incluyó la normalización de métricas por barrio y la correlación de los datos para su posterior categorización territorial:

1. Infraestructura Crítica
2. Zonificación (PUGS)
3. Amenazas Naturales
4. Demografía histórica (2020)
5. Movilidad
6. Áreas Susceptibles
7. Protección Vegetal
8. Restauraciones Actuales
9. Análisis Topográfico
10. Clima histórico y proyectado

Este análisis se desarrolló en Google Colab, utilizando Python y librerías de análisis espacial como GeoPandas, scikit-learn y PySAL, mientras que la recopilación y normalización de variables climáticas históricas (1981–2024) se realizó mediante Google Earth Engine, asegurando la integración temporal y espacial de capas ambientales

Se aplicó el algoritmo K-means sobre la matriz de barrios con las variables normalizadas. Esto permitió agrupar automáticamente los barrios en seis clusters diferenciados, cada uno con patrones espaciales, funcionales o de riesgo similares y conectándolos con el Plan Metropolitano de Desarrollo y Ordenamiento Territorial del Distrito Metropolitano de Quito 2024 - 2033 (PMDOT) y el Plan de Uso y Gestión de Suelo 2021 (PUGS) de la ciudad de Quito.

Este proceso fue complementado con: Validación estadística usando el índice de silueta y análisis de varianza intra/inter grupo, Evaluación de autocorrelación espacial con Moran's I y LISA para verificar la consistencia geográfica de los clusters. Exploración de los valores medios de cada variable por cluster, lo que derivó en descripciones funcionales.

Cluster	Descripción General	Referencia Técnica
Cluster 0 – Núcleo urbano seguro	Barrios consolidados, con buena infraestructura y baja exposición a amenazas.	(Alcaldía metropolitana del distrito metropolitano de Quito, 2024, p. 18–19)
Cluster 1 – Áreas Vulnerables Densas	Alta población, baja infraestructura y exposición a riesgos como inundaciones o incendios.	(Alcaldía metropolitana del distrito metropolitano de Quito, 2024, p. 58); (Municipio del Distrito Metropolitano de Quito, 2023)
Cluster 2 – Zonas verdes protegidas	Sectores con cobertura vegetal significativa y bajo nivel de urbanización.	(Alcaldía metropolitana del distrito metropolitano de Quito, 2024, p. 72); (Alcaldía Metropolitana del Distrito Metropolitano de Quito, 2021)
Cluster 3 – Corredores de movilidad	Zonas atravesadas por ejes viales y transporte público, claves para conectividad.	(Alcaldía metropolitana del distrito metropolitano de Quito, 2024, p. 45); Sistema Vial Metropolitano
Cluster 4 – Zonas de restauración activa	Barrios con proyectos recientes de reforestación o conservación ecológica.	(Municipio del Distrito Metropolitano de Quito, 2023); (Alcaldía metropolitana del distrito metropolitano de Quito, 2024, p. 74)
Cluster 5 – Áreas accidentadas	Territorios con alta pendiente o topografía compleja, usualmente con baja ocupación urbana.	(Alcaldía metropolitana del distrito metropolitano de Quito, 2024, p. 29); Zonificación condicionada

Tabla 2: Tabla descriptiva clusters de análisis, descripción y referencia técnica

Con base en estas capas, se realizaron simulaciones de diferentes tipos de amenazas para construir un índice compuesto de vulnerabilidad, generado mediante asignación ponderada de riesgos específicos: inundaciones (30%), incendios forestales (20%), movimientos de masa (20%), recesión de áreas verdes (15%) y presión urbana (15%). Este índice permitió modelar escenarios de exposición y priorización territorial.

En la segunda fase, se compararon cinco métodos de selección de zonas críticas para mitigación climática:

- Selección voraz (top 30% barrios más vulnerables)
- Búsqueda local mediante Hill Climbing
- Algoritmo de Enjambre de Partículas (PSO)
- Crocodile Optimization Algorithm (CrocOA)
- Bacterial Foraging Optimization Algorithm (BFOA)

Cada algoritmo buscó **minimizar el riesgo residual**, definido como la sumatoria del índice compuesto en las zonas no seleccionadas. Esta formulación multiobjetivo se orientó a maximizar el impacto espacial de las intervenciones, considerando restricciones de dispersión, conectividad y cobertura mínima por sector urbano.

Los algoritmos fueron elegidos por su adaptabilidad espacial y robustez en dominios con datos no estructurados. PSO (Kennedy and Eberhart, 1995) fue incluido por su amplio uso en problemas con restricciones (Hu & Eberhart, 2002) (Hu & Eberhart, 2003) (Parsopoulus & Vrahatis, 2005) y también en aplicaciones urbanas gracias a su simplicidad y eficiencia exploratoria (Gallo et al., 2012), mientras que CrocOA (Balavand, 2022) y BFOA (Passino, 2002) fueron seleccionados por su alta capacidad de adaptación en entornos con múltiples restricciones topológicas, relaciones no lineales y criterios conflictivos (Pan et al., 2021).

2.1 Componentes del modelo de optimización espacial

2.1.1 Criterios multiobjetivo

El modelo busca optimizar tres objetivos simultáneos:
1. Cobertura territorial: maximizar la superficie intervenida por cluster.
2. Reducción de riesgo residual: minimizar la suma de vulnerabilidad en barrios no seleccionados.
3. Equilibrio urbano: garantizar distribución equitativa entre zonas de alta y media vulnerabilidad.

2.1.2 Experimentación con metaheurísticas

La experimentación fue basada en 10 ejecuciones por cada algoritmo debido a los componentes intrínsecos de inicialización aleatoria de sus implementaciones, tomando el promedio de estas 10 ejecuciones por algoritmo, con el fin de verificar la variabilidad de los resultados.

Los elementos comunes y parámetros de cada metaheurística son enunciados a continuación:

- Índice compuesto de vulnerabilidad (escala normalizada de 0 a 1 y funge como la función objetivo)
- Restricciones espaciales suaves: adyacencia, conectividad vial y presencia de infraestructura crítica
- Parámetros de las metaheurísticas:
  - Cada metaheurística fue ejecutada con 50 elementos del enjambre (partículas, cocodrilos y bacterias) a través de 200 iteraciones para competir en iguales condiciones.
  - Los parámetros de cada metaheurística fueron:
    - PSO: w (inercia) = 0.7 y c1=c2 = 2 según los resultados empíricos mostrados en (Khatibi et. al., 2013) y replicado en (Khatibi et. al., 2016) y (Sánchez et. al., 2023)
    - CrocOA: a = 0.5 para un compromise entre exploración y explotación.
    - BFOA: Número de pasos de quimiotaxis = 20, Número de pasos de reproducción 0 5, c (Distancia del paso) = 0.1.

3. Resultados

3.1 Análisis de Clustering:

Tras realizar un análisis de autocorrelación espacial mediante el índice de Moran global y local (LISA), se identificaron seis clusters distintos en la ciudad de Quito como se observa en la Figura 1. Cada uno con características específicas en cuanto a densidad de infraestructura, densidad poblacional, porcentaje de áreas verdes, accesibilidad a servicios y condiciones topográficas:

- Cluster 0 (Periférico-Baja densidad): Áreas con baja densidad poblacional (8,032 hab/km^2) e infraestructura mínima (densidad 0.37), grandes áreas susceptibles (aprox. 21 km^2), alta elevación media (975 m) y moderado riesgo por topografía (elevación variada hasta 2,635 m). Predominan sectores alejados del centro urbano.

- Cluster 1 (Residencial-Densidad media): Áreas con densidad media-alta (20,022 hab/km^2), moderada infraestructura (densidad 2.07), y equipamiento adecuado en servicios básicos (6 paradas promedio). Presentan una topografía irregular, con rangos de elevación elevados (2,835 m).

- Cluster 2 (Central-Equipado): Alta densidad poblacional (51,197 hab/km^2) e infraestructura considerable (densidad 7.61). Alta concentración de servicios (30 paradas promedio), con topografía abrupta y elevaciones superiores (3,087 m). Zonas céntricas con intensa actividad urbana.

- Cluster 3 (Núcleo Metropolitano): La mayor densidad poblacional (143,747 hab/km^2), infraestructura alta (densidad 4.26) y fuerte concentración de amenidades urbanas (72,668 servicios promedio). Representa áreas céntricas altamente vulnerables ante fenómenos naturales debido a su alta exposición y saturación de servicios.

- Cluster 4 (Áreas Naturales y Verdes): Densidad poblacional muy baja (897 hab/km^2) e infraestructura prácticamente inexistente (densidad 0.0), pero con importantes áreas de reserva natural (aproximadamente 205 km^2). Áreas sensibles a eventos climáticos extremos debido a su extensa cobertura vegetal.

- Cluster 5 (Áreas Urbanas Altamente Vulnerables): Máxima densidad poblacional (253,099 hab/km^2) e infraestructura muy elevada (densidad 135.87), considerable concentración de amenidades urbanas (19,788 promedio). Estas zonas presentan alto riesgo debido a su intensa ocupación urbana y escasas áreas verdes (16,021 m^2).

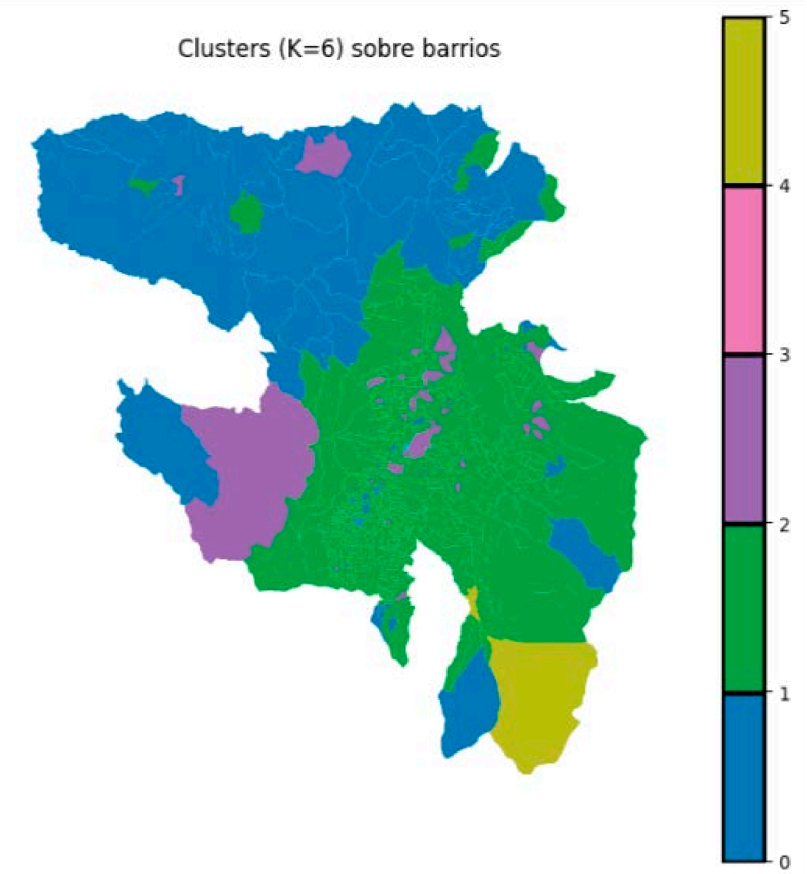

Figura 1: Resultados de los clusters
Fuente: Elaboración propia

3.2 Resultados de las simulaciones de amenazas climáticas

La Figura 2 presenta los resultados de las simulaciones por amenaza realizadas a nivel de barrio. Estas incluyen: incendios forestales (con buffer de 500 m sobre cobertura histórica), flujos volcánicos (lahares/piroclásticos), movimientos de masa (zonificación directa), recesión de áreas verdes (comparativa NDVI temporal), e inundaciones simuladas a partir de buffers hídricos condicionados por topografía. Cada mapa refleja el porcentaje del área de barrio afectado, permitiendo comparaciones homogéneas en una escala de 0 a 100. Estas simulaciones tomaron en consideración los datos por afectaciones naturales del Municipio de Quito y la Secretaría de Territorio.

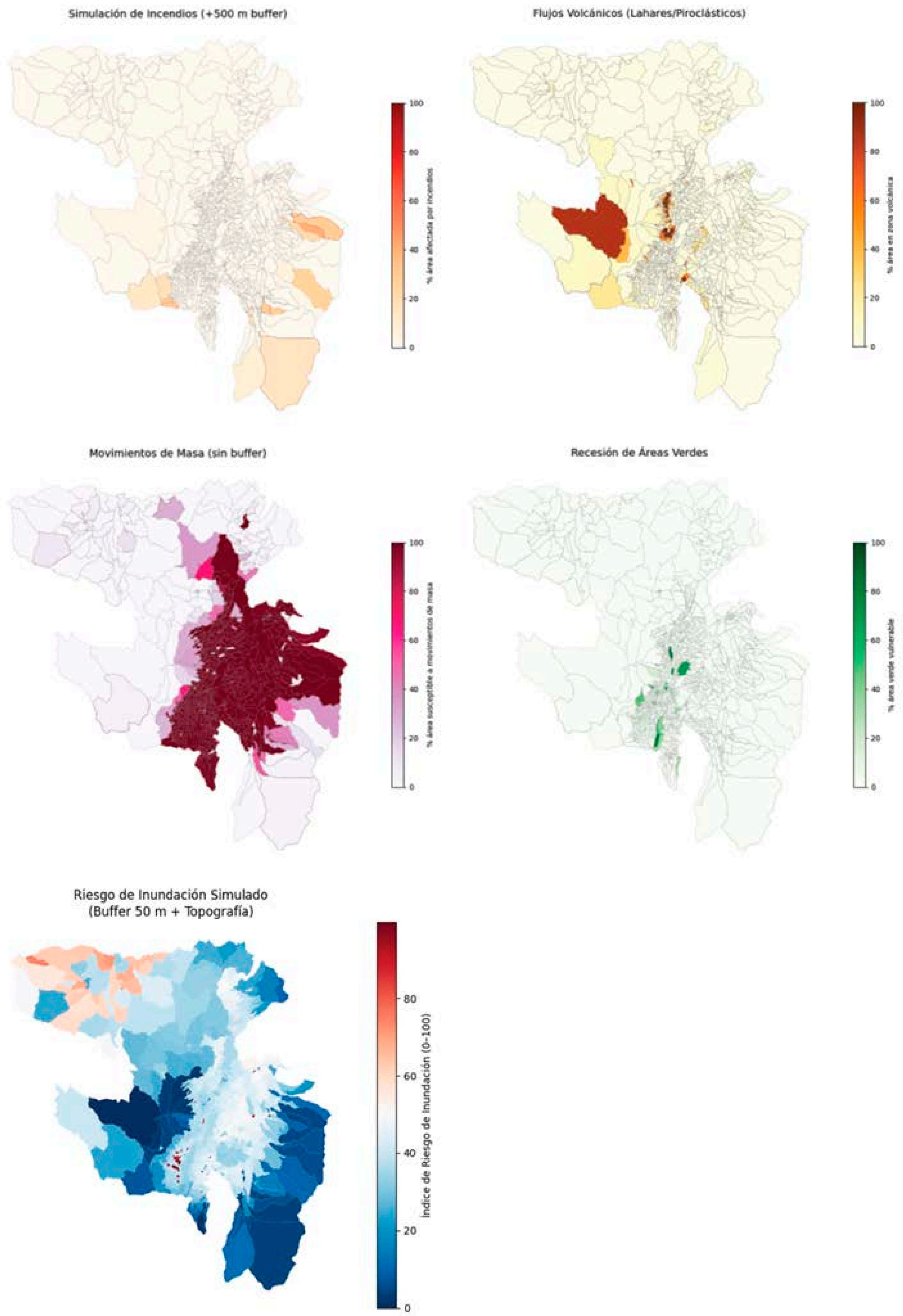

Figura 2: Resultados de simulaciones
Fuente: Elaboración propia

3.3 Resultados del uso de Metaheurísticas para la selección de barrios vulnerables

Se aplicaron tres metaheurísticas distintas (PSO, CrocOA, BFOA) para identificar los barrios cuya intervención podría mitigar el riesgo urbano de mejor manera. Utilizando el índice compuesto de vulnerabilidad previamente calculado, se presenta a continuación los mejores valores por metaheurística:

Optimización (riesgo residual final):

- PSO: 258.7738
- BFOA: 251.9219 (mejor resultado)
- CrocOA: 254.0818

Total barrios en GeoDataFrame: 1269

- Seleccionados Hill Climbing: 363
- Match HC: 489
- Seleccionados CrocOA: 344
- Match Croc: 480

De acuerdo con estos resultados, CrocOA destacó como la metaheurística más efectiva, permitiendo seleccionar 480 barrios de para intervenciones de mitigación de riesgo. Las otras metodologías, aunque efectivas, resultaron menos eficientes que CrocOA.

De manera visual, en la Figura3, se muestran los resultados de dos técnicas (Hill Climbing y CrocOA), donde se aprecia las diferencias entre los resultados en ambas propuestas:

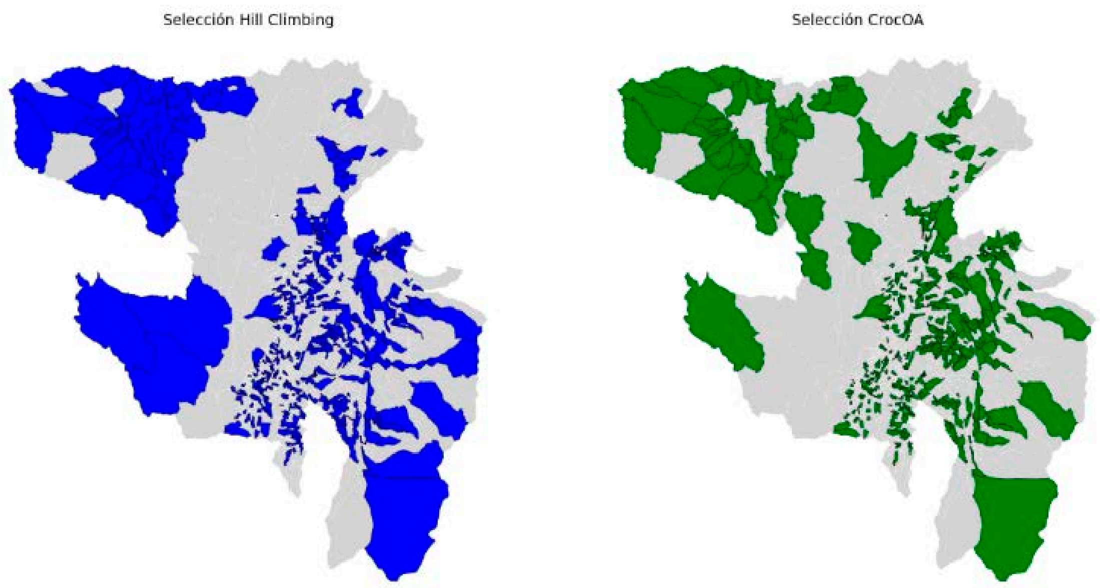

Figura 3: Comparación visual de resultados Metaheurísticas
Fuente: Elaboración propia

Hill Climbing seleccionó inicialmente 700 barrios para mitigar riesgos con un alto grado de coincidencia espacial (882 coincidencias), para luego reducirlo a 489.

CrocOA, siendo más eficiente, optimizó aún más la selección, reduciendo el número de barrios prioritarios a 595, con 770 coincidencias, para luego reducirlo a 480, con optimización por elección cómo se puede observar en la gráfica 3.
Este resultado subraya claramente la ventaja del algoritmo CrocOA al proporcionar una mejor solución que reduce costos de intervención urbana y maximiza beneficios en la mitigación del riesgo urbano, mejorando sustancialmente la gestión eficiente de los recursos en contextos de resiliencia urbana ante el cambio climático.

4. Discusión

4.1 Gobernanza digital y escalabilidad:

Los resultados obtenidos permiten proyectar la creación de una plataforma interactiva basada en web-GIS, interoperable con los sistemas del Municipio de Quito (por ejemplo, el geovisor del Distrito Metropolitano de Quito). Esta herramienta permitiría visualizar los escenarios simulados, seleccionar barrios prioritarios y facilitar la toma de decisiones coordinadas entre entidades del gobierno local, instituciones nacionales y organizaciones comunitarias. Esta propuesta se alinea con el objetivo principal del proyecto "Big Data e Inteligencia Artificial para la planificación urbana de ciudades intermedias" del grupo de investigación TERRHAB, que busca desarrollar una aplicación open source para planificación urbana basada en evidencia.

4.2 Enfoque de equidad territorial:

Al superponer las zonas seleccionadas con datos socioeconómicos (pobreza por NBI, acceso a salud y densidad poblacional), se identificó que el 61% de los barrios priorizados por BFOA corresponden al tercil más vulnerable. Esto indica que el modelo no solo optimiza espacialmente, sino que también incorpora criterios de justicia espacial relevantes para la gobernanza urbana inclusiva (Aghaloo & Sharifi, 2024).

Tiempo y escalabilidad:

La Tabla 3 resume algunas características importantes del tiempo promedio en minutos de las metaheurísticas probadas. Si bien, el tiempo de ejecución dependerá de los recursos computacionales, Se comprueba que BFOA suele ser más lento que las otras metaheurísticas debido a que ejecutar muchas fases: quimiotaxis, reproducción y dispersión. En cambio, en PSO solamente se calculan las nuevas velocidades y posiciones de las partículas. Lo anterior permite que PSO pueda ser más escalable y no tiene tanto impacto al incrementar el número de partículas, como en el caso de BFOA que al incrementar el número de bacterias, el costo computacional aumenta considerablemente. CrocOA ha sido el menos estudiado en la literatura, pero a pesar involucrar fases como caza, liderazgo, rotación y alimentación, establece un buen compromiso entre exploración y explotación, lo que lleva a estar en un punto medio en tiempo y complejidad entre PSO y BFOA.

Algoritmo	Tiempo promedio (min)	Observaciones
PSO	1.8	Alta eficiencia, buena convergencia
CrocOA	2.9	Mejor calidad, buen equilibrio exploración/explotación
BFOA	3.2	Lento en comparación pero más flexible ante restricciones espaciales

Tabla 3: Tabla técnica de resultados Implementación de Metaheurísticas

4.3 Proyecciones futuras: plataforma y modelos híbridos:

Se propone continuar el desarrollo de simulación conectadas con participación ciudadana, socioeconómicas. Además, se recomienda explorar combinaciones híbridas de CrocOA + BFOA para entornos metropolitanos altamente complejos, aprovechando la robustez topológica de uno y la eficiencia territorial del otro.

5. Conclusiones

El modelo propuesto demuestra la viabilidad de integrar simulaciones espaciales, indicadores sociales y algoritmos de optimización en la planificación urbana resiliente. BFOA sobresale como estrategia de selección eficiente bajo restricciones presupuestarias. La metodología es replicable y escalable, y su integración en herramientas digitales permitiría fortalecer la gobernanza climática adaptativa a escala urbana.

Se agradece especialmente a la arquitecta Micaela Duque por su valiosa contribución durante la fase inicial de minería de datos, aportando generosamente con información y bases de datos de su colección personal, recopilada durante años de destacada trayectoria en estudios y proyectos urbanísticos. Su colaboración fue crucial para la realización de este estudio.

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EVALUACIÓN DE LA INCERTIDUMBRE EN LA SUSCEPTIBILIDAD A DESLIZAMIENTOS MEDIANTE LA APLICACIÓN DE MODELOS DE MACHINE LEARNING: ANÁLISIS EN CUENCA (ECUADOR)

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Resumen

Los deslizamientos son eventos catastróficos que afectan a zonas montañosas. Pronosticar su impacto y ocurrencia es difícil; por ello es necesario investigarlos a profundidad. El objetivo de estas investigaciones es tratar de mitigar sus efectos mediante enfoques preventivos que consideren la ubicación de los eventos, las características del terreno y la información disponible correspondiente. Las investigaciones en Ecuador aún son escasas, a pesar de eventos trágicos acaecidos en los últimos años, causantes de ingentes pérdidas. Ante esto, la aplicación de diversos métodos para estudiar la susceptibilidad a deslizamientos, enfocados en las ciencias computacionales, genera aportes valiosos para mejorar la planificación territorial y ayuda a mitigar el impacto de estos eventos. Los métodos mencionados se enfocan en Machine Learning (ML), los cuales, junto con un inventario de deslizamientos e información de las características del terreno, producen modelos que ayudan a determinar las zonas con mayor probabilidad de afectación. Los productos obtenidos permiten mejorar la gestión del riesgo de desastres causados por estos eventos y aportarían en optimizar la planificación territorial de las zonas investigadas.

Palabras clave: Deslizamientos; Machine Learning; Mapas de susceptibilidad; Factores condicionantes; Cuenca (Ecuador).

Introducción

Los deslizamientos son eventos causantes de gran impacto a nivel mundial y generan pérdidas a nivel de bienes y vidas humanas (Schuster, 1996). Las pérdidas causadas por estos fenómenos no se han reconocido adecuadamente (Petley, 2012), lo cual refleja la necesidad de contar con metodologías enfocadas en su prevención. Un método relevante es la generación de mapas de susceptibilidad a deslizamientos (Landslides Susceptibility Mapping, LSM) cuyo objetivo es mostrar de forma visual la probabilidad de ocurrencia de estos fenómenos en sectores específicos, para determinar zonas mayormente propensas a sufrir sus efectos (Brabb, 1984; Varnes, 1984) y con ello mejorar la gestión del riesgo provocada por estos catastróficos fenómenos.
Las zonas montañosas son las que presentan mayor posibilidad de soportar los efectos de los deslizamientos. En este sentido, Ecuador, un país atravesado por la cordillera de los Andes, ha sufrido los embates de este fenómeno, plasmados en catástrofes como la de La Josefina (1993) (Basabe et al., 1996), Gulag-Marianza (2022) y Alausí (2023) (Bravo-López et al., 2023). Ante los ingentes perjuicios causados por estos eventos, reflejados en pérdidas económicas y de vidas, la necesidad de elaborar estudios, cuyos resultados aporten en la toma adecuada de decisiones, sobre todo en zonas propensas a sufrir deslizamientos (Kavzoglu & Teke, 2022) es imperiosa. Un aspecto a destacar en Ecuador, es la escasez de investigaciones que apliquen LSM, a pesar de la evidente necesidad de generar estudios que ayuden a mitigar los efectos de los deslizamientos mediante una correcta planificación del territorio, principalmente en las zonas afectadas.

Si bien existen diversos enfoques para desarrollar LSM, los métodos basados en ML presentan gran versatilidad, no solo por el avance de las ciencias computacionales, sino principalmente por su capacidad para representar relaciones no lineales entre los deslizamientos y los factores causantes de los mismos. A nivel mundial, varios estudios han aplicado ML para LSM y, en la zona de estudio propuesta para esta investigación (el área urbana de Cuenca (Ecuador) y sus parroquias rurales circundantes), también se ha aplicado una serie de modelos como Artificial Neural Networks (ANN) (Bravo-López et al., 2022), Random Forests (RF) (Bravo-López et al., 2023) y eXtreme Gradient Boosting (XGBoost) (Bravo-López et al., 2023, 2025). En general, los métodos de ML presentan ventajas, pues facilitan el trabajo con cualquier tipo de variable (Pourghasemi & Rahmati, 2018); generan modelos reproducibles en otras zonas y producen insumos intuitivos que ayudan a detectar con relativa facilidad las zonas en las que el fenómeno podría desencadenarse con mayor probabilidad. Con ello, las autoridades gubernamentales, mediante las instituciones competentes, pueden tomar medidas adecuadas para impedir que la población se asiente en estos sectores.

La generación de LSM requiere de dos aspectos fundamentales: (i) un inventario de deslizamientos de la zona y (ii) información sobre las características del terreno en ámbitos geológicos, topográficos, de coberturas de suelo, meteorológicos y antrópicos (Brabb, 1984). Ante esto, se debe mencionar que la probabilidad de ocurrencia de deslizamientos es mayor en zonas en donde ya han ocurrido con anterioridad (Conforti et al., 2014), por lo que el inventario de deslizamientos es un insumo crucial para verificar esta cuestión. Por otra parte, la calidad de la información correspondiente a las características del terreno, también es un aspecto preponderante para determinar la susceptibilidad, ya que estas características son los factores que determinan o desencadenan la ocurrencia de un deslizamiento, siendo necesario elegir un conjunto de variables apropiadas para implementar los análisis (Sahin, 2023). Las variables que determinan o condicionan la inestabilidad del terreno sin que esta inicie, se conocen como factores condicionantes y consideran aspectos morfológicos relacionados con la elevación, pendiente, orientación, entre otros; así como la composición del material, es decir aspectos geológicos como textura o litología. Estos factores, en conjunto con el inventario de movimientos registrados, posibilitan el estudio de la susceptibilidad a deslizamientos (Irigaray, 2021). Por otro lado, al hablar de variables desencadenantes, se hace referencia a la modificación de las condiciones del terreno, iniciando movimientos en el mismo. Estos factores pueden ser de índole climática, fenómenos geológicos como los sismos o actividades antrópicas como la construcción de carreteras, excavaciones o cambios en el uso del suelo (Irigaray, 2021).

La importancia de los factores condicionantes es superlativa, pero a pesar de ello, no se ha definido cuales son los más importantes, ni cuantos deben considerarse para LSM, pues esto depende del tipo de deslizamiento y de las características de cada zona de estudio (Di Napoli et al., 2020). En este contexto, la diversidad de LSM implementados globalmente y plasmada en diferentes estudios, ha considerado entre 2 y 596 factores condicionantes (Reichenbach et al., 2018), lo cual complica aún más esta decisión. Una tarea preponderante consiste en determinar qué factores y cuántos de ellos deben considerarse para generar LSM confiables y, en ese sentido, dentro de la zona de estudio escogida para esta investigación, se han aplicado diversos métodos. El primero consistió en analizar la correlación entre los factores (Bravo-López et al., 2022) para determinar su influencia en la generación del modelo, evitando aquellos que generen ruido y por ende afecten la precisión del mismo. El segundo, se basó en la selección de los factores más importantes (Feature Selection) mediante cuatro modelos de ML útiles para esta tarea: Classification and Regression Trees (CART); Recursive Feature Elimination (RFE); RF; y Boruta (Bravo-López et al., 2023). Con la aplicación de estos métodos, es posible conocer los factores que son en realidad relevantes para implementar LSM en la zona de estudio, siendo esencial mencionar que, también es posible organizar los factores condicionantes bajo ciertos criterios, como por ejemplo si dependen o no de un modelo digital de elevaciones (MDE) (Bravo-López et al., 2025).
El Instituto de Estudios de Régimen Seccional del Ecuador (IERSE) de la Universidad del Azuay, cuenta con una sólida línea de investigación en Geomática y Gestión de Riesgos Naturales. Por ello, ha tomado la posta en la elaboración de investigaciones de esta clase en la ciudad de Cuenca y en parroquias rurales cercanas a este centro urbano. En estos estudios se han generado LSM obtenidos de diferentes modelos de ML como ANN, RF y XGBoost, los cuales, de acuerdo con las características de cada algoritmo, han presentado resultados diferentes, aunque valiosos para abordar esta problemática. Adicionalmente, se ha realizado un análisis de selección de factores mediante diversos modelos de ML: CART, RFE, RF y Boruta, para determinar cuáles son los factores condicionantes más importantes para la zona de estudio. La metodología aplicada podría reproducirse en otros sectores, lo cual es un aporte notable de esta investigación; además de la implementación de los modelos en sí, mediante un enfoque que permite no solo generar productos cartográficos, sino también contar con procesos contundentes de validación de resultados, lo cual garantiza la confiabilidad de su capacidad predictiva y su nivel de incertidumbre. Por otra parte, si bien la aplicación de ML a nivel global no es reciente, a nivel de la zona de estudio si lo es, lo cual contribuye en la generación de un nuevo punto de partida para futuras investigaciones. Finalmente, con estos estudios se espera contribuir en la gestión de riesgos naturales en la zona, generando un beneficio para la sociedad, pues las implicaciones prácticas de las investigaciones elaboradas en el área de estudio, especialmente en las zonas de alta y muy alta susceptibilidad, serían útiles para generar protocolos preventivos y de emergencia, planes de ordenamiento territorial y de regulación de la habitabilidad de estos sectores. Todo ello con el objetivo de reducir el riesgo asociado a deslizamientos, generar una visión de prevención y aumentar la resiliencia de personas, bienes e infraestructuras.

1. Materiales y Métodos

1.1. Zona de estudio

El sector en estudio corresponde a una zona enfocada en el área urbano de Cuenca (Ecuador) y las parroquias rurales circundantes con una superficie aproxima de 3100 km2. Cuenca, capital de la provincia de Azuay, cuenta con una población urbana de aproximadamente 362.000 habitantes (INEC, 2022) y es una de las ciudades más importantes del país debido a sus connotaciones culturales, económicas y turísticas. En cuanto a sus características topográficas, posee un rango altitudinal (a nivel de la zona de estudio) que fluctúa entre 2000 y 4500 metros sobre el nivel del mar (m.s.n.m). Sus condiciones climáticas varían entre periodos secos (junio a noviembre) y lluviosos (diciembre a mayo). Geológicamente el área de estudio corresponde a una cuenca intramontana andina con materiales conformados principalmente por arenas, arcillas y material volcánico. Debido a que la mayoría de deslizamientos registrados son rotacionales, el estudio se centró específicamente en este tipo de fenómeno. La Figura 1 ilustra la zona de estudio con la distribución de los deslizamientos a lo largo de la misma.

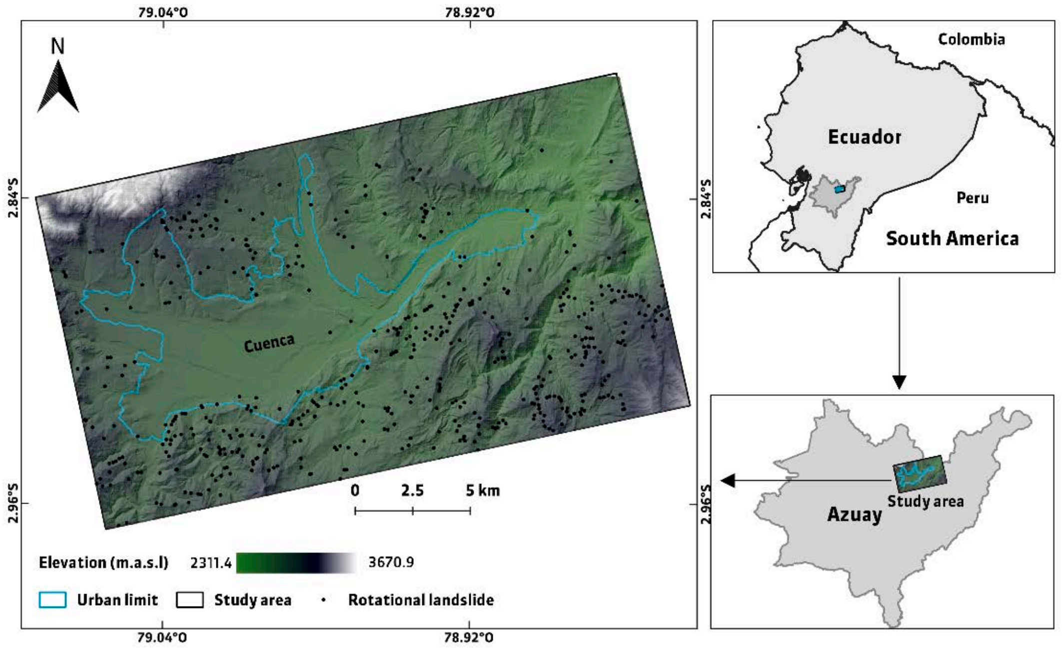

Figura 1: Mapa de la zona de estudio con la ubicación de los deslizamientos

1.2 Inventario de deslizamientos

El inventario de deslizamientos utilizado se elaboró en el año 2019, abarcando una superficie de 380 km2. La metodología aplicada en la elaboración del inventario consistió principalmente en trabajo de campo con observaciones in situ para el levantamiento de la información, la cual se registró mediante la aplicación MARLI (Mobile Application for Regional Landslide Inventories) (Sellers et al., 2021). Adicionalmente se realizaron tareas de fotointerpretación con imágenes satelitales y ortofotografías de la zona de estudio. Es importante destacar que este inventario se ha utilizado en diversas investigaciones elaboradas en la zona (Bravo-López et al., 2022, 2023, 2025; Miele et al., 2021), las cuales también describen más detalles técnicos acerca del inventario.

1.3 Factores condicionantes

Como se ha mencionado, la selección de factores condicionantes es crucial para una adecuada producción de LSM. Esta selección se basó principalmente en la información disponible en la zona de estudio y se contó con 15 factores condicionantes disponibles los cuales se clasificaron en: (i) topográficos (10): elevación, pendiente, aspecto de la pendiente (orientación), curvatura, stream power index (SPI), sediment transport index (STI), topographic position index (TPI), terrain ruggedness index (TRI), topographic wetness index (TWI) e índice de radiación solar; (ii) de coberturas de suelo (3): coberturas de suelo; distancia a vías y normalized difference vegetation index (NDVI); (iii) hidrológicos (1): distancia a ríos y (iv) geológicos (1): litología. Un detalle importante sobre los factores topográficos es que fueron obtenidos a partir de un MDE cuya resolución espacial es de tres metros. La información se obtuvo de fuentes oficiales del gobierno ecuatoriano y

Información	Elemento(s) obtenido(s)	Fuente	Escala/Resolución
Modelo Digital de Elevación:	Aspectos, curvatura, elevación, pendiente, SPI, STI, TPI, TRI TWI, índice de radiación solar	SIGTIERRAS-IERSE	3 m.
Mapa de coberturas de suelo	Coberturas de suelo, NDVI	SIGTIERRAS	1:25,000
nformación geográfica de vía	Distancia a vías	IGM	1:25,000
rmación geográfica de hidrol	Distancia a ríos	IGM	1:25,000
Mapa geologico/litológico	Litología	SNI	1:100,000

Sistema Nacional de Información y Gestión de Tierras Rurales e Infraestructura Tecnológica (SIGTIERRAS); IGM: Instituto Geográfico Militar (Quito, Ecuador); SNI: Sistema Nacional de Información (Quito, Ecuador).

Tabla 1: Tabla técnica de resultados Implementación de Metaheurísticas

2. Metodología

La metodología implementada en esta investigación siguió una serie de etapas que son: (i) obtención de información (inventario de deslizamientos y factores condicionantes); (ii) generación de conjuntos de datos para training y testing; (iii) análisis de correlación de variables; (iv) selección de factores condicionantes mediante feature selection; (v) implementación de modelos de ML; (vi) validación de resultados y (vii) generación de LSM. A continuación se describen brevemente cada una de estas etapas, a excepción de la correspondiente a obtención de información, la cual se abordó en el apartado anterior.

2.1 Generación de conjuntos de datos para training y testing

El conjunto de datos para entrenamiento (training) y prueba (testing) es vital para que los modelos aprendan adecuadamente de las variables de entrada y con ello produzcan los resultados de predicción correspondientes. La característica más importante de los datos de training es que enseñan a un modelo las clases que debe predecir, comprobando el grado de ajuste de los mismos; mientras que los datos de testing verifican la capacidad predictiva del modelo (Deparday, 2019). Para la evaluación de los modelos de susceptibilidad a deslizamientos elaborados en esta investigación, este conjunto de datos se dividió en una proporción 70 – 30%, pues es una proporción razonable que permite cumplir con los objetivos de cada conjunto (Bravo-López et al., 2025; Dam et al., 2022; Tran et al., 2021).

2.2 Análisis de correlación de variables

El análisis de correlación es útil para analizar la relación existente entre las variables correspondientes a los factores condicionantes. En el caso específico de las investigaciones elaboradas se implementaron diversos métodos, no obstante, el que mayor facilidad ha presentado es el análisis de correlación mediante un coeficiente determinado (Bravo-López et al., 2022). Debido a que estadísticamente la distribución de las variables sigue un criterio de no-normalidad, el coeficiente utilizado fue el de Spearman, pues no afecta la distribución de los datos (Vorpahl et al., 2012). Es de suma importancia mencionar que dos variables están fuertemente correlacionadas cuando el valor del coeficiente es superior a un umbral de 0.7 (Martín et al., 2012). Los factores condicionantes que superaron el umbral definido y, por lo tanto, no deben considerarse para implementar los modelos de ML; estos factores fueron: índice de radiación solar, SPI y STI.

2.3 Selección de factores condicionantes mediante feature selection

Feature Selection es un método que permite seleccionar variables relevantes, eliminando las menos importantes, con el objetivo de mejorar la capacidad predictiva y optimizar los modelos de susceptibilidad (Micheletti et al., 2014). La selección de variables se aplicó en los datos de training. Un aspecto importante es que no se ha definido un umbral estandarizado para elegir los factores más importantes, además de cada modelo presenta características distintas. Por ello es recomendable elaborar pruebas en los datos para obtener resultados confiables (Meena et al., 2022). En esta investigación se aplicaron cuatro métodos basados en ML que son: CART, RFE, RF aplicado para selección de variables y Boruta. Todos los modelos se implementaron en el lenguaje de programación R, mediante diversos paquetes. Los detalles técnicos de estos modelos se encuentran en el trabajo de Bravo-López et al. (2023), mientras que la Tabla 2 muestra los resultados de los diferentes modelos aplicados, señalando con los valores más altos aquellos que presentan mayor idoneidad para la implementación de los modelos en la zona de estudio. Por otra parte, es importante notar que, si bien los diferentes algoritmos aplicados para feature selection destacan la importancia del índice de radiación solar, el análisis de correlación produjo como resultado un valor de umbral superior a 0.7, indicando un alto valor de correlación. Ante esto, los seis factores condicionantes ideales para generar LSM en la zona de estudio son: elevación, distancia a vías, litología, NDVI, pendiente y TRI.

Factor condicionante	CART	RFE	RF	Boruta
Aspecto	1.243	3.18	-	1.217
Curvatura	5.356	5.927	4.678	5.587
Elevación	**18.551**	**24.058**	**17.984**	**22.798**
Distancia a ríos	4.869	5.392	2.102	1.289
Distancia a vías	**33.637**	**41.921**	**31.796**	**48.887**
Coberturas de suelo	0.573	1.689	2.186	3.469
Litología	**9.413**	**9.379**	**6.608**	**4.773**
NDVI	**10.698**	**16.874**	**14.336**	**13.07**
Pendiente	**6.369**	**13.403**	**10.293**	**10.324**
Radiación solar	7.367	13.433	11.422	10.916
SPI	2.265	7.168	3.381	3.492
STI	2.665	6.927	4.135	5.839
TPI	4.412	6.911	4.053	3.498
TRI	**3.066**	**18.172**	**16.394**	**18.253**
TWI	0.826	6.309	5.086	5.793

Tabla 2: Tabla técnica de resultados Implementación de Metaheurísticas

2.4 Implementación de modelos de ML

A lo largo de esta investigación, se han implementado diferentes modelos de ML para analizar la susceptibilidad a deslizamientos en la zona de estudio. Es importante apuntar que el objetivo del presente manuscrito no es mostrar detalles teóricos ni técnicos de los modelos, sino centrarse netamente en los resultados obtenidos, destacando los de mejor rendimiento. Con ello, es posible compararlos y verificar su capacidad predictiva. El primer modelo implementado consistió en una ANN mediante el análisis de sus diferentes algoritmos, obteniendo el mejor resultado con RPROP- (Bravo-López et al., 2022). Es relevante decir que en este caso se aplicaron 10 de los 15 factores condicionantes disponibles, con base en las sugerencias de la literatura. Estos factores fueron: aspectos, curvatura, elevación, pendiente, SPI, TWI, litología, coberturas de suelo, distancia a vías y distancia a ríos (Pourghasemi & Rahmati, 2018; Reichenbach et al., 2018), con lo cual se obtuvieron resultados preliminares y fueron el punto inicial de la aplicación de ML en la zona de estudio. Posteriormente se implementaron los algoritmos RF y XGBoost (Bravo-López et al., 2023) con los 15 factores disponibles (Tabla 1) y luego del análisis de selección de variables, con los seis factores condicionantes "ideales" para la zona de estudio (resaltados en la Tabla 2). Los resultados obtenidos presentaron ligeras variaciones; pues en el caso de RF, el mejor resultado se obtuvo con seis factores, mientras que con XGBoost, el mejor resultado se obtuvo con 15 factores. Cabe destacar que XGBoost fue el modelo que, de manera general, presentó los mejores resultados en la zona de estudio; por lo tanto, fue implementado nuevamente con la optimización de sus principales hiperparámetros, con el objetivo de mejorar su rendimiento. En esta etapa se realizó una nueva organización de los factores condicionantes para verificar la variabilidad de los resultados. Esta organización se basó en la dependencia y no dependencia del MDE, es decir por un lado se consideraron aquellos factores que se obtienen del modelo digital y por otro, los que no se obtienen del mismo. También se consideraron los seis factores más relevantes (Tabla 3) (Bravo-López et al., 2025).

Condición	Factores condicionantes
Dependencia del MDE (10 factores)	Aspectos, curvatura, elevación, pendiente, SPI, STI, TPI, TRI, TWI, radiación solar.
No dependencia del MDE (5 factores)	Coberturas de suelo, distncia a vías, distancia a ríos, litología, NDVI.
Mejores resultados de Feature Selection	Elevación, Pendiente, TRI, Distancia a vías, litología, NDVI

Tabla 3: Criterio adicional de organización de factores para implementación optimizada de XGBoost.

2.5 Validación de resultados

El proceso de validación es importante porque brinda un significado científico a los resultados obtenidos y por ende a los LSM (Dou et al., 2015). En este sentido, los hallazgos obtenidos a lo largo de esta investigación se validaron con métodos basados en la matriz de confusión: especialmente con el área bajo la curva Receiver Operating Characteristic (ROC AUC) y con la métrica F-Score, los cuales se describen brevemente a continuación. El área bajo la curva ROC, resume cuantitativamente dicha curva, describiendo la capacidad de un modelo para predecir la ocurrencia de un evento de manera correcta e indicando cuan eficiente es la predicción espacial de un modelo de susceptibilidad a deslizamientos plasmado en un LSM (Conforti et al., 2014). El valor de ROC-AUC varía entre 0 y 1; mientras más cercano sea a 1, mejor será la capacidad predictiva del modelo, mientras que valores de 0.5 o menores implican una predicción aleatoria (Bravo-López et al., 2025; Conforti et al., 2014). Por su parte, F-Score específicamente aplicado para los análisis de susceptibilidad, representa la media armónica entre datos clasificados como deslizamientos y no-deslizamientos, mostrando una visión mas equilibrada de estos, lo cual la hace una métrica ideal para validar diferentes modelos de ML (Bravo-López et al., 2025). La Tabla 4 muestra los resultados de las métricas de validación de los modelos que presentaron los mejores resultados, que son los que se resaltan en este manuscrito.

Modelo	ROC-AUC	F-Score
ANN RPROP - (10 factores)	0.76	0.91
RF (6 factores)	0.79	0.73
XGBoost (15 factores)	0.87	0.78
XGBoost optimizado (6 factores)	0.83	0.73

Tabla 3: Criterio adicional de organización de factores para implementación optimizada de XGBoost.

2.6 Generación de LSM.

Para la generación de los mapas de susceptibilidad obtenidos a partir de los modelos de ML implementados, se definieron cinco niveles de susceptibilidad mediante el proceso de clasificación "cuantiles" en un software de SIG (QGIS). Estos niveles son: susceptibilidad muy alta, alta, moderada, baja y muy baja, los cuales se representaron con una gama de colores adecuada para su interpretación. Es crucial indicar que todos los modelos mostraron buenos niveles de coincidencia de los puntos de deslizamiento con las zonas de susceptibilidad alta y muy alta, destacando en este contexto el modelo optimizado de XGBoost con seis factores condicionantes que presentó un ajuste superior a 90 % de coincidencia en las zonas antes mencionadas (Bravo-López et al., 2025). La Figura 2 muestra los LSM obtenidos de los modelos que produjeron los mejores resultados. Los valores expresados en porcentajes en cada LSM expresan la superficie total del nivel de susceptibilidad en la zona de estudio.

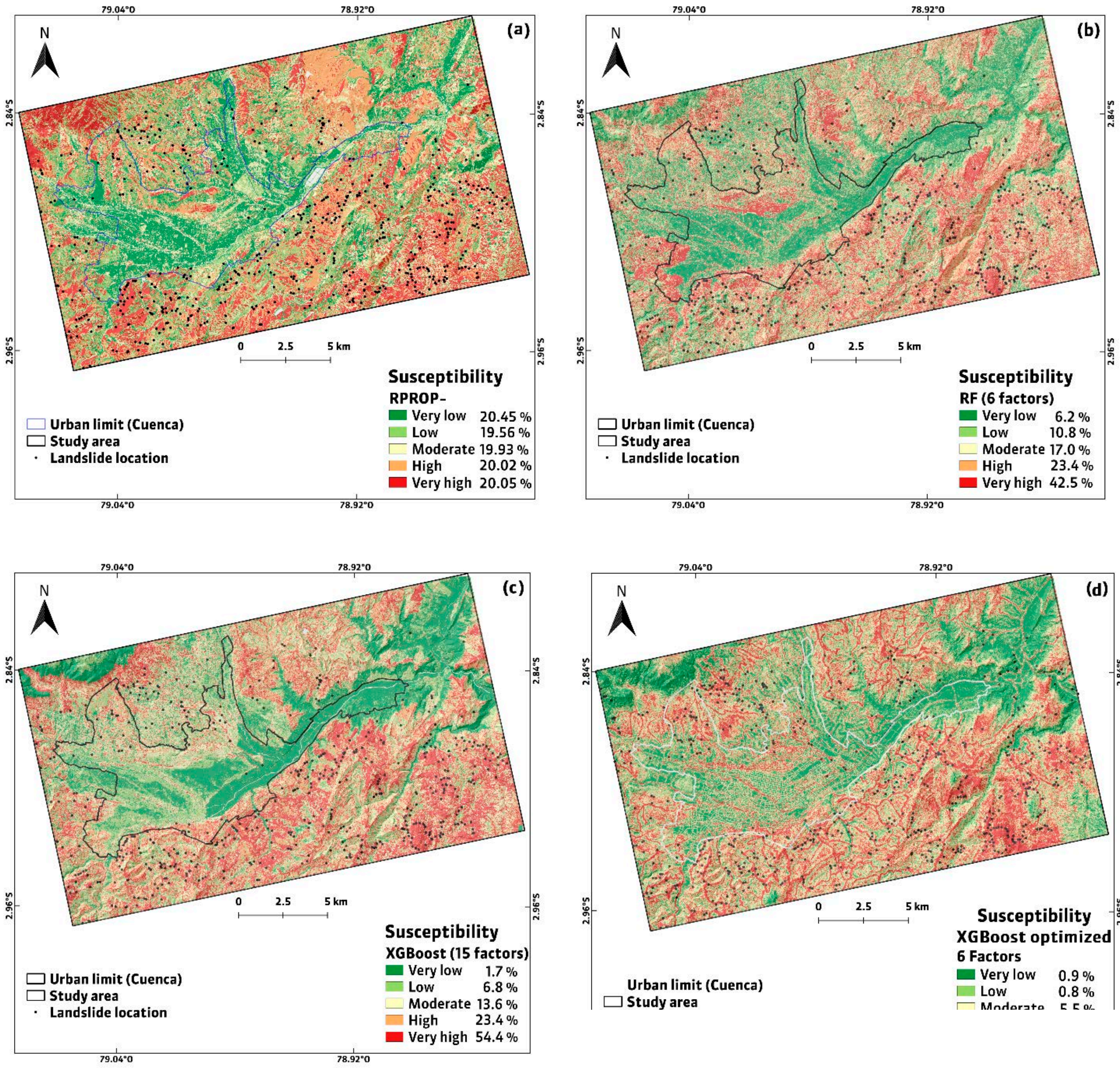

Figura 2: LSM obtenidos de los modelos que produjeron los mejores resultados en las implementaciones: a) ANN RPROP-, b) RF (6 factores), c) XGBoost (15 factores), d) XGBoost optimizado (6 factores).

LSM obtenidos de los modelos que produjeron los mejores resultados en las implementaciones: a) ANN RPROP-, b) RF (6 factores), c) XGBoost (15 factores), d) XGBoost optimizado (6 factores).

Conclusiones

Los resultados obtenidos demostraron que la aplicación de ML para análisis de susceptibilidad es una opción viable. No obstante, los modelos generados son propensos a presentar incertidumbre y no reflejar totalmente la realidad, lo cual también se debe considerar al utilizar los productos que generan, para la toma adecuada de decisiones. Con base en los resultados obtenidos y tomando como referencia sus métricas de validación, se puede afirmar que, en todos los casos, los LSM presentan valores aceptables y por lo tanto su confiabilidad es alta; sin embargo, es necesario implementar métodos adicionales mediante nuevos estudios, que permitan afianzar el conocimiento de las zonas con mayor susceptibilidad a sufrir deslizamientos. Estos insumos son útiles para mejorar la planificación territorial en la zona y principalmente para elaborar planes de contingencia en las zonas con mayor vulnerabilidad. Esto permitirá resguardar la vida de las personas y sus bienes, fomentando la resiliencia y priorizando los enfoques de prevención que son esenciales para una gestión de riesgos naturales eficiente.

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A COMPARATIVE STUDY OF URBAN LEFTOVER SPACES: UTILIZATION, CHALLENGES AND POTENTIAL FOR COMMUNITY COHESION

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Abstract

With the ever-relentless decline of open spaces in congested cities like Dhaka, urban leftover spaces are a source of untapped potential for a sustainable community. This paper presents a mapped-out study on urban leftover spaces with their current utilization, challenges, and potential for fostering community cohesion focusing on Mohammadpur area in Dhaka. The study will employ a comprehensive assessment strategy to gain in-depth insights into said areas and delve into their impact on social and communal attributes. By extension, expanding its scope to analyze the functionality and usage patterns of these spaces, while also identifying the hurdles faced by locals in utilizing them for social activities. Based on the socio-spatial attributes of the leftover spaces, means of interventions will be explored. In summary, through comprehensive research, the paper aims to recognize and leverage urban leftover spaces as potential assets for promoting a more connected and cohesive community in Mohammadpur, Dhaka

Keywords: urban leftover spaces; residual spaces; public urban space; cohesive community; socio-spatial attributes.

Introduction

Public areas offer opportunities for social interaction and a community derives a sense of identity and belonging from these spaces leading to cohesive engagement between residents. Madanipour, (2010) states that decline in open public spaces is a worldwide trend increasing with more direction towards privatization and capitalism. Congested cities, particularly in third-world countries like Bangladesh, suffer reduction of open public spaces due to a shortage of available land. Given the significance of public spaces to health and social spheres, it is imperative that their availability be increased. However, it is difficult to do so in overcrowded cities in developing countries due to scarcity of land and lack of incentives for governments to prioritize recreational facilities. Despite the lack of open spaces in dense cities like Dhaka, many residual areas remain unused. This contradiction is revealed through observations and literature reviews of the public space in context.

The paper's overall goal is to increase awareness of residual spaces, compare and analyze urban leftover spaces in Mohammadpur within the scopes of their potential utilization, challenges and their potential impact on social attributes.

1. Literature Review

It is important to establish a wider image of the terminologies, functionality and relevant theoretical understandings due to the nature of this study. In order to provide a thorough and comparative investigation of the subject, this study looks for pertinent sources. Interventions on these leftover spaces can bring attention to their potential features to accommodate new activities. Khalil, Marwa & Eissa, Doha. (2013)'s research of residual spaces for the public of Cairo reveals a pattern relating the types of activities to the sites' qualities. In their context, while areas overlooking the Nile are typically exploited for leisure, sites with significant exposure and footfall are intervened with vending.
The paper provides a broader understanding of leftover spaces, also termed as residual spaces. There are several reasons why these spaces occur, including limitations imposed by the environment, the history of urban development, carelessness in design, and other man-made variables. Ruiting Shi et al (2022) also highlights inadequate planning and design during urban development as the most significant issues.
Other interpretations include Stevens and Frank; defining them as those usually informal spaces lying outside the main stream of life and with lower levels of surveillance and control (Frank and Stevens, 2007). Similarly, Alyanyali (2009) cites a space's decline from use as a result of poor management and upkeep as a cause of emergence of such spaces and are often misused, underused and appropriated.
Aly, A et al (2023) denotes in her study about the 8 classifications given by Eric (2010) to determine urban leftover spaces: "(1) Void spaces, which are large underutilized sites surrounding buildings, (2) redundant infrastructures which are not used anymore, (3) spaces below, which are under infrastructural elements, such as elevated railways lines, and (4) rooftops spaces of buildings. Additionally, (5) spaces that result from new developments in the old context when newly positioned buildings create intermediary zones between buildings, and (6) there are spaces between buildings that result after urban demolition. Finally, (7) wedges result from the intersection of urban grids or infrastructural lines and (8) oversized infrastructures", as illustrated in Fig 1.

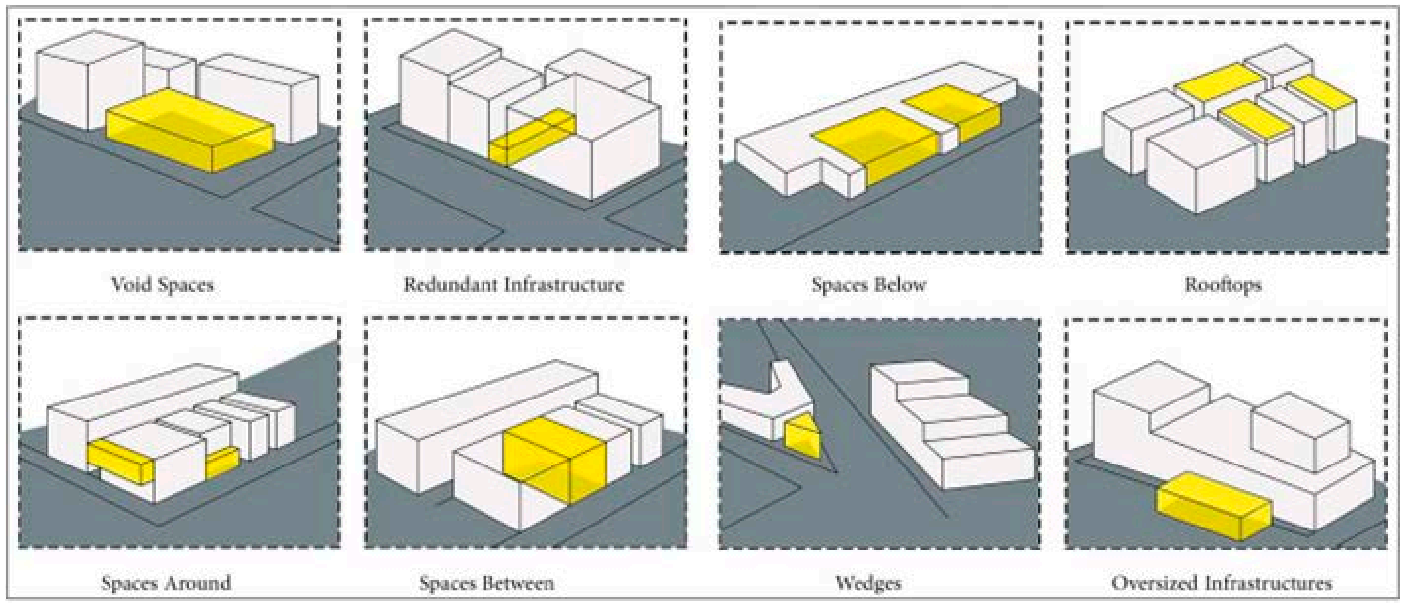

Figure 1: Leftover spaces forms.
Source: Aly, A. et al. (2023)

Upon physical survey, void spaces and redundant infrastructures were the prime determinants of leftover spaces located in the site.

2. Research Methodology

Literature indicates that the impact of green areas on the quality of urban space is relevant to areas with high development and spatial, functional structural density. Bajwoluk and Langer (2023). Due to the dense nature of residential living in Mohammadpur and existing leftover spaces observed from primary survey, it has been selected as the case study. Residual spaces from unplanned urban transformations may be either public or private property. This study solely focuses on the public ones to eliminate conflicts amongst private stakeholders.

El Aziz, N. (2015) in his research mentions that urban open spaces that are turned into pocket parks serves up to a four-block radius, with most of the users coming from within a one-two block radius (Smith, 2005). Hence, the study kept the participant sample within a four-block radius from the residual spaces.

Preliminary mapping, photo-mapping and observation is done to identify the typology, spatial qualities, current use etc. of the spaces. This helps to gather information inconspicuously about people's overall approach toward the selected areas.

Both in-person interviews and online surveys were conducted. In order to offer flexibility to the interviewees, the interviews were semi-structured using both open-ended and close-ended questions.

3. Site Findings and Analysis

For this study, the selected site offers congested residential areas, with limited open spaces apt for a detailed understanding of residual spaces and their communal impact. However, due to time constraints and limited resources, the study area was limited to a segment adjacent to the main road that connects three major nodal points. The chosen area is of approximately 6,25,500 sqft.

Figure 2: Site and adjacent nodes
Source: Author

3.1 Field Observations

It is important to reiterate that the study includes residual spaces in public realms, excluding all private lands. Upon physical site-study, 2 categories of leftover spaces are found in the research area. Category A is defined as Void Spaces which, referring to Fig 1, consist of spaces adjacent to buildings. Three sites have been found in this category. Category B are created by Redundant Infrastructure that are spaces between buildings or surrounded by buildings on 2-3 sides. Amidst Category B, multiple locations were found with identical function, accessibility and placement; therefore, to maintain cohesive data, they will be considered as one.

3.1.1 Category A: Void Spaces

Site 1: Located near the main Town-Hall Bazaar, the site is intended as a park, which is currently inaccessible to the community, being used as a junkyard, parking of City Corporation vehicles and mostly an unattended space.

Figure 3: Leftover Spaces in Site
Source: Author

Figure 4: Category A Site 1: Junkyard
Source: Author

Site 2: Unused, void space beside Shaheed Park Field, occupied by temporary shelters. It is almost 900 sqm in area, filled with rubble, a temporary structure and unattended to.

Figure 5: Category A Site 2: Unused Space Beside Park
Source: Author

Site 3: A vacant parcel of land in front of a government owned building. Previously the building was used as the Head Office of RAB but currently, the area is used by DNCC (Dhaka North City Corporation) as garbage disposal area and go-down.

Figure 6: Category A Site 3: DNCC Garbage Dump
Source: Author

3.1.2 Category B: Redundant Infrastructure

Site: This category of leftover spaces was found in multiple locations. These were alley spaces between buildings, owned by the City Corporation. From field survey, it is understood these passageways intended to connect the neighborhood blocks and provide space for set-backs between buildings. Closed off to the community with gates, these spaces are currently garbage filled, rodent infested causing environmental contamination and posing health risks. Each of the passageways are approximately 3~3.6m in width and x 70~90m in length. Some are currently illegally occupied by temporary food stalls.

Figure 7: Category B Sites: City Corporation Passageways infested with garbage & illegally occupied

3.2 Physical Survey Analysis

From the physical survey, it was imperative to analyze the nature, attributes, current and intended functions, users etc. of the leftover spaces found. The survey was conducted over a period of weeks, from morning to evening to get the full understanding of the relevant context and for the accuracy of the collected data.

Usage Quality of Leftover Spaces				
	Current use for site	**Intended/Previous use for site**	**Current users of site**	**Time of current use**
Void Space 01 (Junkyard)	Junkyard, Parking of unused or Gov vehicles	Park	None	N/A
Void Space 02 (Space Beside Park)	Rubbish dump, Temporary Settlement for Workers		Workers, Guards of the Park	Day, Night
Void Space 03 (DNCC Garbage Dump)	Garbage Dump, Temporary Vendors, Parking	RAB Office	Garbage Disposal	Day, Evening
Redundant Infrastructure (Space between buildings)	Garbage Dump, Rodent Infestation, Illegally Occupied Kiosks	Building Setback	Mostly none, some temporary stall vendors	Day, Night

Table 1: Usage Quality of Leftover Spaces
Source: Author

3.3 Residents' Survey Findings

The research kept the questionnaire and in-person interview participant sample within a four-block radius from the residual spaces for accurate information and from potential users residing in the vicinity. The participant sample consisted of 45 people (n = 45) who are currently using or potential users of these spaces.

3.3.1 Participant Demographic

To keep the survey inclusive and fair, almost equal numbers of men and women were surveyed. Of 45 respondents, 40% were female and 60% were male.

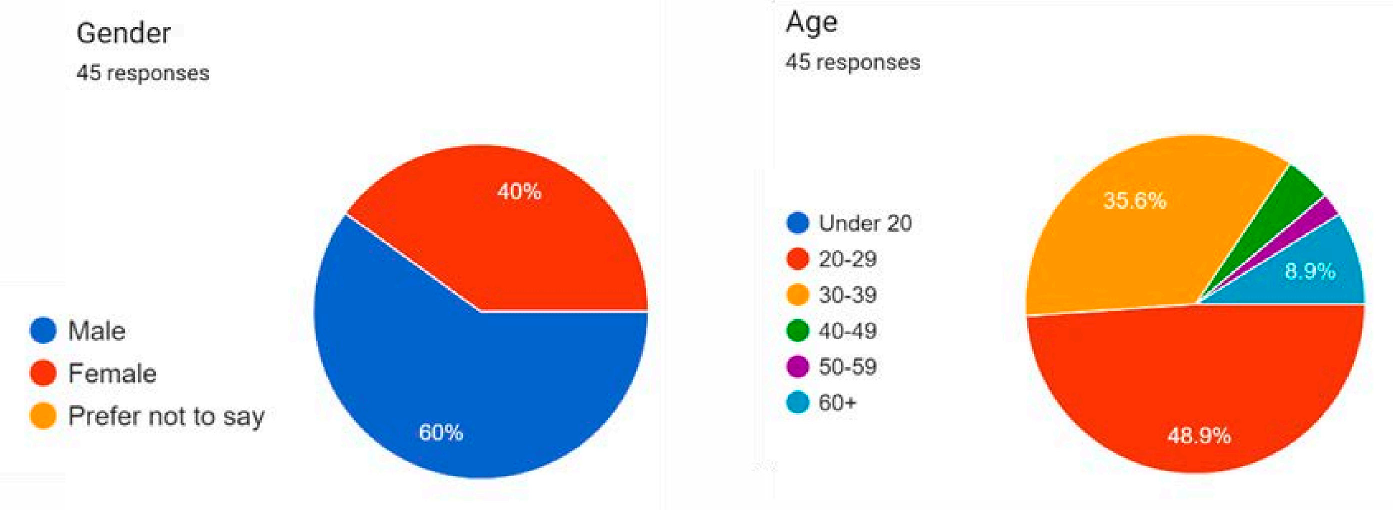

Figure 8: Demographic of Survey Participants
Source: Questionnaire Survey

3.3.2 Local Residents' Observation

Even though a notable number of participants use these spaces on a daily basis, the reports show that they are inaccessible to more than half of them. A staggering 80% of the users have expressed safety concerns that prevent them from using the leftover spaces.

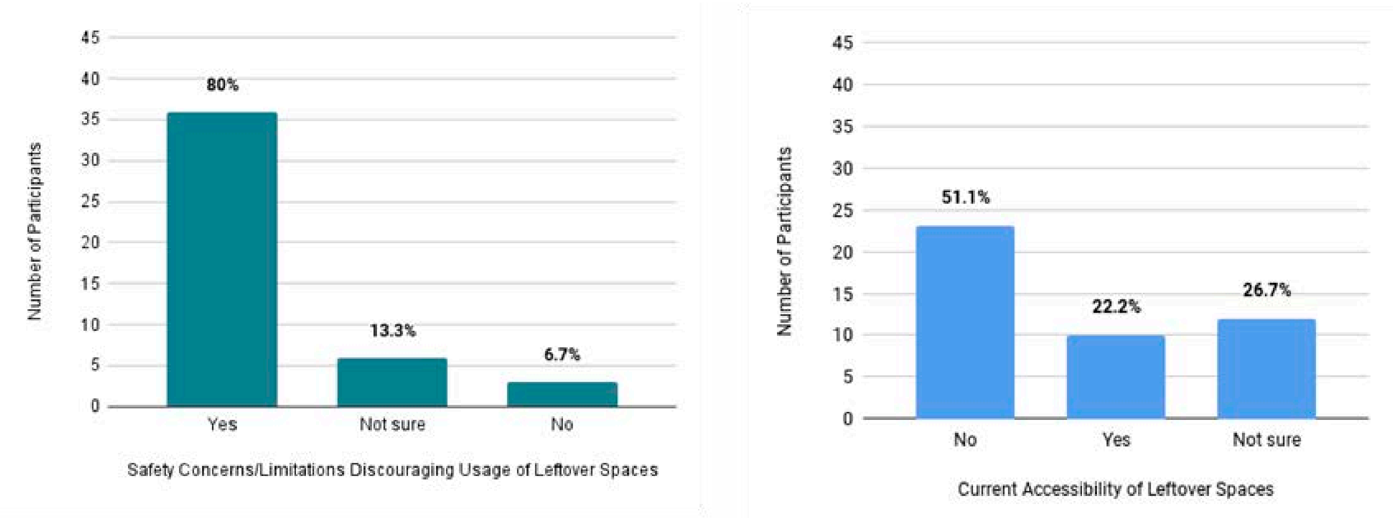

Figure 9: Local Residents' Observation
Source: Questionnaire Survey

4. Results

The survey results prompted a deeper understanding on the users' mindsets, highlighting current usage, user preferences and a deeper grasp of the surrounding contexts. A brief overview of the outcome of the survey.

- An astounding level of 86.7% responses were interested in incorporating vegetation and children-friendly play-spaces to these residual areas.
- 62.2% of the respondents felt that the universal accessibility is crucial.
- Majority of the respondents, 80% to be precise, have stated that the effective use of these leftover spaces has the potential to impact communal experience.

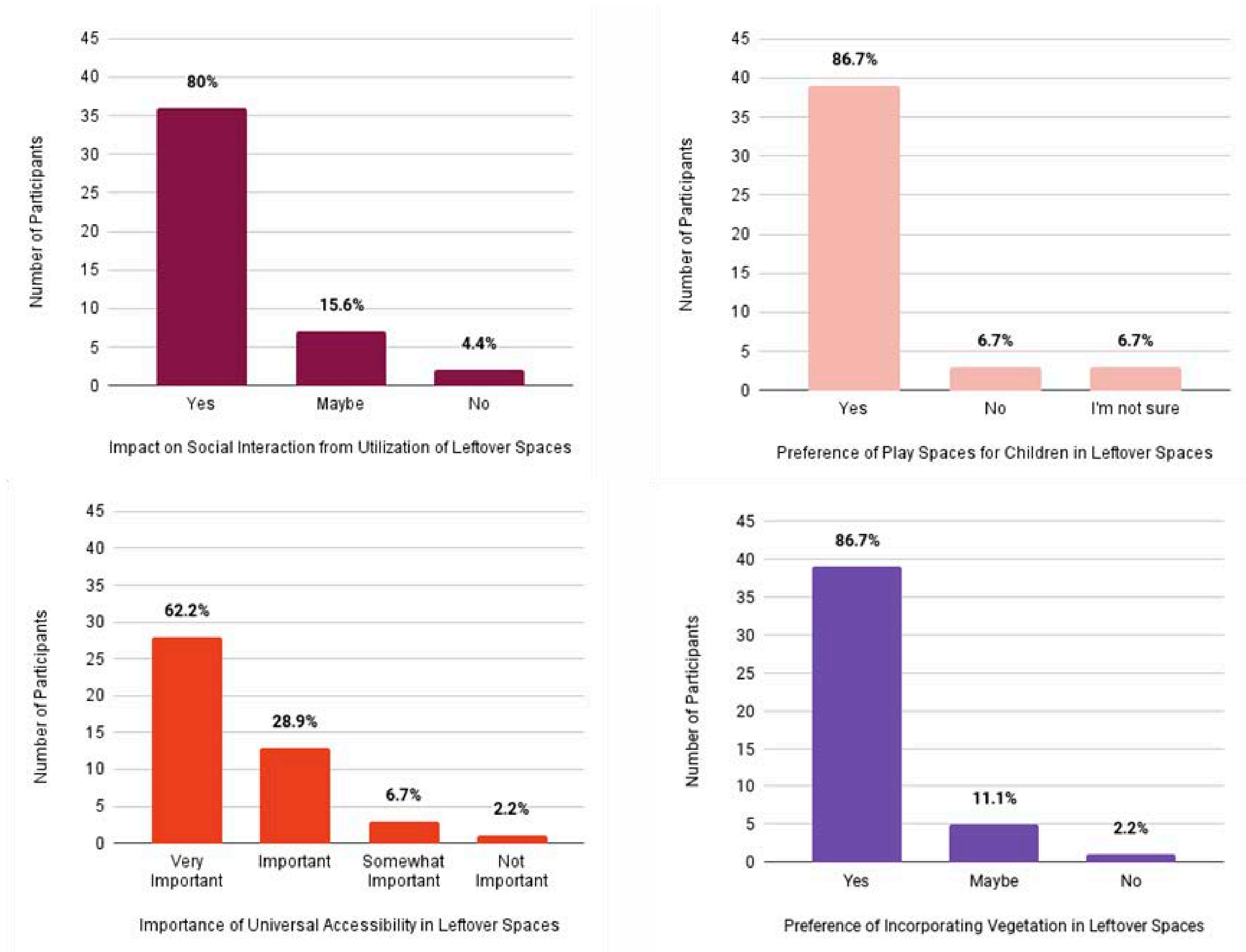

Figure 10: Residents' Preferences
Source: Questionnaire Survey

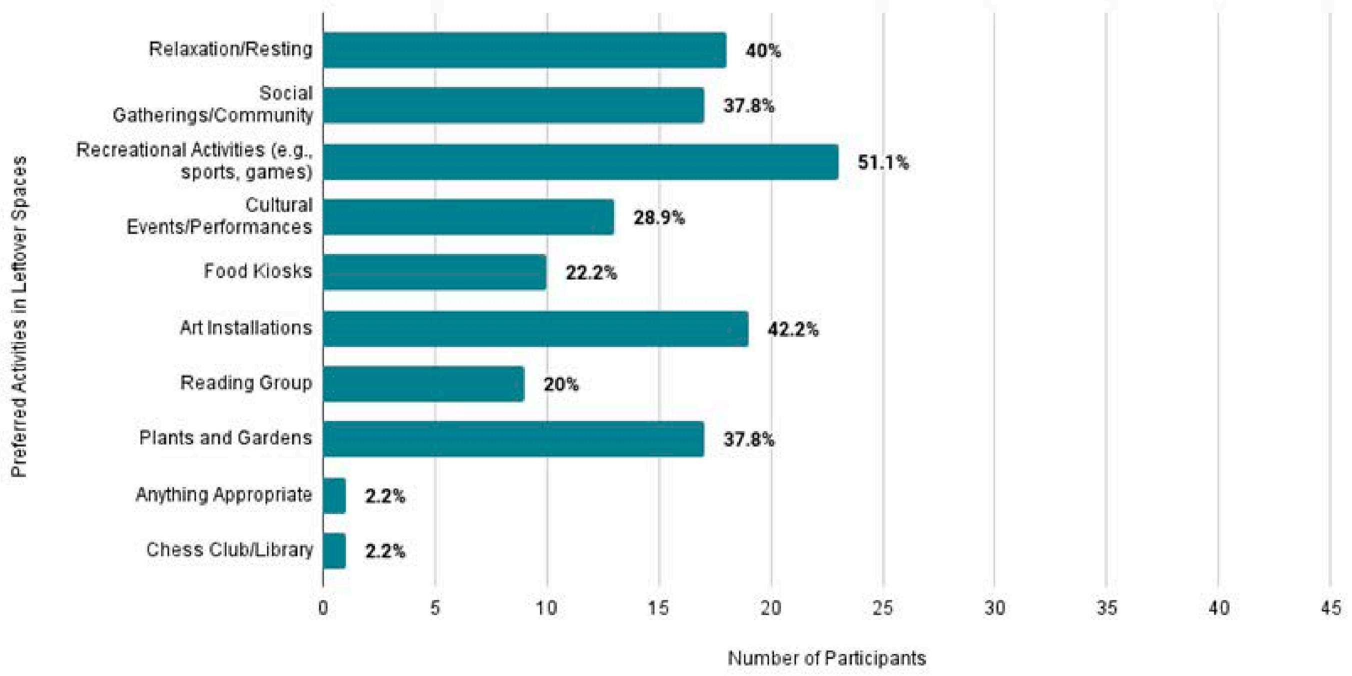

Figure 11: Residents' Recommendation on Interventions
Source: Questionnaire Survey

- The semi-structured survey offered room for suggestions that proposed a variety of interventions. Of which, recreational activities have made the top priority for over half of the participants. Followed by relaxation opportunities and art installations. Other notable intervention suggestions include community gathering spaces and vegetation.
- The study results also imply areas of improvement, where the majority expressed concerns of safety and accessibility.

5. Conclusion

The whole range of uses for leftover spaces of various shapes give residential areas and public spaces in cities a purpose and appeal. Gehl (2011) argues that those spaces are one of the vital city attraction points. Life between buildings ranks more essential and relevant than the spaces and buildings themselves.

For a densely populated city as Dhaka, leftover spaces have resourceful potential, especially in congested residential areas like Mohammadpur. A vast understanding of the leftover spaces is necessary for intervention in order to examine the overall function, physical attributes and challenges of the spaces. Governments have the opportunity to explore this alternative rather than relying solely on vacant lots of land, which are typically limited to begin with. In order to enhance the built community and people's quality of life, urban designers, decision-makers, and city planners need to take leftover spaces into account.

Considering the results, the study recommends improving safety concerns and maintenance of the current leftover spaces as top priority. The surveys also provide an incentive of implementing inclusive design aspects like tactile paving, ramps and pathways making them universally accessible. The spaces in the findings provide ample opportunity to incorporate resting and recreational interventions. However, the category of spaces that fall under 'redundant infrastructure' according to the study, has limited options due to space, privacy and accessibility. Vegetation, gardening and even functional installations with proper infrastructure can be implemented there. The practical implementations remain a matter of manpower, governance and funding, which might not be the focal area of this particular study, but a predicament for future researches. Due to limited resources, the study requires further research on implementable interventions in this particular community. However, the paper aimed to correlate understanding residual spaces in congested areas and the probable potentiality they carry for a well-planned, cohesive community.

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TRACK 2

Resilient Communities in-between Disasters

DESIGN ANTHROPOLOGY FOR CLIMATE RESILIENCE: LEARNING FROM INTERNATIONAL RECLAMATION PRACTICES

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Abstract

This research explores how disasters act as transformative sites through mutual aid networks. Focusing on the Romagna region of Italy, which experienced repeated catastrophic floods between 2023 and 2024, the study examines how communities mobilized solidarity, cultural knowledge, and spatial practices to cope with recurring environmental shocks. Using a design anthropology framework, the project uses oral history to document local responses rooted in contemporary forms of mutual aid. Preliminary findings reveal that emotional labor, storytelling, and space appropriation play critical roles in shaping community resilience strategies, particularly in contexts where official emergency systems is under stress. Preliminary findings reveal that mutual aid networks formed rapidly in response to emotional urgency, with residents driven by empathy, shared identity, and a desire to act despite feeling powerless. These community efforts prioritized relational care, autonomy from institutions, and cultural expressions of solidarity, such as storytelling and communal clean-up efforts. This study contributes to disaster studies and climate adaptation discourse by foregrounding the importance of culturally responsive, community-driven solutions and highlights the potential of mutual aid as both a coping mechanism and a transformative practice in the face of climate-induced disruptions.

Keywords: Design Anthropology, Mutual-Aid, Disaster Awareness, Community-Based Design.

Disasters as Sites of Transformation and Mutual Aid

Contemporary disaster studies increasingly recognize that catastrophic events function not merely as moments of destruction, but as compressed periods of transformation where hope and solidarity emerge through grassroots initiatives and mutual aid networks. As scholars have observed, during the timeframe of a disaster, time feels compressed since a lot is at stake, creating urgent conditions that lead to a microcosm of choices and opportunities where communities demonstrate remarkable capacity for self-organization and collective care. These disaster-induced moments reveal the potential for alternative systems of support that operate according to communal cultural values, challenging top-down emergency response models that often fail to recognize local knowledge and agency (Olshansky et al., 2012).

The emergence of mutual aid during disasters illuminates a fundamental paradox in contemporary emergency management: the misalignment between institutional approaches to drive adaptation strategies and communities that struggle to navigate those systems when they do not fit their lived realities or cultural contexts. However, when communities are granted freedom of movement and the ability to appropriate space in unexpected ways (Lefebvre et al., 1996), community networks demonstrate that supportive systems can be established from the ground up by those who need them most. This phenomenon suggests that disasters, rather than being temporary disruptions to normal social order, represent protracted events that reveal underlying vulnerabilities while simultaneously creating opportunities for transformative practices rooted in local cultural knowledge.

The case of Hurricane Katrina exemplifies this dynamic tension. The media narrative portrayed a society in which solidarity fails in times of need, particularly around the infamous events in the Superdome (Greening, 2011). In contrast, lesser-known stories from the post-Katrina period reveal how individuals like Roishetta Sibley Ozane, a single mother of six from Lake Charles, Louisiana, discovered hope and strength in supporting others facing similar circumstances, sharing information and collecting resources for those in need despite facing powerlessness in navigating FEMA bureaucracy. Her experience demonstrates that when confronted with organizational support scarcity, community networks can flourish because they are "created by those who need it the most and according to communal cultural values." The failures of emergency systems may be attributed, at least in part, to the exclusion of public resources from their purview (Gotham, 2012).

Case Study

The Romagna region of Italy experienced an unprecedented sequence of catastrophic flooding events that began on May 16, 2023, followed by additional major floods in May 2024 and September 2024. The initial alluvione (flood) of May 2023 was preceded by a red alert issued two days prior, though the warning's unusual severity prompted some residents to relocate elderly family members as a precautionary measure. The flooding began with intense rainfall on Monday night, continuing through Tuesday morning with strong wind gusts and relentless precipitation. By midday Tuesday, social media alerts from mayors warned residents to stay away from water, and by 4 PM, the Savio River had breached its banks at multiple points, triggering a cascade of flooding that spread to Forlì, Faenza, and surrounding areas as landslides began occurring throughout the region.

The night of May 16-17 marked the peak of the catastrophe, with entire neighborhoods of Cesena completely submerged under water that reached the first floors of houses. Communication networks failed, leaving residents isolated and authorities unable to coordinate effective responses. Helicopter rescue operations continued through Thursday as communities found themselves cut off from essential services including electricity, water, and gas. The human toll included fifteen fatalities and widespread displacement, while the psychological impact manifested in collective trauma as residents witnessed familiar landscapes transformed into scenes of devastation.

What emerged from this unexpected crisis, however, was a remarkable demonstration of community solidarity and mutual aid. Within days of the initial flooding, informal networks began organizing collection centers for clothing, cleaning supplies, and essential items, with long lines of volunteers forming to contribute resources. Community members who had not been directly affected felt compelled to act, driven by what organizers described as a profound sense of identification with disaster survivors and an overwhelming need to transform feelings of powerlessness into concrete action.

The institutional response was not prepared for such devasting event creating a perception of inadequacy amongst the residents. However, this perception created a space for grassroots initiatives to flourish, operating according to principles of direct assistance and emotional support. Local organizers began collecting not only material resources but also personal testimonies, recognizing that disaster survivors needed opportunities to process their experiences through storytelling and community connection.

The recurring nature of the flooding—with the region experiencing two main events and several additional smaller floods since May 2023—has created ongoing conditions of vulnerability and recovery. Despite temporary mitigation measures such as clearing dead branches from trees, restore levees, drain stagnant water, and clean rivers banks, fundamental infrastructural and environmental issues remain a challenge.

This pattern of repeated flooding has generated both community resilience and frustration, with some residents experiencing multiple losses and reconstruction cycles, creating complex financial challenges around the recovery of repeated damages.

Research Context and Methodology

This ongoing research project investigates the role of mutual aid in the challenges in the Romagna case study aiming to understand the process of mutual aid in a newly floods impacted region to better plan for culturally responsive climate adaptation strategies for communities living in reclaimed riverine landscapes. The repeated flooding events in Romagna present a compelling case study for examining how historical water management practices intersect with contemporary climate vulnerabilities, and how local communities mobilize knowledge, solidarity, and mutual aid in response to recurring environmental challenges.
Design anthropology offers a unique methodological framework that blends ethnographic inquiry, design thinking, and participatory research to understand landscapes as layered repositories of historical, ecological, and cultural events. By decoding these stratified traces, the project aims to envision future solutions grounded in local knowledge systems and practices. This approach recognizes that effective climate resilience strategies must be informed by both historical understanding and contemporary lived experiences, particularly the ways communities have traditionally organized mutual support systems during periods of environmental stress.

The research methodology embraces Atallah's concept of "standing-in-between" dynamic spaces between cultures, values, and practices (Atallah, 2022:83), engaging with communities and their specific struggles not merely to amplify marginalized voices, but to observe, assist, and support the transformative potential that emerges within these interstitial spaces. This approach treats research as a gift from the community to the observer—one that cannot be demanded but only given (Nelson and Shotton, 2022)—and emphasizes storytelling as crucial for understanding humanity in relation to disasters (Wynter and McKittrick, 2015:25) while moving beyond positivistic approaches that diminish the rich diversity of sociological responses to environmental challenges.

The methodology also recognizes that embracing the notion that humans are both biological and sociological beings reveals that "not every individual contributes equally to the environmental crisis" and that "there is no singular approach to understanding its causes or finding solutions" (Wynter and McKittrick, 2015:20, 21).

Preliminary Findings

The research methodology incorporates multiple phases of data collection and analysis, beginning with informal oral history documentation from a local organization that was founded after the first main flood. The oral history provides essential groundwork for understanding contemporary mutual aid practices in the Romagna region and support the development of the research design. Initial fieldwork has revealed compelling patterns of community self-organization following the three major flooding events between May 2023 and September 2024, demonstrating how local residents mobilized cultural knowledge and solidarity networks in response to institutional inadequacies.

Preliminary findings indicate that community-based mutual aid initiatives emerged organically from residents' sense of powerlessness and identification with those affected, reflecting the theoretical framework that community networks develop most effectively when created by those who need them most. Local organizers reported experiencing profound emotional engagement with disaster survivors, describing how they feel empathy with community members and became deeply involved in their recovery processes. This emotional labor represents a crucial component of mutual aid that extends beyond material assistance to include psychological support and community healing.

This approach has revealed three distinct geographical scenarios of disaster response: urban flight from flooding, hillside and mountain isolation due to landslides and infrastructure collapse, and coastal areas dealing with contaminated water that failed to drain to the sea. Each geographical context has different spatial challenges, but all of them shared the same financial struggles and a generalized lack of disaster awareness and education.

Significantly, the research has documented how community-initiated aid organizations have deliberately maintained independence from institutional oversight, choosing what is perceived as transparency through direct community engagement rather than integration with municipal or regional authorities. This finding supports theoretical arguments about the importance of freedom of movement and space appropriation in disaster response, while also revealing community skepticism toward official emergency management systems.

The preliminary analysis suggests that disaster preparedness remains inadequate in the region, with residents reporting they were unprepared for the scale and frequency of flooding events. However, the research has identified emerging practices of disaster education and community resilience building that operate through informal networks and cultural institutions. These initiatives represent attempts to address the gap between official emergency preparedness and community-based knowledge systems.

This initial phase of oral history collection will inform subsequent scoping interviews with key community organizers and disaster survivors, leading to comprehensive archival research on historical water management practices in the region. The final phase will involve structured ethnographic interviews that explore the intersection of historical land reclamation knowledge and contemporary mutual aid practices, examining how communities draw upon both inherited and emergent strategies for flood resilience.

Significance and Future Directions

The significance of this research is multifold. It contributes to disaster studies scholarship by emphasizing the importance of cultural context in developing sustainable solutions and demonstrating the potential of participatory, historically informed design processes in addressing complex environmental challenges. The research recognizes that disasters are not one-time events but rather "the cumulative result of incremental and repeated minor changes" (Droege, 2010:31), necessitating adaptation strategies that function not only during emergency periods but also in the interstitial periods between events through sustained mutual aid networks.

As Rebecca Solnit eloquently articulated, hope finds its place in the premises that we do not know what will happen and that within the spaciousness of uncertainty, there is room for action. "When we acknowledge uncertainty, we recognize the potential to influence outcomes" (Solnit, 2017:33). Building on this understanding, the project establishes foundations for future ethnographic research in Romagna while contributing to broader theoretical discussions about how hope and solidarity serve as mediating forces between institutional emergency response systems and community-based adaptation practices.
By examining how communities in reclaimed landscapes navigate recurring floods through both inherited knowledge and emergent mutual aid practices, this research aims to inform more equitable and culturally responsive approaches to climate resilience. The approach embraces the "wonder of the hybrid human when they act out in the [disaster] aftermath" (Easthope, 2022:202), recognizing that only in compressed disaster time can researchers and practitioners truly observe hope and transformative potential embedded within disaster experiences.

Acknowledgement

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LANDSLIDES AND FLOODS RISK ASSESSMENT AND DEVELOPMENT OF CLIMATE CHANGE ADAPTATION MEASURES TO INCREASE RESILIENCE IN THE POPULATION OF CUENCA, ECUADOR

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Abstract

The study assessed the climate risk of landslides and floods in Cuenca, Ecuador’s urban and peripheral areas, and identified and proposed adaptation measures in line with the national climate change plan. Integrated methodology was used, including risk assessment, exposure, and vulnerability testing. The results show spatial variation in the risk levels, allowing for the prioritization of sectors such as Marianza, El Despacho, and La Viola for landslides and sectors such as Coliseum, Sayausí, Puertas del Sol, and Quinta Lucrecia for flooding. Adaptation measures have been proposed and grouped into five categories: nature-based solutions, technological and traditional infrastructure, capacity building, and spatial planning. These strategies aim to reduce risk, increase resilience, and promote sustainable urban development. The study highlights the importance of linking science, technology, and local knowledge to tackle climate change and proposes strengthening cross-sectoral cooperation for effective implementation.

Keywords: climate risk assessment; urban resilience; adaptive land management; hydrometeorological hazards; risk mapping.

Introduction

The effects of climate change have become more intense and frequent worldwide, leading to increased extreme climatic events such as floods and landslides (Gariano & Guzzetti, 2016; Stott, 2016; Tabari, 2020). These phenomena pose a particular threat to urban areas in the Andean region, where the combination of complex topography, heavy rainfall, and urban planning, which is often not respected or implemented, increases the vulnerability of populations and existing infrastructure (Hardoy & Pandiella, 2009; Sepúlveda & Petley, 2015). Risk assessment is therefore essential for identifying and proposing adaptation and resilience measures for cities.

Comprehensive risk assessment and adaptation planning must be based on reliable scientific information, hydrological and hydraulic modelling tools, and the integration of technical and societal knowledge (Apel et al., 2009; Few et al., 2017; Reichenbach et al., 2018; Scolobig et al., 2012). Furthermore, these strategies must be aligned with national plans. In Ecuador's case, the National Climate Change Adaptation Plan (MAATE, 2023) is the first public policy instrument in the country and aims explicitly to strengthen adaptation capacity by supporting coordinated action between public, private, academic, and civil society actors. Through multidisciplinary research, climate change challenges can be addressed effectively and measures to mitigate impacts can be developed in various cities, such as Cuenca in southern Ecuador.

Cuenca is exposed to these risks because it is located at the confluence of major rivers, such as the Tomebamba and the Yanuncay, whose hydrological dynamics are influenced by natural and human factors. The Tomebamba and Yanuncay river basins are particularly prone to landslides, particularly in areas with steep slopes and unstable soils (Bravo-López et al., 2022; Khalili et al., 2024), and their flood risk is increasing as a result of urban sprawl, soil impermeability and the conversion of natural water courses. Given this situation, adaptation measures must be developed and implemented to reduce risks, strengthen the resilience of local communities, and ensure sustainable urban development.

Therefore, this study's objective is to evaluate risk and identify adaptation measures for floods and landslides in urban and peripheral areas of Cuenca.

1. Materials y methods

Study zone

The study area is in Cuenca, and its surroundings encompass urban and peri-urban areas. As one of the main cities in the country, Cuenca is exposed to hydrological risks because of its mountainous topography and rainfall variability. The fact that the territory is fragmented, combining densely populated urban areas with more vulnerable rural areas, poses a significant challenge in assessing and managing these risks.

Risk assessment

Risk assessment was based on a comprehensive analysis that included landslide and flood hazard assessments and the identification of exposure and vulnerability. The Mora-Vahrson method (Mora C. & Vahrson, 1994) was applied to the landslide hazard using the following variables: slope obtained from a 3-meter resolution Digital Elevation Model (DEM) provided by SIGTIERRAS (http://www.sigtierras.gob.ec); geology and lithology derived from the PRECUPA project (PRECUPA, 1998); land cover and use for 2022 provided by the Ministry of the Environment, Water and Ecological Transition of Ecuador (MAATE - http://ide.ambiente.gob.ec/mapainteractivo/); seismicity according to data from the Geophysical Institute of the National Polytechnic School (IGEPN - https://www.igepn.edu.ec/peligro-sismico); and future precipitation projected using the CSIRO climate model, with data preprocessed by the RISKEN group at the University of Cuenca (Valdivieso-García et al., 2024). Flood hazards were assessed by simulating flows using the HEC-HMS hydrological model, which considered land cover and use for 2022 as inputs, as well as future precipitation estimated from the CSIRO climate model. Flood zones were obtained from the outputs generated with the HEC-RAS model.

Exposure was assessed based on the number of households and people per census tract, using data from the 2022 Population and Housing Census (Instituto Nacional de Estadísticas y Censos INEC, 2022). Vulnerability was estimated based on two components: sensitivity and adaptive capacity. Sensitivity was defined based on demographic variables, such as the number of women, children, older adults, and people with some functional disability at the census tract level. Adaptive capacity was assessed based on the number of non-poor households (based on the index of unmet basic needs), literate people, and employed people; information derived from INEC.
Once threat, exposure, and vulnerability results had been obtained, the information was collated to create risk maps. These maps identified the areas with the highest risk levels and proposed specific risk adaptation measures.

Selection of Adaptation Measures

The measures were identified based on a literature review, prioritizing those feasible to implement in the priority areas and consistent with Ecuador's National Climate Change Adaptation Plan (MAATE, 2023).

2. Results

Risk assessment

Figure 1 shows landslide risk levels vary significantly among the three assessed sites. In the El Despacho sector (Figure 1b), located in the El Valle parish, areas with high and very high-risk levels were identified, making it the most susceptible area within the study. In contrast, the Marianza sector (Figure 1a), located in the Sayausí parish, predominantly presents a medium risk level. Finally, in La Viola (Figure 1c), located in the Paccha parish, risk levels range from low to medium. This spatial differentiation of the threat allows for prioritizing, formulating, and implementing adaptation mea-

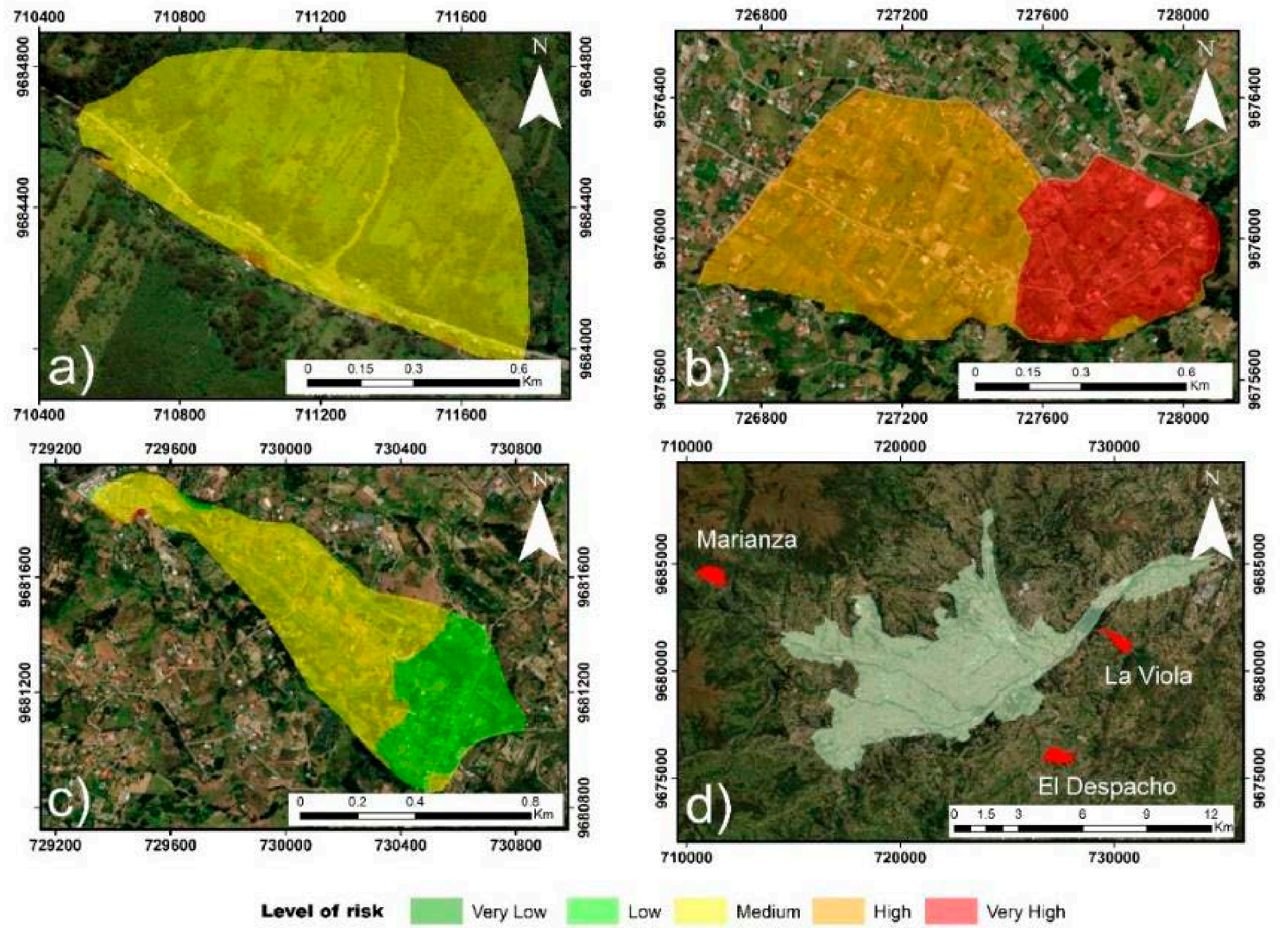

Figure 1: Landslides risk analysis in a) Marianza, b) El Despacho, and c) La Viola.

Regarding flood risk, Figure 2 presents the risk levels in five representative sectors of the city of Cuenca. In the Coliseum sector (Figure 2a), areas with a predominantly high-risk level are identified, reflecting elevated exposure to flood events. In the Sayausí parish (Figure 2b), risk levels range from medium to high. Puertas del Sol (Figure 2c) shows a high-risk concentration along the riverbed and covering residential areas. The Misicata sector (Figure 2d) also presents high-risk levels, mainly in areas adjacent to the river. Finally, in the Quinta Lucrecia area (Figure 2e), risk levels range from medium to very high, with flood zones extending into residential areas. These results will allow for establishing priorities for implementing adaptation measures and strengthening urban resilience to flooding.

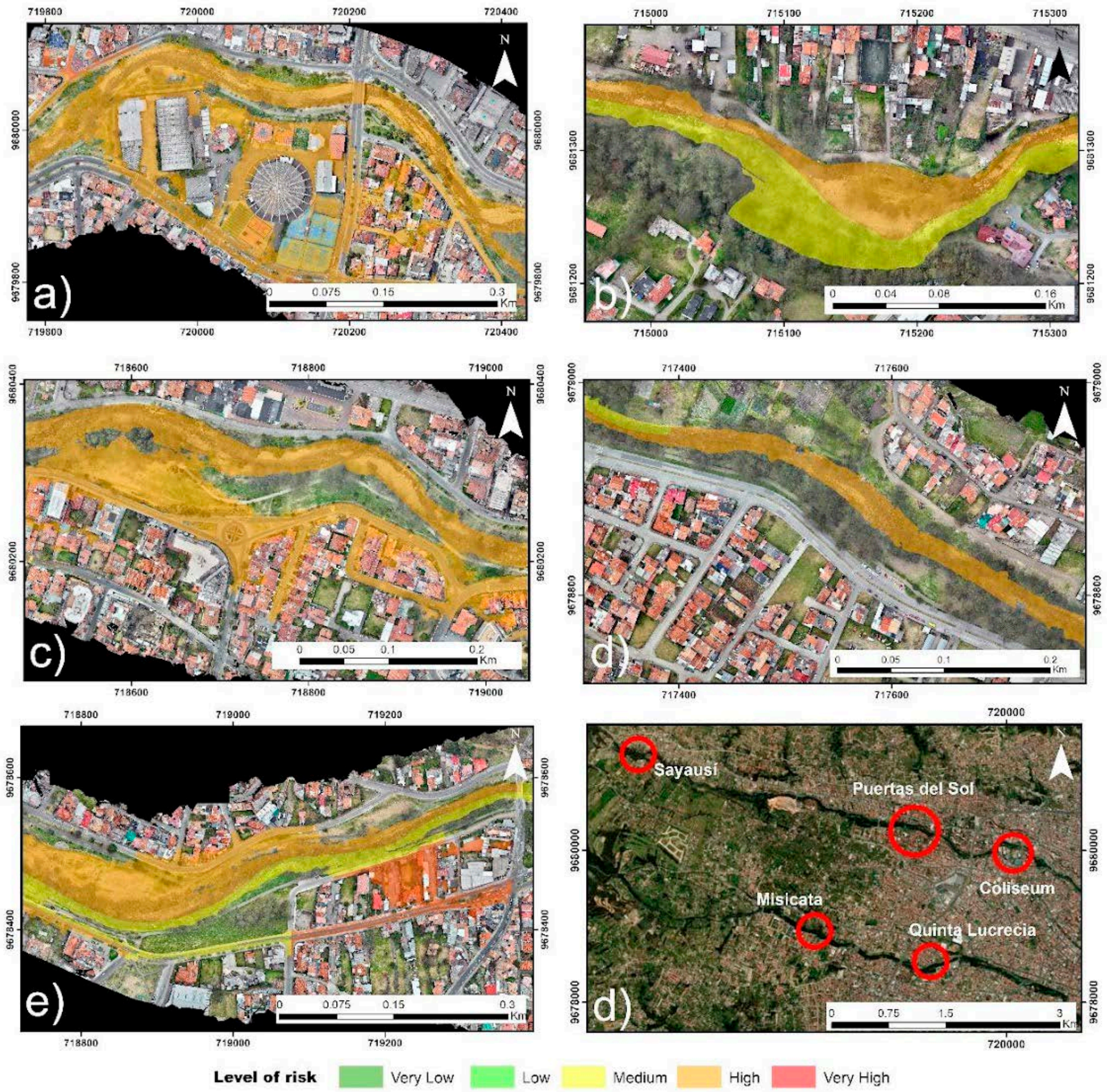

Figure 2: Floods risk analysis in a) Coliseum sector, b) Sayausí, c) Puertas del Sol, d) Misicata, and e) Quinta Lucrecia.

Generation of adaptation and resilience measures

The proposed adaptation measures were aligned with the Ecuadorian National Plan for Climate Change Adaptation (PNACC) (MAATE, 2023), which sets priorities such as protecting water and natural resources, human settlements, and critical infrastructure. Similarly, measures have been aligned with specific PNACC objectives such as Goal 1.1, which aims to ensure early access to climate information; Goal 2.3, which aims to strengthen public awareness and resilience; and Goal 4.1, which aims to promote the integration of climate change adaptation into sectoral and local planning and budgets.

Based on an evaluation carried out and aligned with the Ecuadorian National Plan of Action (PNACC), specific adaptation strategies have been defined that respond to both the territorial priorities and the objectives of the PNACC, as also supported by the literature. These strategies were organized into five main categories, allowing for a comprehensive and multi-dimensional response to the impacts of climate change in Cuenca.

- Nature-based measures, including forest protection and restoration in landslide areas. Including areas along the riverbanks of the Tomebamba and Yanuncay rivers, where floodwater can affect the houses. These measures will increase water infiltration, develop barriers, and stabilize soils, making houses less vulnerable to hazards (Boardman & Poesen, 2007; Bonnesoeur et al., 2019; de Koning et al., 2011; Gray & Sotir, 1996; V. et al., 2018).

- Measures based on technological infrastructure, including monitoring and early warning systems. Besides, hydrometeorological monitoring networks in the urban area and the basin's upper reaches should be extended. Moreover, using inclinometers and piezometers would help continuously monitor the soil's stability in landslide-prone areas. Studies in different regions (Dixon et al., 2022; Molina et al., 2021) validate these actions, allowing a better understanding of other areas vulnerable to landslides and flooding.

- Capacity-building measures prioritize flood risk education to strengthen communities' capacity to respond to floods in sectors such as the Jefferson Pérez Coliseum, Puertas del Sol, Sayausí, Misicata, and Quinta Lucrecia. It is recommended that flood preparedness programs be implemented in educational centers, especially those near floodplains, and that awareness campaigns on land use management be conducted in Marianza. In addition, digital platforms and mobile applications are proposed to enable citizens to access real-time information on hotspots and preventive measures. These measures have proven effective in various parts of the world (Morote & Hernández, 2021; Morote Seguido & Souto González, 2020), where flood risk education has significantly increased community resilience and emergency response capacity.

- Management and spatial planning measures have been identified, including developing a municipal policy requiring drainage systems in new buildings in high-risk areas such as El Despacho and La Viola. These regulations will enable sustainable urban development and reduce the exposure to extreme weather events (Asian Disaster Reduction Center, 2015; Der Sarkissian et al., 2019; United Nations, 2008). Furthermore, resilience criteria should be included in spatial planning plans, ensuring that future infrastructure is designed based on sustainability and climate adaptation principles (Water Directors of the European Union, 2003; Yang et al., 2018).

- Measures based on traditional infrastructure. These include constructing flood walls and dikes in the Jefferson Pérez Coliseum area and structural reinforcement of buildings adjacent to the Coliseum. These measures would help to minimize the impact of flooding on the sector and protect key infrastructure. Improvements to storm drainage systems in vulnerable sectors are also proposed to reduce water build-up and prevent damage to buildings and houses in high-risk areas(Chen et al., 2021).

3. Conclusions

The study provided a scientific and technical basis for implementing specific adaptation and mitigation measures in Cuenca city following the Ecuador National Plan for Adaptation to Climate Change. However, complementary research is recommended to improve the proposed strategies and the capacity to respond to future extreme weather events.

In addition, cooperation between the public, private, academic, and civil society sectors must be strengthened to ensure the effective implementation of these actions. Community awareness is crucial for promoting a preventive and adaptive culture. Cuenca faces many challenges regarding the impact of climate change. Still, it can move towards a more resilient and sustainable future through proper planning and effective integration of science, technology, and community knowledge.

4. Acknowledgments

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WALKING AS A RIGHT: A CRITICAL LOOK AT WALKABILITY IN GAINESVILLE, FLORIDA

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Abstract

This study investigates pedestrian experiences in Gainesville, Florida, using participatory design methods grounded in ethnographic observation and spatial analysis. Through activities such as collaborative mapping, sensory walking, and in-situ reflection, participants (none of whom were U.S. natives) engaged with their surroundings while marking areas of discomfort, exclusion, or connection. Their cultural backgrounds may have shaped how they perceived the local environment, helping to reveal hidden barriers or feelings of exclusion for marginalized groups that locals might overlook or take for granted.

The research uncovers key tensions: the cultural expectation to have a “reason” to walk, the dominance of car-centric infrastructure, safety concerns—especially for women—and the ineIiciency of public transit systems that reinforce car dependency. By focusing on historically segregated neighborhoods like Pleasant Street and Duckpond, the study situates these issues within broader socio-spatial inequalities and the legacy of exclusionary planning.

Drawing on frameworks from critical urbanism and feminist geography, the project positions walking as an emancipatory and political act—one that reclaims space and builds agency, connection, and inclusion. The intended outcome is to inform pedestrian-centered design practices and contribute to ongoing academic and policy conversations around urban mobility and social equity.

Introduction

Urban mobility, particularly pedestrian rights, is deeply shaped by power dynamics that influence who can move freely and safely through city spaces. Access to public spaces is not equally distributed, and for many, walking the streets can be a risky and unwelcoming experience (Middleton, 2018). Jacobs (1961) further stresses the importance of 'eyes on the street', where active ground-level engagement enhances safety and vibrancy.

Bauman (1994) captures this sentiment by highlighting how urban walking is often driven by fear, where individuals rush through the streets, "as fast as one can manage," avoiding engagement with their surroundings. For those who cannot aIord the security of a car, the street becomes a place of necessity rather than opportunity, marked by danger and discomfort
(Bauman, 1994).

This disparity in access to urban spaces is further compounded by urban planning practices that continue to prioritize cars over pedestrians. Contemporary design often focuses on facilitating the flow of traIic, neglecting the social and communal needs of neighborhoods. As a result, public spaces are diminished, and urban environments are increasingly structured around the needs of vehicles rather than people (Barnett, 2003). While some designers argue that cities should be designed for people, not just for cars, and that urban spaces should prioritize social interaction, sustainability, and aesthetic value (Papanek, 2021).

In the face of these challenges, walking as a method of engaging with urban space oIers an alternative perspective. Walking is not just a mode of transportation but a form of urban emancipation that allows individuals to interact with and understand the city in more meaningful ways (Middleton 2018). The concept of the flâneur, the urban wanderer, has long been used as a tool for "reading" cities, exploring the more subjective and nuanced aspects of urban life. By embracing walking as a method of understanding, we can challenge the dominant car-centric narratives of urban design and advocate for more inclusive, people-centered cities that prioritize accessibility, community, and democratic participation (Pink, 2008).

1. Personal Motivation

The research took place in Gainesville Florida among the students of MXD. Participants were recruited from diverse backgrounds, including diIerences in age, gender, ethnicity and cultural habits, with all sharing a professional foundation in the field of design. Many had experience living in various cities or countries, bringing a range of perspectives that enriched insights into urban walkability.
This research aims to explore the walking experiences of residents in Gainesville, with a brief consideration of alternative transportation options for those without cars.
Personal motivation for this research stems from my own experiences navigating urban environments without a car. Having moved to the United States from a diIerent cultural context, I was struck by how central cars are to daily life here, especially in places like Gainesville, where walking or cycling often feels like an afterthought. As someone who relies on walking or biking to get around, I've faced frequent challenges, like a lack of sidewalks or lights to cross a street. In Gainesville, walking also seems to require a "reason," like walking a dog or pushing a stroller. Many times, I've felt a subtle tension when crossing streets, especially as the only one on the road, as if
I were disrupting the flow of traIic, with impatient glances from drivers. These personal experiences have driven me to explore how urban spaces can be reimagined to prioritize people over vehicles, fostering an environment where walking and biking are not only possible but enjoyable.
There is also a pressing issue with traIic control that often prioritizes the regulation of pedestrians in Gainesville. As a result, there are fewer safe streets for walking and biking, while aggressive driver behavior is prevalent. A recent post from Alachua County highlighted the pressing need for safer streets for pedestrians and cyclists, announcing a community workshop focused on addressing street safety and infrastructure planning. This initiative underscores the urgency of improving pedestrian and bike mobility in Gainesville, where pedestrian deaths and safety concerns have become a critical issue.
I feel that people, and especially designers, need to be more active in representing pedestrians' rights in the city. Concerns with people's rights to move in, through, across, and between diIerent places are fundamental to understandings of everyday urban mobility, because "the capacity to move is central to what it is to be a citizen" (Middleton, 2018). The links between walking encounters and urban sociability can be thought about more closely in relation to the 'right to the city' and the everyday tactics of urban pedestrians. Reinterpreting the "right to the city" through everyday pedestrian practices can lead to a deeper understanding of urban politics. By focusing on the small, daily actions of pedestrians, we can move beyond broad political rhetoric to foster more inclusive, equitable cities where mobility and interaction are integral to citizenship and community. (Middleton, 2018).

2. Step 1: Participant Backgrounds and Initial Mapping of Walkability Patterns

Walkability is the potential of the built environment to encourage individuals walking. Among the multiple definition of walkability we claim it is a composite quality of urban space produced by the combination of several spatial factors related to the organization and functionality of cities: the physical configuration of the urban fabric with its block structure and the connectivity of pathways; the presence and variety of activities intended as possible origin and destinations of trips; the quality of pedestrian accessibility which depends on the level of comfort, convenience, safety and pleasantness of footpaths, as well as on the attractivity and imageability of the traversed environment (Fancello et al., 2020).
During this step was established a baseline understanding of participants' existing movement habits and perceptions of Gainesville's walkability in comparison with their previous experiences. Pattern collections are a foundation for dialogue between everyone involved. Our world can be understood as if it were interwoven by conscious and unconscious patterns, whereby each pattern is linked to other patterns (Leitner, 2015) Using an Interaction – Analysis approach, participants visually (using stickers and markers) mapped their typical walking or driving patterns, oIering a broad picture of how designers navigate Gainesville (Figure 1). They were asked to reflect on the routes taken, as well as the enjoyment or challenges associated with these experiences. Additionally, participants compared their current routines to those in past environments, discussing specific locations, purposes, and the time spent walking, driving, or taking public transport. This contrast underscored how varying urban settings shape the quality and frequency of movement and contributed to a deeper understanding of the designer's interaction with city spaces. The entire process was video recorded for playback and future analysis (Jordan& Henderson, 1995).

Figure 1: Codesign activity representing mapping process, 2024.

During presentation of the 'maps' many participants found Gainesville less walkable than their hometowns. Student from Iran noted that in her hometown, destinations like grocery stores were within a short walking distance, while in Gainesville, longer distances and limited public transport make a car more necessary. A student who had lived in a smaller city in South Korea before also mentioned that in his hometown, he typically walked or took buses for longer distances. However, in Gainesville, he prefers driving due to the greater distances (Figure 2).

Gainesville's hot climate was a deterrent for many, making walking and even biking uncomfortable. However, a student from Ghana, accustomed to warm weather, expressed a love

for walking. Yet, he found Gainesville's long distances between destinations challenging, forcing him to rely on the city's ineIicient bus system. This often meant he still had to walk significant distances (Figure 2).

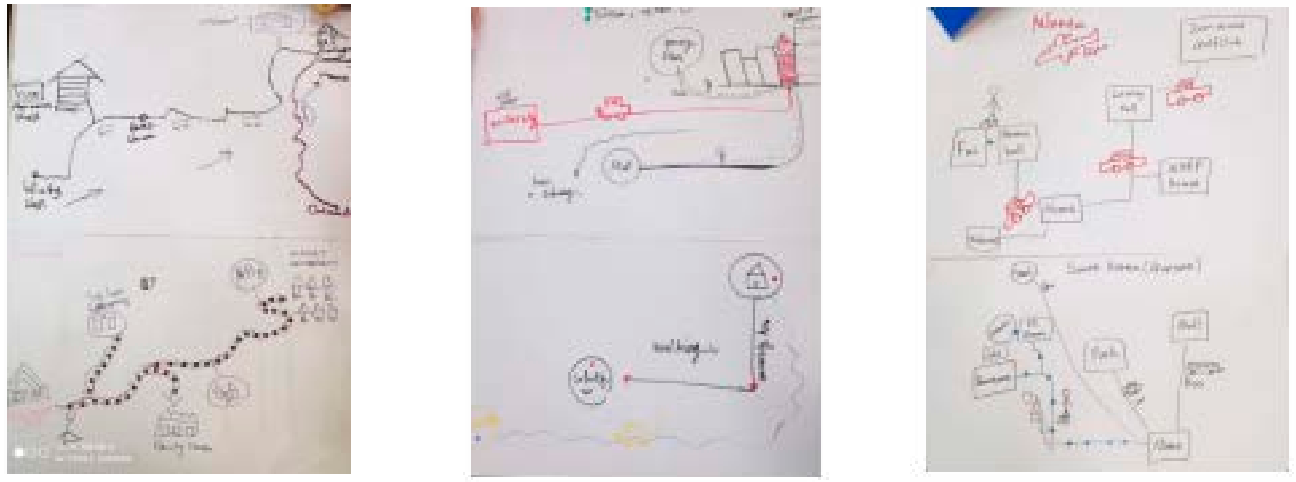

Figure 2: Mobility patterns showing diIerences between walking experience in Gainesville and towns, like Tehran (Iran), Accra (Ghana) and Gunsan (South Korea), 2024.

Many participants noted diIerences in the social atmosphere of walking back home or in other American cities versus in Gainesville. For instance, students who had previously studied in Vermont and Savannah fondly recalled spontaneous late-night walks with friends, while an experience they felt was less safe or feasible in Gainesville. Also, the lack of places to linger or gather (like cafes or scenic spots) in Gainesville seemed to lessen participants' motivation to explore by foot. They shared how community-oriented spaces, such as cafés, parks, and familiar gathering spots back home or in other American cities, contributed to a more engaging and social walking experience. One participant missed the scenic beauty of places like Vermont and DC, where mountain views and cleaner streets made walking enjoyable; however, others didn't view Gainesville's cleanliness as a significant issue compared to their previous environments. One student also mentioned that she enjoys running to a beautiful overlook point on the Hawthorn Trail (Figure 3).

During the first part of the activity, participants were asked if they used any step-counting apps. Those who did shared with laughter that on days without classes, they might only take 200– 300 steps. However, on class days when they walked more, their step count ranged from 1,500 to 3,000 steps. A few students also mentioned that they simply don't enjoy walking in general and prefer staying home, often ordering groceries online rather than walking or taking a cab or a bus to stores. Also, the same student said that she would be happy to go out if somebody call her, showing initiative.

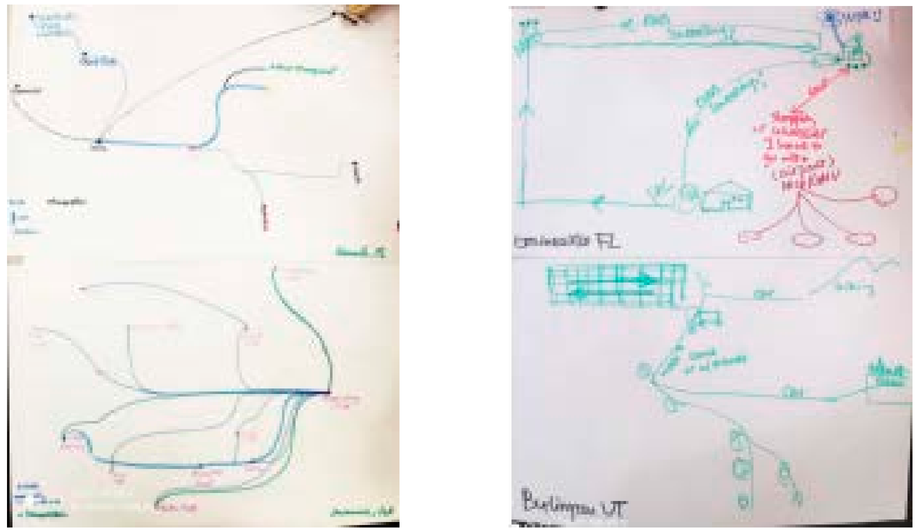

Figure 3: Mobility patterns showing diIerences between walking experience in Gainesville and other towns in the U.S., 2024.

This highlighted the varying attitudes toward walking and the significant role that daily activities, personal preferences, and the local environment play in shaping participants' walking habits. Such insights into how other people walk and create routes in urban contexts, and how they themselves reflect on these practices, provide something of a key to understanding their ways of being in the world (Pink, 2008).

3. Step 2: The debate

To better understand participants' attitudes toward walking and their physical interactions with the environment, we held a debate on whether designers should go outside to explore and study the world firsthand, engaging with their surroundings, or if technology alone is suIicient for creating eIective designs within a team of peers, without ever leaving the studio. Some literature highlights key benefits from debate as a teaching-learning strategy for developing critical thinking and analytical skills while fostering teamwork and communication. Debate also allows students to move beyond "rote learning of facts, theories, and technique," and provides an opportunity for applying knowledge through role-playing while demonstrating their ideas, values, and attitudes (Darby, 2007).

The participants were divided into two groups without prior preparation. One group was tasked with arguing why designers should walk and engage with the world physically, while the other group had to counter with reasons why designers can eIectively work from their studios in today's technological age (Figure 4). This spontaneous debate format allowed for immediate, dynamic exchanges of ideas, with participants drawing on their personal experiences and broader

knowledge to support their positions. This method introduced the idea that co-design is about dialogue and exchanging arguments back and forth, which resonates with the importance of active communication in co-design methods (Jordan& Henderson, 1995).

The first student emphasized the depth of observation and engagement that walking enables, arguing that walking allows one to experience the environment in a way that driving or even public transport does not. This perspective aligns with the principle of inclusiveness that emphasizes empathy and user experience, demonstrating that understanding a space requires direct interaction with it (Jordan& Henderson, 1995).

As a respond another student introduced the idea of technology, suggesting that digital tools and transport could provide adequate means to observe the world and interact with the environment without physical walking. She also added that sometimes technology is the only way to interact with the environment especially if it's another city or country. She believes that designers must adapt to technological advancements, which could mean using digital tools to simulate or experience environments in new ways. This suggests a shift towards more flexible, tech-enabled co-design methods, where participants can engage remotely or virtually. Technology-mediated communication has transformed our notion of the relation between place and community (Tillander, 2014).

Another student from pro-walking team argued that walking allows designers to fully engage with all senses, not just the visual, which is essential for understanding the environment in its totality. This aligns with the idea that, while we live in a three-dimensional world, we can fully understand it by engaging all our senses. Even the subtle changes in the surface beneath our feet provide valuable information about our environment (Papanek, 2021).

A student from the pro-technology team attempted to present a counterargument, but unintentionally extended the previous idea. She acknowledged that walking provides rich sensory experiences but suggested that buses, too, could serve as spaces for reflection.

After that, the pro-technology team attempted to strengthen their argument again. One participant shared a personal experience of driving through a highway, observing various building designs in a short span of time, which prompted thoughts related to a design assignment. It highlighted the idea that any interaction with the environment, even passive like driving, can trigger reflective thoughts that inform a designer's work.

Figure 4: Codesign activity representing debate, 2024

Figure 4: Codesign activity representing debate, 2024

A third participant from pro-walking team added that walking alone, without any distractions, oIers the best opportunity for designers to connect with their surroundings. He implies that walking is not just for socializing or observing others, but for a deeper, personal engagement with the environment and self-reflection that can inspire more thoughtful and authentic design. Their team also raised an important point about the sedentary nature of design work. They argued that designers, who spend most of their time sitting while designing or using a laptop, are neglecting the physical aspect of their health. He proposed that designers should incorporate physical activity into their work process, suggesting that walking or moving around could benefit both mental and physical well-being. This resonates with the idea that design is not just an intellectual process but a holistic one that engages the body and self-observation as well.

A student from the opposite team argued that she has all the equipment necessary to exercise at home. Although, in the end, she acknowledged that both technology and real interaction are important, and that they should not cancel each other out, but rather complement one another in the design process. This notion mirrors the principles of co-design, where technology is often used to enhance or expand participation rather than replace traditional methods. However, despite this optimistic conclusion, we can see that technology is indeed

replacing physical interactions with the world, not just for designers, but for communities in general (Tillander, 2014). And the previous data of the first step proves it.

The dialogues helped crystallize key themes related to sensory experience, user engagement and interaction, self-observation and the evolving role of technology in design

(OpenAI, personal communication, November 9, 2024).

4. Step 3: Walking around Gainesville

Existing ethnographic uses of walking methods incorporate various visual and digital media. Shared walks with informants are often used to collect information about their experiences, as well as insights from the researcher (Lee and Ingold, 2006). The idea of walking as a multi-sensory experience has increasingly been discussed across the social sciences and humanities. Walking,

particularly sensory walks, has become an established method in fields like geography and ethnography, allowing researchers to engage with environments in a more immersive and reflective way. As geographer Paul C. Adams points out, "To walk through a place is to become involved in that place with sight, hearing, touch, smell, proprioception, and even taste." Fieldnotes, traditionally seen as objective records of external reality, are now understood as more subjective and personal, reflecting the ethnographer's own sensory experiences. The distinction between objective and subjective is increasingly seen as unnecessary, with a more integrated approach emerging through reflexive ethnography. Photographs, for example, illustrate how data from the field can convey both objective information and subjective, experiential qualities of space (Pink, 2008).
The aim of the walking activity was to immerse participants directly in Gainesville's urban environment to capture real-time sensory feedback on their walking experience. This step aimed to identify emotional and sensory reactions to urban features and encourage participants to actively observe their surroundings, noting areas that felt safe and welcoming or unsafe, and to document these impressions with stickers. Insights were gained into how diIerent urban elements, like shade, traIic, architecture, and social atmosphere, impact the pedestrian experience. Walking through diverse parts of Gainesville - such as busier University Avenue and quieter, more scenic areas - helped participants identify factors that either support or hinder walkability, including sidewalk width, shade availability, points of interest, and urban noise. Through group discussions at various points, participants reflected on their personal experiences and observations, revealing common themes and contrasting perspectives while encouraging dialogue on walkability improvements.

After agreeing that walking is an essential part of a designer's activity and daily life, participants were invited to walk around the town. The route was planned in advance, starting from their design studio on campus, through University Avenue, and into Downtown (Figure 5).

They were asked to focus on their feelings along the way and mark locations where they felt unsafe (e.g., lack of shade, no sidewalks, heavy traIic) or areas that felt welcoming, using prepared stickers. The facilitator took photos and videos each time the group stopped to place a sticker and discuss their feelings, and also took on the role of a participant. Safety instructions were provided before the walk.

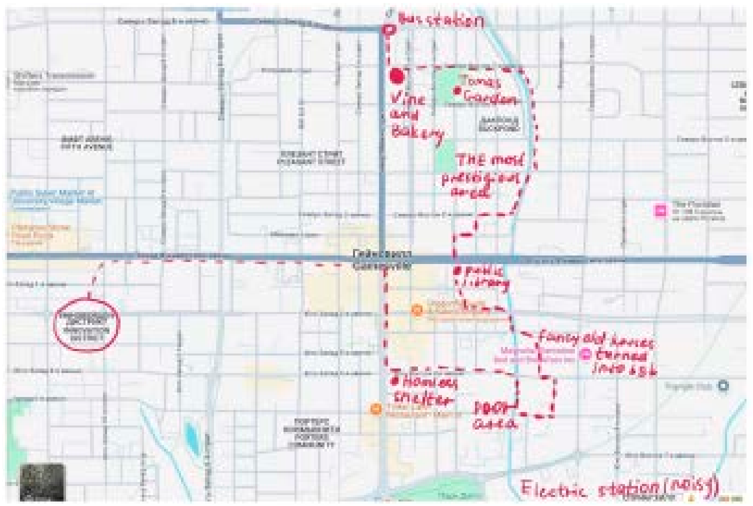

Figure 5: Planned rout for the walking activity, 2024

At the very beginning, one student placed a sticker on a bus sign, mentioning that he feels safe when he sees a bus stop in a town. Another student, however, argued that there is no shade or bench at the bus stop, and you don't know how long you would have to wait. We didn't feel like waiting and walked further (Figure 6).

The next stop was the intersection of 6th Street and University Avenue. One participant complained about the very narrow sidewalk, the lack of shade, and the absence of any interesting buildings to look at while waiting a long time for the light, especially if you need to cross the street twice (Figure 6).

Figure 6: Participants marking with stickers places where they feel safe or unsafe, 2024

The entire walk to downtown wasn't enjoyable; there was no interesting architecture along University Avenue, and the traIic was too loud to have a conversation. Only when we turned onto a smaller street in downtown, we started to feel more relaxed - there was no traIic, and a square paved with old bricks appeared (Figure 7). People were sitting outside next to a bar, adding to the pleasant atmosphere. However, there were still many abandoned buildings, even in such a nice area. Soon, we began to feel a bit tense as we approached a homeless shelter surrounded by a lot of trash and people wandering around (Figure 7). Then the student from Ghana noticed bamboo, which reminded him of home and gave him a sense of safety (Figure 7). That reminded one student that she experiences similar feelings when she senses familiar scents from certain plants, even if the plants are diIerent from those in her home country. Of all our senses, smell gives us our most direct link with the environment (Papanek, 2021)

Figure 7: Participants marking with stickers places where they feel safe or unsafe, 2024

We continued walking through the poorer area of downtown, passing numerous abandoned houses and businesses as we approached the noisy electrical station (Figure 8). We didn't encounter any people along the way, which felt eerie. One student noted that the wooden utility poles around town, with their dozens of tangled wires, made her feel unsafe

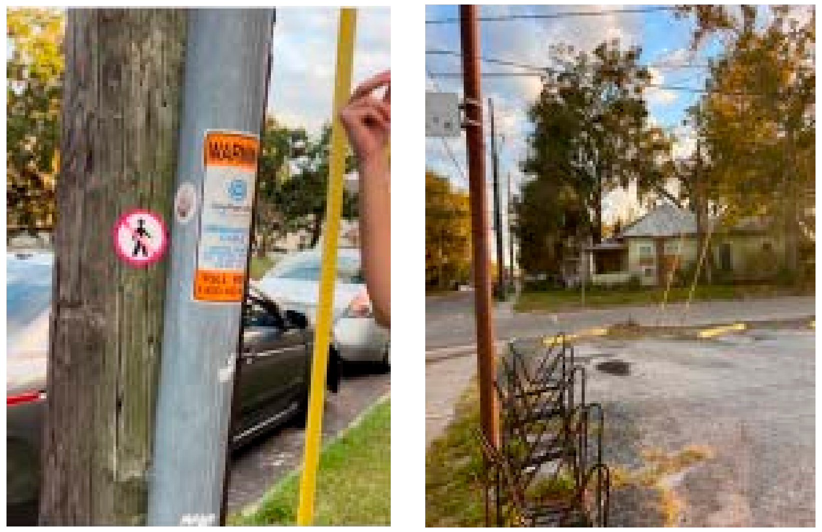

Figure 8: Abandoned houses and a participant marking with a sticker unsafe place, 2024

Right behind the abandoned part of town was the liveliest area of Gainesville, with its restaurants, theater, and even an amphitheater with a stage. Some students were surprised to see it and expressed a desire to return someday for a concert. We took the opportunity to grab some ice cream and tacos, thus incorporating the sense of taste into our exploration of the city. Now we finally felt like we were in a real little town, with all the bars open, people chatting, and pedestrians strolling around. There is also the collective unconscious, which makes us feel comfortable with some places and spaces but distraught with others (Papanek, 2021). By that time, we had been walking for almost an hour, and some participants were tired and decided to leave.

The rest of us crossed the busy road and arrived at the most privileged part of town- Duck Pond. We immediately felt the diIerence, with beautiful Victorian houses, wide separated sidewalks, big trees and even their own squares and little creek with swans. All of us felt relaxed and happy, and despite having already walked a lot, we were willing to keep walking. The atmosphere of the place was very welcoming. Although the flourishing of this area is a result of historically established inequality. There were houses of the wealthiest white people in Gainesville, while just across the street were the African-American neighborhood, called Pleasant Street, with no sidewalks and noticeably fewer trees. The neighborhood operated as a "town within a town" during Gainesville's decades of segregation (Gainesville Neighborhood Voices).

Even today, there are only two places where you can safely cross busy Main Street to get to Duck Pond from the Pleasant Street district. And the distance between these two crossings is 0.6 miles.

Walking through both aIluent and less privileged neighborhoods allowed participants to experience and discuss disparities in urban infrastructure and accessibility, recognizing how these inequalities impact community walkability and social engagement.

Although at the end we walked through the most welcoming and interesting parts of the town, where most of the participants had not been before, they didn't show much excitement or a desire to return (except for the concert amphitheater). This is likely due to the distance, as everyone lives far from downtown, and the city doesn't oIer attractions that justify the long journey.

5. Limitation of the experiment

One significant limitation of this experiment is the short duration of participants' time in Gainesville. Most of the participants had only been living in the city for three months, which means their perspectives on the city's walkability and urban environment may not fully reflect those of long-term residents. Their experiences are likely influenced by initial impressions and limited exposure to diIerent areas of the city. A longer duration of residence might provide a deeper understanding of the nuances of the urban landscape, as participants would have had more time to adapt to local conditions and to experience a wider range of environments within the city. Furthermore, the participants' busy schedules-balancing work, study, and other commitments

could aIect their ability to form a comprehensive view of Gainesville.

The facilitator's experience in Gainesville, having lived there for three years, provided a contrast to the participants, but this still doesn't fully mitigate the challenge of limited exposure. Though the facilitator's longer residence gives her more local knowledge, the facilitator's perspective could still diIer from those of participants who are encountering the city for the first time, which could lead to diIerent interpretations of the urban environment.

Another key limitation is the fact that none of the participants were U.S. residents. This introduces a cultural factor that could influence how the participants perceive the environment. Non-U.S. residents may have diIerent expectations or experiences of urban spaces compared to local residents, especially if they come from countries with distinct urban planning norms or pedestrian cultures. But at the same time, this bias could be useful if we acknowledge it and explore the city through the lens of foreigners, which is particularly relevant since many foreigners come to UF to study.

Walking in a group made observation challenging. There were too many distractions, and we had to remain constantly aware of traIic while also trying to document and reflect on the experience. This activity could be developed into a more thoughtful and extended observation

with fewer participants (3 instead of 5). By walking shorter distances and spending more time at each point, we could even incorporate observational sketching as a tool.

6. Conclusion

This research highlighted that urban walking is under threat not only from visible issues-such as great distances, inadequate sidewalks, crosswalks, and the dangers posed by cars- but also from societal shifts driven by new technologies (Tillander, 2014). Many people find it unnecessary to go outside when they can access everything from deliveries to social connections online. As a result, pedestrian presence on city streets is dwindling. This decline weakens the collective voice needed to defend pedestrian rights. Once infrastructure essential for walking is removed or neglected, it becomes very diIicult to bring it back, allowing cars to dominate and subtly shifting the balance of urban life. This threat extends beyond sidewalks to other public spaces as well, from bus stops to schools. As aIluent societies lean toward individualism - favoring cars, private schools, and personal convenience - public spaces risk becoming marginalized and underutilized, further reducing communal spaces that support active, shared urban life (Bauman, 2005).

Although none of the participants initially mentioned these obstacles to walking around Gainesville. However, while walking with a student from Vietnam, she shared that being alone on nearly empty streets makes her feel like an outsider, very diIerent from the locals. This sense of alienation can lead to discomfort and even feelings of unsafety. Concerns around race are also significant in discussions of pedestrian power relations. Additionally, from a woman's perspective, being alone on empty streets, especially after dark, can feel particularly unsafe. For example, Wilson (1991) draws attention to how the city is not only a place of excitement and opportunity for women but also one fraught with safety concerns. She argues that 'women's experience of urban life is even more ambiguous than that of men, with safety being a crucial issue.' Studying urban walking is interesting not just as a practical aspect of mobility, but as a socially and politically meaningful activity. This perspective goes beyond logistics and looks at how walking intersects with social interactions, urban power dynamics, and the concept of the "right to the city" - meaning individuals' rights to access, shape, and feel safe in urban spaces (Middleton 2018). This approach invites analysis of how walking connects to broader concerns in urban life, such as inclusivity, community belonging, and the structures that prioritize or marginalize certain groups within public spaces. There should be more focus on the social and cultural aspects of everyday walking practices. It calls for a stronger connection between theoretical walking studies and practical, real-world research to better understand how walking is experienced and shaped in diIerent contexts (Middleton, 2018).

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ChatGPT by OpenAI was used to assist with editing and enhancing clarity in certain sections of this document.

POSTERS

Adaptation and Transformation-Community-Led Stories of Positive Change

MIXED JAMAICAN DIASPORA

AUTHOR

ARTIS TRICE

Nyam Like Yaad Abroad: Food, Memory, and Homemaking among the Jamaican Diaspora

Artis Trice, MA, Latin American Studies, University of Florida

Background

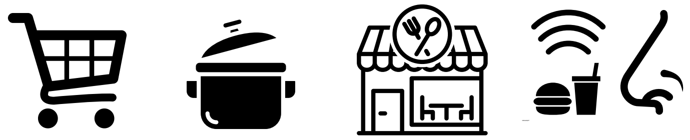
Jamaicans hold food as an integral part of our national identity and connection to the island (Sperry, 2021). Nyam, a Jamaican Patois word, means eat. Yaad (yard) in Jamaican Patois refers to 'home' both as a place of residence and Jamaica as a homeland. This project analyzes food memory of Jamaicans living in the Southern United States. Using Elizabeth Jelin's (2003) definition of memory entrepreneurs, I position my family members as people attempting to cultivate social awareness of Jamaica in the Southern U.S. through food. By sharing memories and cooking Jamaican food, they work to maintain their identity, source Jamaican food locally **(SDG 12)**, improve cultural food security **(SDG 2)**, demonstrate cultural resilience, and pass food, foodways, and sourcing strategies to other Jamaican immigrants.

- **If Jamaican food creates reinforces identity in the diaspora, what does it mean to go without a taste of home?**
- **To what extent does Jamaican food play in their memories of the island?**
- **When eating these foods are no longer part of everyday customs and routines, how is memory recalled?**

Methods

- Memory project with 6 semi-structured interviews with family who migrated between 1980 and 2024
- Transcribed interviews analyzed for key themes
- Narrative created using memory and postmemory, which is passed from one generation to the next and interpreted through the second-generation experience (Hirsch, 2008)

Triggers of Food Memory



- Buying, cooking, eating, and smelling Jamaican food sourced locally helped interviewees to recall Jamaica, promote belonging in the US, and maintain ties to the island (Abarca & Colby, 2016).

Discussion and Key Findings

- Cooking and finding Jamaican food was a challenge for Jamaican immigrants in the 1980's/1990's
- Friends, family, neighbors, and community are important support networks for people to find Jamaican food in Atlanta and South Florida
- Life changes such as migration, getting married, and having children marked diet change (Ando, 2019)
- Interviewees in South Florida mentioned having higher access to fruits similar to those in Jamaica
- Food memory works to create positive environmental and cultural images of Jamaica in the diaspora

Stories about family dinners at Aunt Ouida's house came up in every interview with my family members. Here, Snide, carves a ham for Christmas dinner. Photos like this triggered food memories and nostalgia of Jamaica in interviews.

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I would like to thank my family members for trusting me with their interviews and stories. I am truly appreciative of your knowledge and resilience. Many thanks to my classmates in the Politics and Poetics of Memory and Dr. Carmen Martinez-Novo for listening to the drafts of my work I would also like to thank the Resilience Symposium, UF Office of Research, and Center for Latin American Studies for travel funding.

MODELLING THE INEQUITABLE DISTRIBUTION OF AESTHETIC GREEN VIEWS ACROSS DIMENSIONS OF SUPPLY, DEMAND, ACCESSIBILITY, AND FLOW

AUTHOR

JOSEPH BRIAN BENJAMIN

Gaps between aesthetic green view supply, accessibility, and realized flows

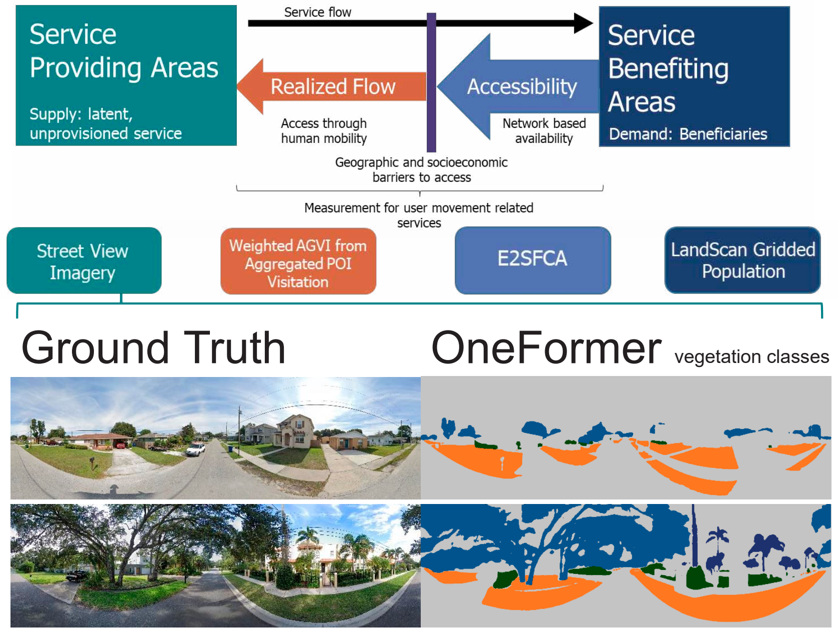
Joseph Benjamin[1], Dr. Weizhe Weng[2], Dr. Chang Zhao[3]

1. College of Design, Construction and Planning, University of Florida, 2. Food and Resource Economics Department, University of Florida, 3. Agronomy Department, University of Florida

Introduction & Methods

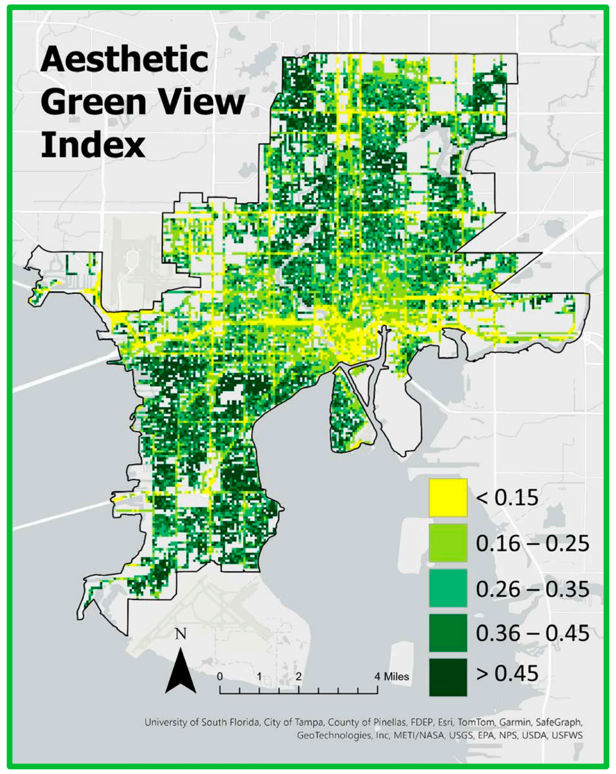
Aesthetic green views (AGV) is an important cultural ecosystem service (CES) that can improve quality of life for human beneficiaries, with delivery dependent on both the supply and , and the actual use—or realized flow—of these services by human beneficiaries.

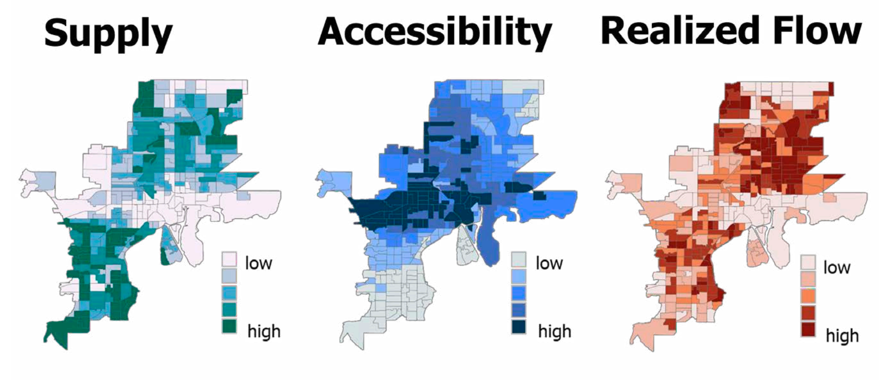
Pixel counts and vegetative diversity across Tree, Plant, Palm, and Grass classes were measured using OneFormer, a transformer-based model pretrained on the ADE20K dataset. Together, they generated an Aesthetic Green View Index (AGVI). On a validation dataset of 100 street view images, the model achieves AP = 49.4 and mIoU = 65.2 across relevant classes.



Results

- Bivariate analysis shows that indicators of higher socioeconomic status (SES), such as income, educational attainment, home and car ownership, have a significant positive correlation with in-situ supply of AGV and a negative correlation with accessibility.
- A Durbin spatial regression model shows that the interaction between in-place supply and accessibility is significant predictor of higher realized flows ($p<0.05$). Almost all SES indicators were not significantly correlated when controlling for spatial dependence of the response variable.





Discussion

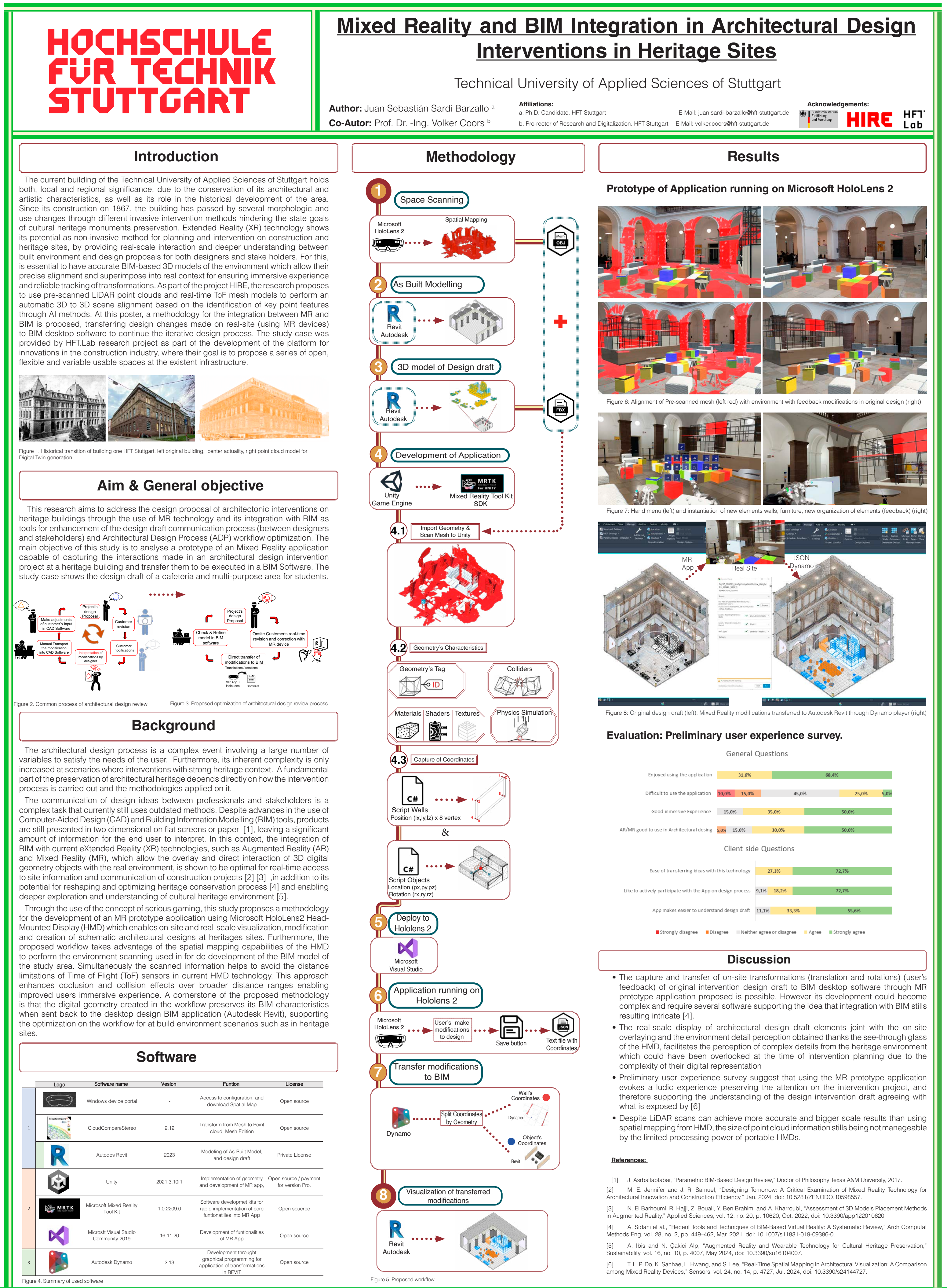
- There are stark inequities in AGV supply, particularly in lower income, minority communities.
- Despite higher network accessibility to green POIs, these communities do not experience the benefits of such connectivity – indicating a disconnect between access and use.
- Visited green views (realized flows) could help compensate for insufficient home views (flows that stem from residential in-situ supply).

There are sharp inequities in AGV supply, highlighting the need for streetscape greening initiatives. While seeing the benefits of such work takes time, high accessibility in low-SES block groups presents a more immediate opportunity to enhance realized flows through improved transit connectivity.

MIXED REALITY AT ARCHITECTURAL DESIGN INTERVENTIONS IN HERITAGE SITES: METHODOLOGY OF COMMUNICATION OF DESIGN IDEAS THROUGH BIM

AUTHOR

JUAN SEBASTIAN SARDI BARZALLO



RESILIENCE
In urban environments
toward SDG sustainable
cities

UF UNIVERSITY of FLORIDA   UCUENCA ARQUITECTURA

PROPUESTA DE PROTOTIPO DE VIDEOJUEGO COMO HERRAMIENTA DE DIFUSIÓN DE PATRIMONIO. CASO DE ESTUDIO: CASA DE LAS POSADAS

AUTHOR

MATÍAS ISMAEL MONTERO ANDRADE

THE SOCIALITIES OF EVERYDAY URBAN WALKING

AUTHOR

TATIANA GLAKHOVA

WALKING AS A RIGHT: A CRITICAL LOOK AT WALKABILITY IN GAINESVILLE, FLORIDA

AUTHOR

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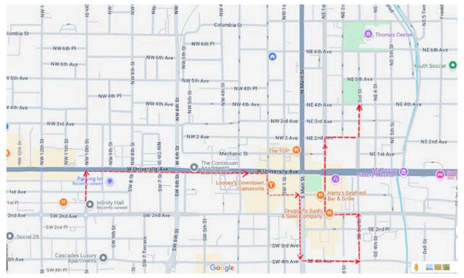
Walkability goes beyond logistics and looks at how walking intersects with social interactions, urban power dynamics, and the concept of the "right to the city" - meaning individuals' rights to access, shape, and feel safe in urban spaces (Middleton, 2018).



01. Introduction

This research explores walkability in Gainesville, Florida, through a socio-political lens, examining how car-centric planning affects mobility, safety, and inclusion. It frames walking not merely as transportation but as a transformative act that reclaims public space for community, sustainability, and equity. By centering designers as both observers and potential advocates, the study introduces a new perspective to walkability discourse, emphasizing the emotional, cultural, and identity-based dimensions of urban mobility. Methodologically, it combines participatory mapping, storytelling, structured group debate and observational walking to generate qualitative, experience-driven insights that broaden what counts as data in urban design research.

02. Objectives

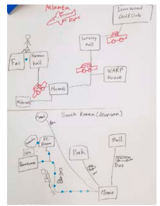
- To explore how individuals from diverse cultural and gender backgrounds experience walkability in Gainesville in comparison to their previous cities.
- To uncover the emotional, sensory, and social dimensions of pedestrian life in a car-centric environment.
- To understand how urban features (such as shade, noise, sidewalk width, city life, and architecture) shape feelings of safety, joy, and inclusion or contribute to discomfort and exclusion.

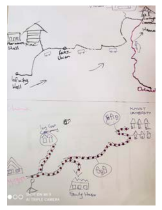
Aknowledgement:
Since all participants grew up outside the U.S., their cultural backgrounds may have influenced how they perceived the local environment and helped reveal hidden barriers or feelings of exclusion for marginalized groups that locals might overlook or take for granted.

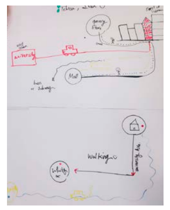
03. Methodology

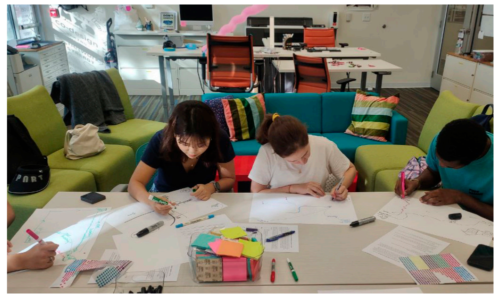
This study employs participatory design methods, including:

1. Mapping individual walkability patterns for each participant.
2. Facilitating a group debate to explore participants' attitudes toward the necessity of walking in modern life.
3. Observational walking sessions (from campus to down town area), using special stickers for participants to mark and express their feelings about different urban features.









04. Findings

The mapping activity and debate revealed diverse attitudes toward walking and showed how daily routines, personal preferences, and the local environment influence walking habits. Participants noted that their walking routines had decreased compared to those in their home countries or other U.S. cities, such as Savannah. Although participants agreed during the debate that walking and real interactions with the world are important, many still don't see the opportunity or motivation to improve their walking patterns, at least not in Gainesville.

Some participants shared that being alone on nearly empty streets makes them feel like outsiders, very different from the locals. This sense of alienation can lead to discomfort and even feelings of unsafety, especially for immigrants who don't look like local population.

Even today, there are only two places (spaced 0.6 miles apart) where you can safely cross busy Main Street to get from the Pleasant Street district to Duck Pond — neighborhoods that were historically segregated.

Participants noted the long waiting times at crosswalks, often with no shade or visual interest around to make the wait more bearable.

While walking, they engaged with the environment using all their senses, including smells and sounds, that sometimes evoked good memories and made them feel safe.

05. Outcomes

Many people find it unnecessary to go outside when they can access everything from deliveries to social connections and entertainments online. Additionally, hostile car-centric atmosphere outside doesn't make walking appealing to motivate people to go out.

As a result, pedestrian presence on city streets is dwindling. This decline weakens the collective voice needed to defend pedestrian rights. Once infrastructure essential for walking is removed or neglected, it becomes very difficult to bring it back, allowing cars to dominate and subtly shifting the balance of urban life.

Concerns around race are also significant in discussions of pedestrian power relations. Additionally, from a woman's perspective, being alone on empty streets, especially after dark, can feel particularly unsafe.

Concerns around race are also significant in discussions of pedestrian power relations. Additionally, from a woman's perspective, being alone on empty streets, especially after dark, can feel particularly unsafe.

Based on this analysis, several suggestions for improving pedestrian safety and comfort were developed and submitted to the Alachua County transportation survey. One of them was recently implemented — an additional crosswalk between historically segregated neighborhoods.

06. Conclusion

Studying urban walking is interesting not just as a practical aspect of mobility, but as a socially and politically meaningful activity. This approach invites analysis of how walking connects to broader concerns in urban life, such as inclusivity, community belonging, and the structures that prioritize or marginalize certain groups within public spaces. There should be more focus on the social and cultural aspects of everyday walking practices. It calls for a stronger connection between theoretical walking studies and practical, real-world research to better understand how walking is experienced and shaped in different contexts

GROWING IN PLACE: METHODS OF UNCOVERING COMMUNITY TENDENCIES AND ECOLOGICAL COMPLEXITIES

AUTHORS

MICHAEL DIEFFENTHALLER
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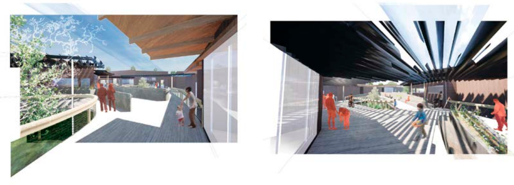
SARAH SPAYD

Growing in Place: Methods of Uncovering Community Tendencies and Ecological Complexities

Michael Dieffenthaller, Eric Rykard, Sarah Spayd, & Karla Saldaña Ochoa

Growing in place explores how resilient architectural design may emerge from a process of learning hidden rhythms and layered interactions between people, the environment, and time. Using traces in neighborhoods, whether ecological, spatial, or behavioral, as critical data creates a framework for the project that is analytical and site specific. These traces can be found as used as records of habits, tools for design, and indicators of resilient natural systems already present. It also suggests methods of how built interventions can enhance dialogue between people and the environment they live in.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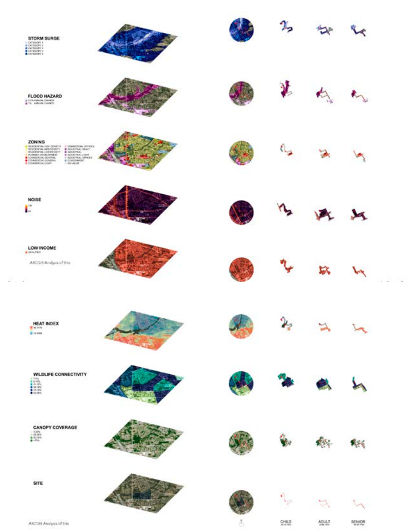
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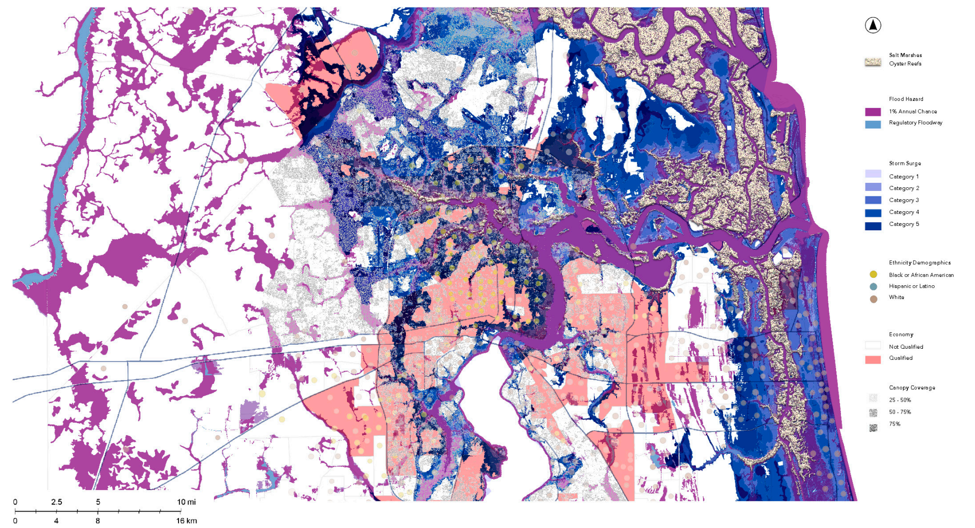
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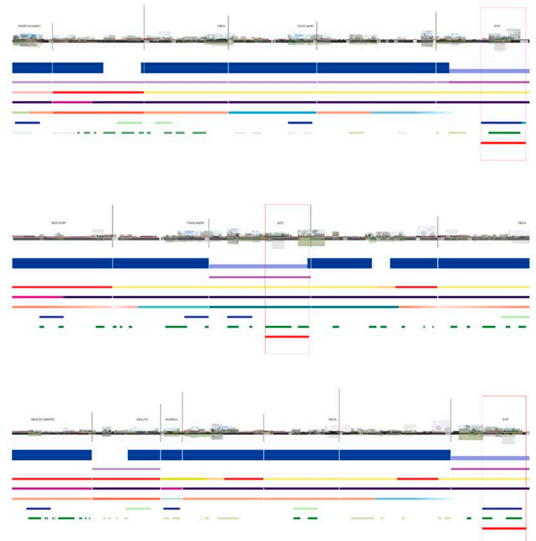
Process, People, & Place

This project centers on neighborhoods adjacent to the Ribault River in Jacksonville, Florida, where long-standing communities shape and utilize the space. Through field research and transect mapping, behavioral patterns and tendencies of age specific demographics were analyzed and shared spaces of each group such as schools, clinics, food marts, transit stops, and community centers as well as related overlaps of experience, flooding events, and other conditions of the site.

Rather than a top-down perspective, the methodology embeds social knowledge and generational history to learn the routines and valuable locations and conditions of a place. Being informed by the residents familiarity and proximity of the site allows for the mapping of movement and experience and how it changes as each resident ages in the site. Architectural interventions in pursuit of place-making can then be informed by the identified paths, landmarks, and conditions and their associated relevance and impact to the community so that intangible social patterns can respond with spatial relationships.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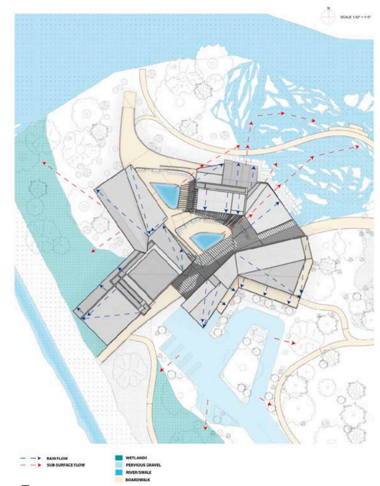
Environmental Responses & Adaptive Design

The site's ecological and hydrological complexity introduces further challenges that require responsive and sensitive designs. The site being subject to seasonal flooding, storm surges, and sea level rise means the landscape needs to allow for adaptability rather than resistance. Architectural interventions were considered to allowing elevated water to easily flow around the structures. For the events of high flooding, program spaces such as labs and storage included buoyant, enclosed resistant walls, and track-guided bases allowing these spaces to rise with the water and return to their original positions. This created a resilient project that is shaped by the water's presence rather than attempting to prevent it.

The larger ecological stances of the project includes fostering existing and new biodiversity conditions through designed floating islands, wetlands, marsh gradients, and additional vegetation zones to attract and support native species and ecosystems. These ecological zones also clean water, mitigate runoff, and add to the sensory experiences of the site.

Overall, this approach uses the architecture as an intersection between the environment and the people present through the various stages of their life and their active engagement in the early stages of design through the life and use of the project, including program and public space. Anticipating and responding to change with the community so that the whole site becomes one living system.



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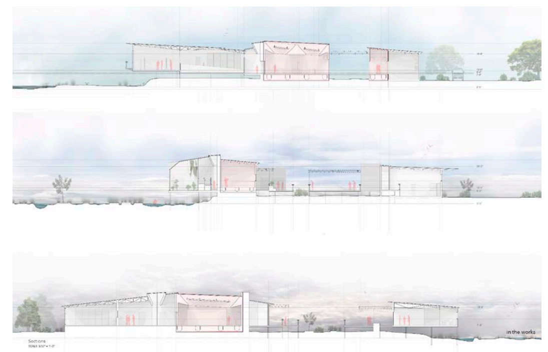
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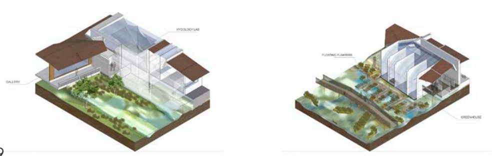
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1. Perspectives of proposed project. Left perspective is of the interior courtyard. Right perspective is entering between the educational room and welcome center.

2.Transect mapping analysis with exploded fragments associated with each age demographic studied along a "typical" path of travel. From left to right it is child, adult, and senior. The layers studied along each path from top to bottom are as follows: storm surge, flood hazard, zoning, noise, low income regions, heat index, wildlife connectivity ratios, canopy coverage, and the base site and paths of travel.

3. Site map with various ecological and socioeconomic data. The layers include salt marsh oyster reefs, flood hazard, storm surge, ethnicity demographics, low income qualification, and canopy coverage.

4. Sketches for organizing and exploring relations between program, movement of people, and site conditions.

5. Site map with proposed intervention.

6. Transect section analysis studying paths of travel of child (top), adult (middle), and senior (bottom) and site conditions they intersect including storm surge, flood hazard, zoning, noise, low income regions, heat index, wildlife connectivity ratios, and canopy coverage.

7. Rain and water flow analysis mapping.

8. Building sections. (Top) human systems lab, hydrology lab & storage. (Middle) greenhouse, botany lab & storage. (Bottom) hydrology lab & education center.

9. Building vignettes. (Left) gallery, river, & hydrology lab. (Right) Floating planters, boardwalk, & greenhouse.

MIXED JAMAICAN DIASPORA

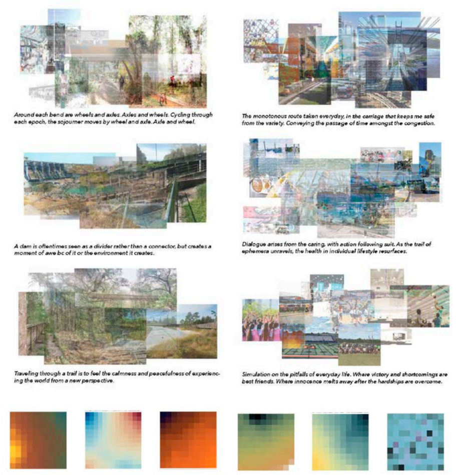
AUTHORS

RUTH HUNTER IGLEHART
REAGAN JOHNSON
MICHAEL NEMERY

By Modal | JIN Studios

Reagan Johnson, Ruth Iglehart, Michael Nemery, & Karla Saldaña Ochoa

By Modal explores ideas of impermanence and disappearance as the nature of the shoreline is unpredictable; it approaches and recedes.
How might we help low-income youth and their households in riverside communities **by** improving access to recreational activities, **even though** the current location between existing parks in the area are distant.

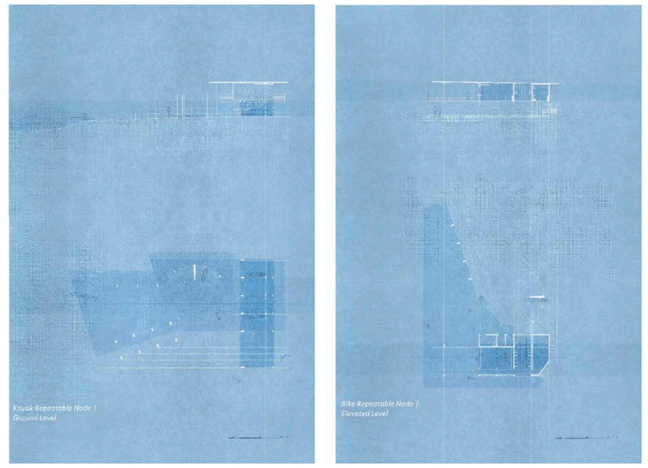


Repeatable Node

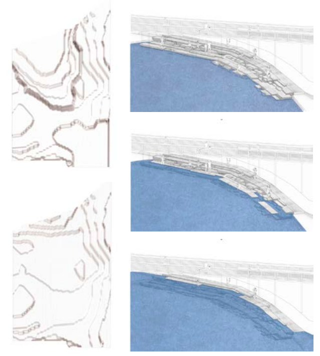
To promote other forms of transportation other than by motorized vehicle, we propose a modular node to mitigate this issue that can be replicated throughout the city populating amongst its existing trail systems and waterways.

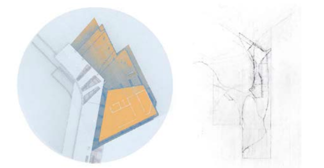
This nodal element is comprised of two modules: the bike node and the kayak node. These nodes allow for the rental of bikes and kayaks, as well as the inspecting and repairing of bikes within the community. These two modules are able to be constructed together, or separate, depending on its adjacency to water or land.

Apart from servicing modes of transport, the nodes double as an emergency disaster relief storage and distribution center in times of need, recognizing that these underserved communities along the river are also at a higher risk for severe weather events and flooding.



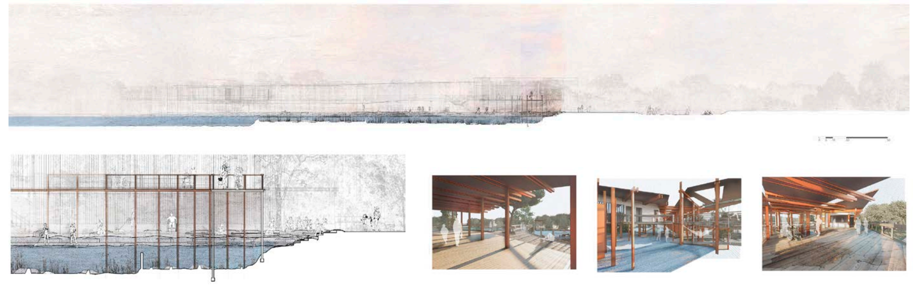
We have a vision of our node becoming deployed throughout Duval county in a variety of areas for a variety of demographics, ultimately connecting all communities within the metro area. Each of these locations underwent a mutation to show the how influential context can be in shaping the form and function of the nodes based on the determined need in the area.

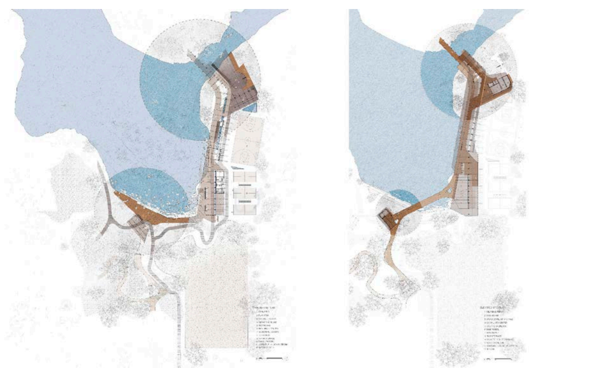




Occupiable Rip Rap

To help prevent shoreline erosion and mitigate flood waters, we designed a specific shape of stone that slows down incoming tides. This feature doubles as shoreline recreational acccess for visitors, playing into our intention of merging natural flood prevention with recreation.





Predicting the Future

The *By Modal* intervention exists elevated from the ground, anticipating that rising sea levels will extend the existing shoreline to reach farther into the surrounding neighborhood.

The main programmatic spaces are elevated, with the expectation that our anticpated interconnecting site trail system and, ultimately our intervention, are able to function for several years to come. As the water rises, what was once traveled by bike is now able to be crossed by kayak, or other vessels by transport of water.

The kayak rental space under the bike rental, however, adapts to rising water via an interlocking floor system that rises with the tide. This ensures that storing and launching kayaks will be available at every point in time, not simply when the water reaches the elevated floor plane. In this way, we sought to have multiple modes of recreation accessible despite the changing environment, mirroring how communities adapt to evolving conditions

On the City of Jacksonville's current and future resiliency strategies in different economic, social, and environmental sectors:

City of Jacksonville, et al. Resilient Jacksonville. 2023. https://www.jacksonville.gov/departments/planning-and-development/community-planning-division/resilient-jacksonville/docs/resilient-jacksonville_oct2023_pages.aspx

On shoreline maintainence and stability; methods for on-land and underwater applications and strategies:

Friar, Greta, and Abdul Latif Jameel. "A Solution for Urban Storm Flooding." MIT News | Massachusetts Institute of Technology, July 12, 2018. https://news.mit.edu/2018/storm-flooding-engineered-urban-green-space-0713.

On altering shorelines and flood landscape based floot mitigation strategies:

After the Flood: The Pioneering Architects Embracing Flood-Conscious Design - Design & Build Review: Issue 43: April 2018." Design & Build Review | Issue 43 | April 2018, May 20, 2024. https://designbuild.nridigital.com/design_build_review_issue_43_april_2018/after_the_flood_the_pioneering_architects_embracing_flood_conscious_design.

FINAL NOTES

The Resilience Symposium has received grants from the International Center, the Center for Latin American Studies, the College of Design, Construction and Planning, and the School of Architecture at the University of Florida, and from the College of Architecture at the University of Cuenca to support its organization. This booklet marks the third year of this initiative, which began in 2022 in Ecuador, continued in 2024 in the USA, and is scheduled for 2025 in Ecuador. Discussions at the event indicate that fostering resilience goes beyond mere improvement and sparks an ongoing dialogue about who benefits from these innovative approaches. All stakeholders must collaborate closely to promote a future that is not only "better" but also safer and healthier. This symposium encouraged encounters that stimulated debate, facilitated international exchanges, and fostered networking. It also linked discussions on sustainability and resilience in urban areas introduced by the SDG Sustainable Cities, empowering local and international practitioners, researchers, policymakers, activists, students, and volunteers to work together to envision resilient futures.