CROSS-SYSTEMS RELATIONSHIPS

WEINA ZHANG
Associate Professor, at the National University of Singapore (NUS)'s Business School, and Deputy Director of Sustainable and Green Finance (SGFIN). She researches and teaches sustainable investment, focusing on responsible finance and its impact in global and emerging markets.

FANNY XUEQI OR
Research Analyst at SGFIN

ZHANG FEIMO
Research Associate at SGFIN

JEFFERSON
Research Associate at SGFIN

Rethinking Value Creation in Building Sustainable and Regenerative Cities

The NUS E7 facility, a green building which bridges research between the Engineering and Medical fields, the state-of-the-art Wet Science Building, as well as energy-related initiatives.
Image: National University of Singapore

Urban development is at an inflection point. As the climate crisis intensifies and cities swell under demographic, ecological, and economic pressures, planners, developers, and investors are re-evaluating what constitutes value.

> Green buildings enhance economic resilience, strengthen natural capital resilience, forge a net-zero pathway, and create liveable cities.

Traditional financial metrics like internal rate of return (IRR) and net present value (NPV), while still relevant, no longer capture the full spectrum of impact generated by buildings and districts. To address this gap, the Sustainable and Green Finance Institute (SGFIN) at the National University of Singapore (NUS) has developed an Integrated Return on Investment (IROI) framework—a methodology that quantifies and monetises economic, environmental, social, and governance (EESG) outcomes of urban development.

The IROI framework offers a holistic valuation tool applicable at both the building and district levels. It enables stakeholders to answer a fundamental question: for every dollar spent on sustainability, what is the true value created for people, the planet, and investors?

Theory of Change

To answer the preceding question, we first asked ourselves why green buildings are needed and what value propositions they offer to society and the environment. A key method that we used to identify stakeholders and establish input-output causality was the Theory of Change (ToC). This helped us better understand the role of green buildings in contributing to a more sustainable future.

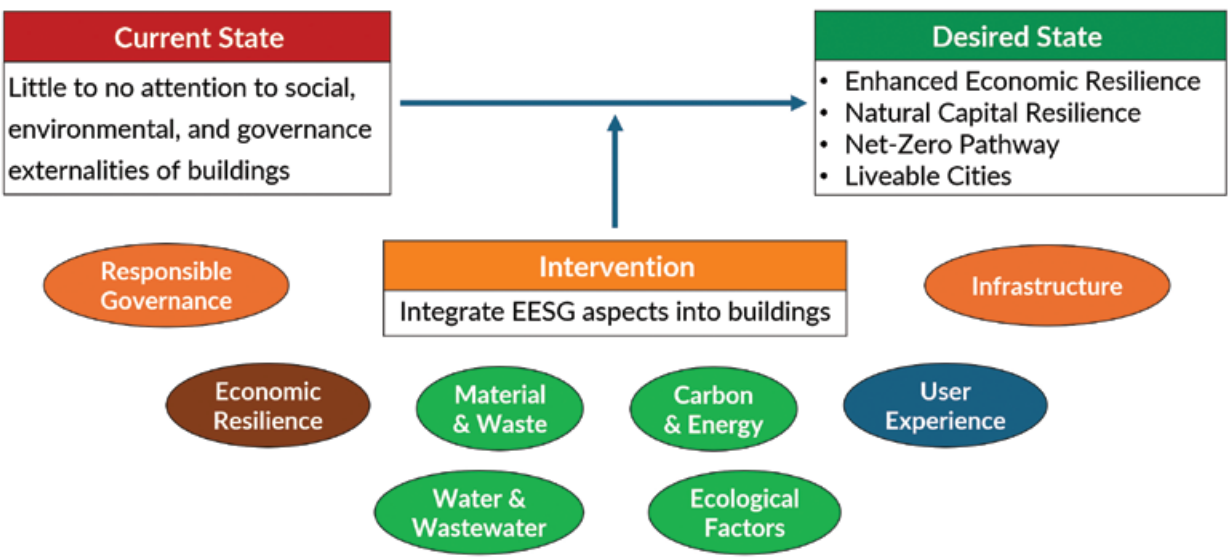
In developing the ToC, we identified four long-term impacts of green buildings for key stakeholders, society, and the environment:

- Green buildings enhance **economic resilience** by reducing operational costs, attracting higher occupancy through green premiums, and creating jobs across the construction value chain.

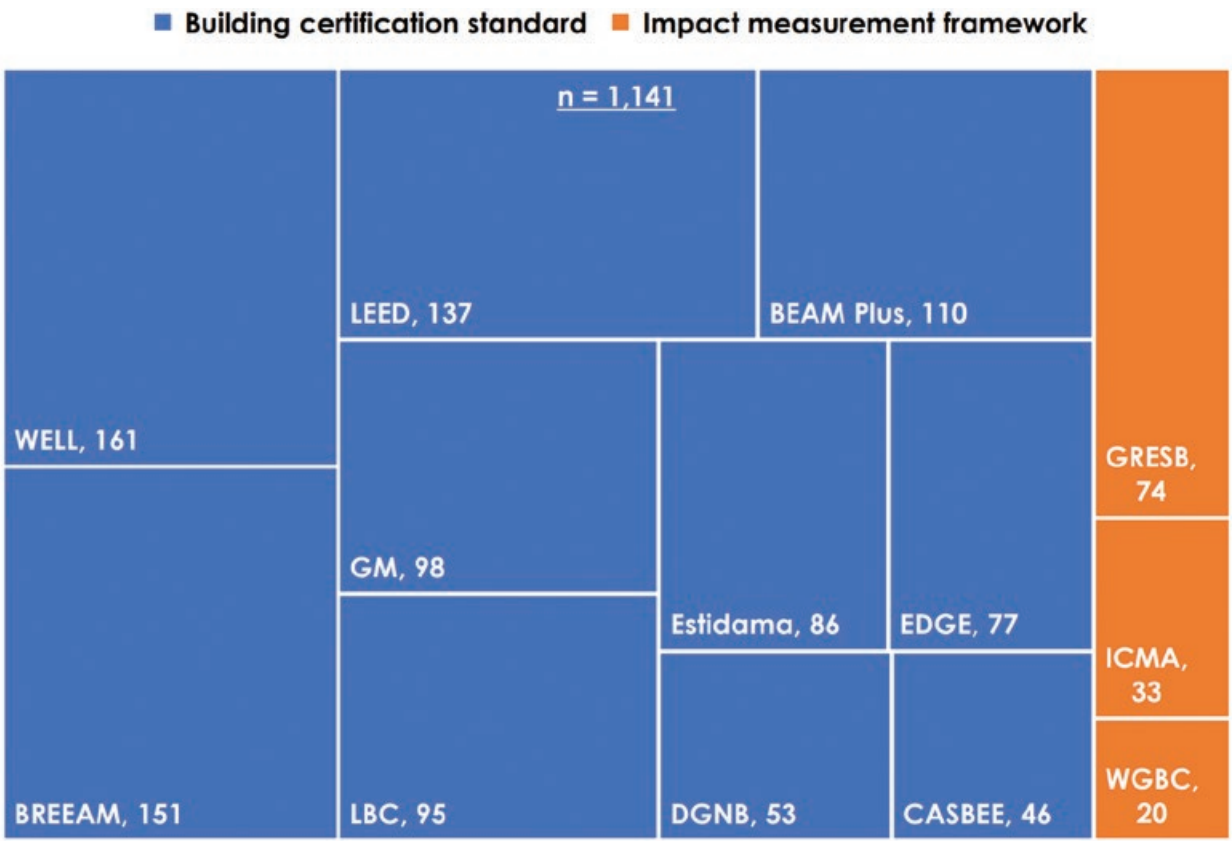
> Building projects can improve how they manage their assets and surroundings, such as by better integrating with transportation and infrastructure to meet future urban and climate goals.

- They strengthen **natural capital resilience** by minimising environmental footprint and supporting the regenerative capacity of essential natural resources.
- They are critical components for building a **net-zero pathway** through energy-efficient design, retrofitting, and adoption of zero-carbon technologies.
- They contribute to creating **liveable cities** by improving environmental quality, fostering social inclusion, and supporting urban biodiversity.

Currently, many buildings are constructed with little attention to their environmental, social, and governance externalities, exacerbating global challenges. **Economically**, buildings must justify their investment and reflect integrated costs and benefits. Yet, despite massive global investment, only a small share is allocated to green buildings. Future stakeholders must move beyond traditional profit maximisation and account for ESG impacts. **Environmentally**, buildings often overlook their impact on surrounding ecosystems, with low energy efficiency, high GHG emissions, inadequate water management, and poor material and waste practices remaining widespread. **Socially**, developments often insufficiently consider their direct and indirect impacts, including indoor environmental quality and their role in promoting health and food resilience, which are critical to user experience. **Governance**-wise, building projects can improve how they manage their assets and surroundings, such as by better integrating with transportation and infrastructure to meet future urban and climate goals. These gaps substantiate the need for intervention—to integrate EESG aspects into buildings. We present the ToC below to illustrate the entire value chain.



Theory of Change for Green Buildings in Singapore.
Image: The Integrated Impact Valuation Framework for Green Buildings, 2024, SGFIN Whitepaper Series 04



Building Indicators under Different Standards and Frameworks.
Image: The Integrated Impact Valuation Framework for Green Buildings, 2024, SGFIN Whitepaper Series 04

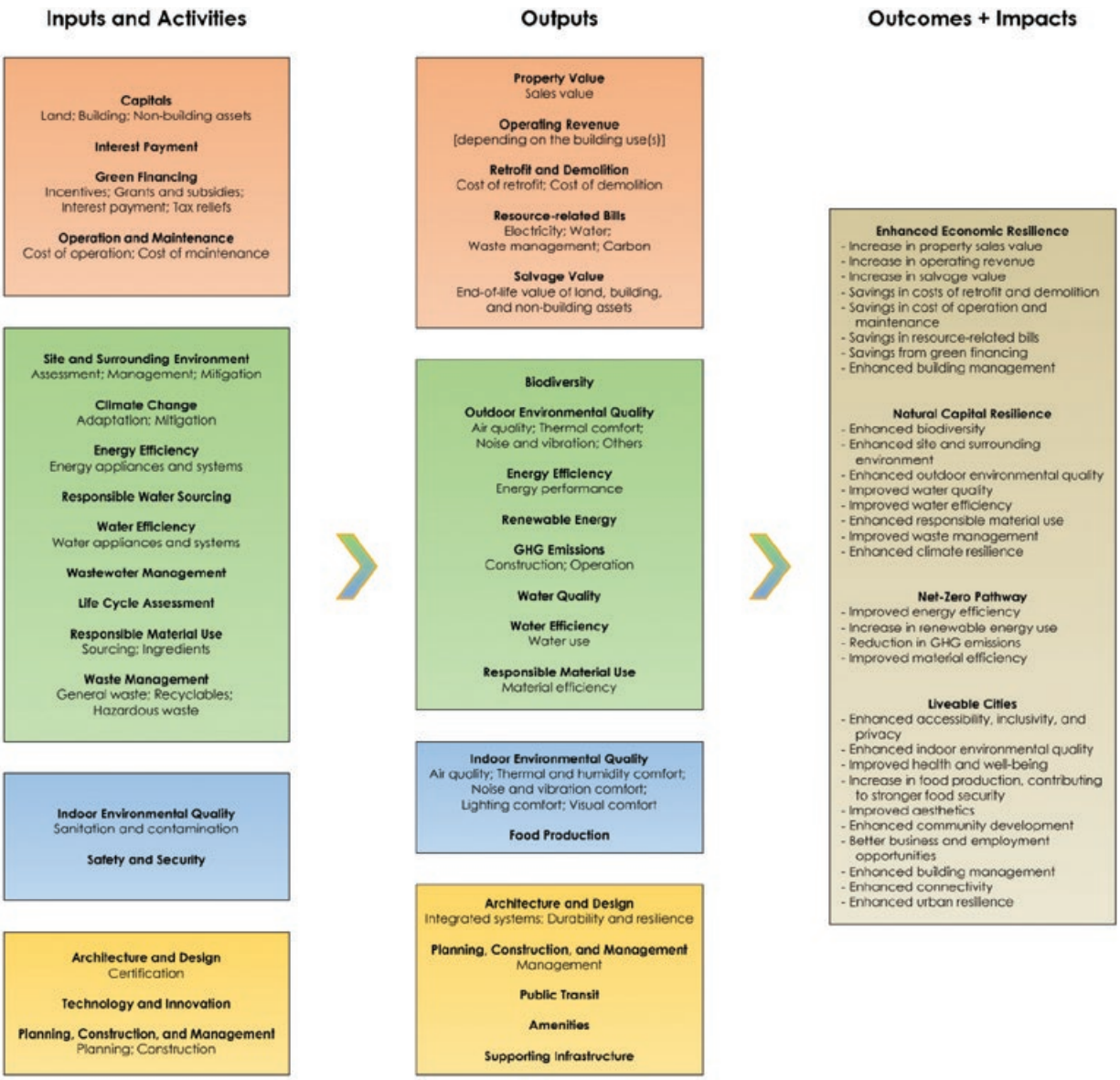
Logic Model

Working in tandem with the ToC is the Logic Model, which maps the pathway from resource inputs and intervention activities to outputs and short- to medium-term outcomes.

We developed the logic model by first harmonising 1,141 building indicators from established building certification standards and impact measurement frameworks, and then categorising them into inputs/activities, outputs, and outcomes/impacts to capture the multifaceted nature of a green building.

These components reconcile the objectives of achieving robust economic returns while maximising integrated impact across a building's lifecycle.

The logic model (shown on page 86) displays the key elements aligned with the EESG pillars and clear value chains. The outcomes/impacts are consistent with the desired state outlined in the earlier ToC, demonstrating that a sustainable future can be achieved through the intervention of green buildings and sustainable developments.



Logic Model for Green Buildings in Singapore.
Image: The Integrated Impact Valuation Framework for Green Buildings, 2024, SGFIN Whitepaper Series 04

Integrated Return on Investment (IROI): Building a Common Language

Traditional financial Return on Investment (ROI) considers only direct financial and economic results, often overlooking many intangible benefits and externalities, which can lead to incomplete decision-making. Although numerous sustainability design features can be proposed, a consistent and robust decision process is needed. Moreover, the diversity of stakeholders—with different preferences, risk appetites, and decision-making criteria—makes it difficult to communicate these externalities in ways that resonate with everyone.

In our IROI framework, we identified five key stakeholder groups in the built environment: 1) building owners and developers; 2) building

occupants, tenants, and visitors; 3) investors and financial institutions; 4) governments, regulatory authorities, and certification bodies; and 5) local communities and non-governmental organisations. We assigned value creation to each of these stakeholders and standardised the externalities by monetising the outcomes and impacts most relevant to them. For example, we translated intangible benefits such as improved air quality, enhanced productivity, and healthier indoor environments into monetary terms that directly benefit users. By employing the use of financial proxies, our IROI methodology converts intangible sustainability outcomes into monetary values that are clearly understandable and comparable, enabling informed decision-making across the stakeholder spectrum.

Another key strength of our IROI framework is its use as a forward-looking planning tool. It clearly shows who invests, what results are generated, and how impact values are created and attributed to different stakeholders. By expressing integrated EESG returns as dollar value per unit of investment, IROI fosters alignment, transparency, and more strategic resource allocation—making the case for bolder sustainability investments that deliver lasting co-benefits for the entire ecosystem.

Case Study 1: NUS SDE4 Net-Zero Building

We applied our IROI framework to the SDE4 building at NUS, Singapore's first new-build net-zero energy building, to illustrate the distribution of co-benefits among key stakeholders, namely the building's owner, NUS, and its users. Our calculations accounted for benefits from many innovative features, such as solar panels, hybrid cooling, smart sensors, and water recycling, and produced an IROI of $2.32 per dollar of investment. Interestingly, $1.07 was accrued to NUS through direct utility savings, carbon tax savings, and knowledge sharing, while $1.25 was attributed to SDE4 users. The user benefits primarily arose from improved water and air quality, which generated health benefits and enhanced well-being and productivity. Although SDE4 is well known as Singapore's first net-zero building and now even a positive energy building, our value computation shows that the additional environmental and social benefits are also substantial.

SDE4 Building in NUS.
Image: National University of Singapore

Sustainability is a Journey: Why Time Matters

Resilience and regeneration are inherently temporal processes, yet time is often overlooked in urban valuation. Sustainability is not a one-time intervention but a long-term commitment, with the full value of regenerative design unfolding over years or even decades. Early investments in daylighting and ventilation, for example, can yield decades of improved learning outcomes, while biophilic features, which take time to mature, ultimately enhance biodiversity and flood resilience.

Improvement is also a continuous process. Sustainability efforts must be sustained and adaptive, starting with small steps that, when refined over time, generate significant long-term impact. Developers must assess which green features will continue to generate value in the long run. For instance, the effectiveness of green facades depends not only on installation, but also on ongoing maintenance and the selection of resilient, site-appropriate plant species.

This temporal lens is increasingly shaping both design and financing decisions. A notable example is the United World College of South East Asia (UWCSEA), which has embedded long-term thinking and commitment into its sustainability strategy since 2009.

Case Study 2: UWCSEA Dover Campus

For more than a decade, UWCSEA Dover Campus has progressively implemented a wide range of green features, including green walls and roofs, photovoltaic (PV) systems, daylighting strategies, and a self-developed Building Management System (BMS). The PV systems contribute the largest share—59% of the total net impact value—driven by ongoing dialogue between student-led advocacy and supportive school leadership.

In line with UWC's mission to educate future sustainability experts, these green features are integrated into the curriculum to provide hands-on learning opportunities for students. The BMS not only reduces electricity and water costs, generating economic value, but also creates social value as an educational tool, accounting for 16% of the total impact value. Proper maintenance of the school's chillers has extended the lifespan of the equipment, reducing the need for replacements, and significantly cutting embodied carbon emissions, contributing 12% towards value creation. Many of these features have long-term benefits, and the integrated value grows when designed for durability and maintained over time. Overall, our IROI assessment from 2015 to 2030 estimated an exceptional return of over $5.21 per dollar of investment.

UWCSEA Dover Campus.
Image: United World College—South East Asia (UWCSEA)

Scaling Building-Level Metrics to District Systems

Green buildings are typically evaluated using metrics such as energy efficiency (kWh/m²), water use intensity (L/m²), indoor air quality, occupant satisfaction, and avoided greenhouse gas (GHG) emissions. Beyond the building level, regenerative cities need to also aggregate and adapt these indicators at the district scale.

This is where the scalability of the IROI framework stands out. Within our framework, 82 out of 192 impact value metrics can be aggregated at the precinct or district level. For example:

- **Energy and carbon-related metrics** can be translated into district-wide savings by summing reductions across buildings and infrastructure. These are further enhanced by the synergy between energy-efficient building envelopes and integrated urban planning.
- **Social well-being indicators**, such as improvements in thermal comfort or mental health due to better access to green spaces, can be extrapolated using population-weighted benefits.
- **Resource circularity**, such as shared stormwater systems or waste-to-energy networks, becomes more measurable and impactful when modelled in a collective system.
- **Governance metrics**, such as stakeholder engagement or resilience to disruptions, gain complexity and salience when viewed through multi-building, multi-use, and multi-stakeholder systems.

District-level IROI assessments also account for shared infrastructure, such as mobility corridors, green buffers, distributed energy systems, and digital management platforms, enabling more systemic planning. By treating urban districts as interconnected living systems rather than isolated assets, planners can maximise synergies between ecological and human-centred infrastructure.

By treating urban districts as interconnected living systems rather than isolated assets, planners can maximise synergies between ecological and human-centred infrastructure.

Depiction of Future Jurong East District.
Image: Urban Redevelopment Authority

Case Study 3: Urban Planning for Jurong East District (JED)

In our IROI study of JED, a transit-oriented mixed-use district, conducted in collaboration with researchers from the College of Design and Engineering, NUS, we assessed the potential impact of implementing multiple green features in alignment with national initiatives, such as green retrofitting, district cooling systems, and park connectors. Scaling up from the building level, our model incorporated district-level metrics such as estimated healthcare cost reductions from mitigating the urban heat island effect through collective greening efforts.

The uniqueness of our IROI model lies in its examination of the co-benefits generated by both mandatory measures and voluntary enhancements across stakeholders, including private developers, government, occupants, and the general public. Our hypothetical analysis revealed that if only mandatory measures aligned with national targets were to be implemented, the IROI would be $3.37 per dollar invested. When voluntary enhancements, such as additional PV installations, are included, the IROI rises to $3.46. Notably, electricity bill savings from PV systems alone accounted for 24% of total value creation. This comparison underscores the value creation of going beyond compliance to pursue higher sustainability ambitions in Singapore.

Our valuation exercise further revealed that integrated returns depend on collective investment and management by both the public and private sectors. While private developers could achieve an IROI of $2.84 on their investments, the public sector also played a crucial enabling role by contributing to value creation through public greenery areas and infrastructure projects.

By translating EESG outcomes into a holistic and comparable term, IROI bridges the gap between technical interventions and financial decision-making, allowing developers, investors, users, and policymakers to speak a common language.

Conclusion: Toward a Valuation Paradigm Shift

In an era defined by the breach of planetary boundaries, rapid urbanisation, and climate volatility, sustainability must move from aspiration to accountability. Our IROI methodology offers a next-generation valuation language that captures sustained efforts, stakeholder value co-creation, and system-level interactions, enabling regenerative outcomes to be quantified and rewarded. If resilience is about surviving disruption and regeneration is about thriving beyond it, then our IROI approach can serve as a helpful blueprint for rethinking how we value impact, distribute benefits, and make decisions—not just for buildings, but across districts and urban systems.

This shift is especially timely as green finance instruments, such as green bonds and sustainability-linked loans, gain momentum across public and private sectors. The marketability of these financial instruments requires clear and credible narratives of value creation. By translating EESG outcomes into a holistic and comparable term, IROI bridges the gap between technical interventions and financial decision-making, allowing developers, investors, users, and policymakers to speak a common language grounded in cost, return, resilience, equity, and long-term value.

Note: All case studies are drawn from SGFIN's in-house IROI assessments, using our harmonised indicators across over 1,141 indicators from leading global green building certifications and standards.