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Neighbourhood Design and Affordability

Addressing Infrastructure Challenges through Sustainable Design

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EXECUTIVE SUMMARY

Rapid urbanization poses significant challenges to natural resource conservation and environmental sustainability, particularly in cities where urban sprawl remains the dominant development model. Sprawling cities require extensive infrastructure investments, increasing housing costs and negatively impacting natural landscapes. Conventional infrastructure systems often disregard ecological processes, exacerbating environmental degradation and affordability issues.

A shift towards decentralized, flexible and circular infrastructure systems that return inputs to nature rather than depleting them is essential. Sustainable urban design practices, such as low-impact development (LID), present viable solutions by integrating ecological and built infrastructure. LID techniques, including blue-green infrastructure (BGI), can mitigate environmental impacts while improving affordability and resilience.

Traditional infrastructure development prioritizes standard practice over sustainability, burdening municipalities with high capital costs and diminishing the functionality of natural systems. For example, Calgary faces a projected infrastructure cost exceeding $500 million between 2023 and 2026, with an additional $4 billion required beyond 2027. The traditional approach, intended to stabilize housing prices through an ample land supply, often fails as an affordability strategy. Also, professional silos between municipal engineers and planners contribute to inefficient infrastructure implementation.

LID strategies offer a sustainable alternative by leveraging natural and semi-natural systems for stormwater management, urban cooling, air filtration, noise reduction and biodiversity enhancement. Examples include bio-swales, rain gardens, green roofs, pervious pavements and retention basins. These measures reduce runoff, mitigate flooding risks and preserve ecosystem services while lowering infrastructure costs.

Policy reforms at the municipal and provincial levels are critical to facilitating the adoption of LID and sustainable infrastructure systems. Revisions to zoning codes, permitting processes and development incentives can encourage broader implementation. Financial mechanisms such as tax breaks, grants and funding support for developers to integrate LID principles can further drive the transition towards sustainable urbanization.

By making ecological infrastructure a key part of urban development, cities can create more sustainable, affordable and resilient environments. These approaches reduce environmental degradation and reconnect people with natural landscapes, inviting long-term environmental stewardship and enhancing urban livability.

Rapid urbanization presents daunting challenges to the conservation of our natural resources and environment, particularly in cities where sprawl becomes the dominant development model.

Sprawling cities with newly built neighbourhoods, where green fields used to be, place extensive demands on infrastructure systems. The high cost of extending these systems into peri-urban areas is more often than not passed on to homeowners, thus greatly impacting housing affordability. In addition, there is an aesthetic impact since we observe that the natural features of entire regions are all but eliminated and the developed landscape bears no resemblance to what it was prior to development.

A new way to look at urban infrastructure is urgently necessary, one that works in concert with social and ecological processes, rather than an invisible amenity that most households take for granted. Fortunately, new perspectives have recently been proposed and tested and today we understand that decentralized and flexible systems, which rely on a circular pattern and return inputs to nature rather than consuming them, are a better option.

With that understanding, how do we incorporate these circular systems into our newly built and retrofitted neighbourhoods? How do we take advantage of sustainable design practices to not only impose less impact on the environment, but also make housing more affordable? Ideally, we would design infrastructure systems that work with the environment rather than in opposition to it. Building sites can be designed in a way that complements existing landscapes, reducing infrastructure costs and enabling natural systems to maintain some of their characteristics and properties. Likewise, retrofits and densification projects can return nature to places where traditional development models eliminated natural systems.

This brief explores alternative neighbourhood designs, such as low-impact development (LID), to address some of the challenges of extending infrastructure beyond our urban cores while mitigating the high cost of conventional infrastructure systems, which in turn contributes to housing affordability.

THE CURRENT CONTEXT OF URBAN GROWTH AND INFRASTRUCTURE CHALLENGES

Realizing that urban growth and development remain high on the political agenda while impending climate change effects threaten the quality of life to which urbanites have grown accustomed, cities are looking for adaptive and regenerative policy solutions through sustainable planning, urban greening, biophilic urbanism, green infrastructure and urban ecology (Daniels, El Baghdadi, Desha and Matthews 2020). Traditionally, infrastructure systems have considered ecological systems as obstacles to be overcome rather than worked with. Conventional stormwater drainage systems, roads and utilities, ubiquitous in new developments, are expensive to build and maintain, and often inefficient. This practice, in turn, drives up the cost of housing, as the cost of infrastructure levies is passed on from developers to homebuyers.

In the realm of urban planning, both built infrastructure and ecological infrastructure comprise urban ecosystems. Infrastructure systems that work in concert with natural systems are more sustainable and economical and, beyond sustainability and affordability, offer the added advantage that understanding and adopting such systems helps reconnect people to landscapes, fostering a sense of stewardship with the environment. Rather than being designed for ease of maintenance, recreation and aesthetics, with functionality being added to improve human comfort, urban spaces need to be integrated into natural systems and ought to make use of ecological infrastructure to improve functionality in developed areas.

In Alberta, flexible municipal planning has enabled low-density sprawling developments that require high infrastructure expenditures for roads, utilities and stormwater systems, leading to costly infrastructure expansion. Under the *Municipal Government Act* (MGA), municipalities have significant control over urban development, zoning and infrastructure funding; however, this control has historically led to sprawling suburban developments. Alberta's MGA enables legal and political challenges to more stringent requirements and, even when municipalities try to value ecological features, more traditional planning and building practices prevail. Approving the same kind of development that has been approved for years requires less effort and is generally less costly than considering innovative designs that may require new knowledge and changes to customary practices.

Discrepancies caused by differences in the way municipalities approach development and the way provincial governments structure the policies and regulations that affect it can also give rise to conflicting guidelines or gaps regarding issues that are not addressed by either municipal or provincial jurisdictions. For example, one issue is the gap left by lack of clarity or determination of responsibility regarding infrastructure, of which some developers have learned to take full advantage. In Calgary, 48 per cent of the approved and proposed land supply requires new (conventional) infrastructure, representing a capital cost of more than $500 million between 2023 and 2026, and another $4 billion beyond 2027 (City of Calgary 2022, 2023). The argument for a surplus of serviced land is that an ample supply will keep housing prices stable, but this is a faulty affordable housing strategy. Another issue is the professional divide that can exacerbate these potential conflicts. Infrastructure is often under the purview of municipal engineers while municipal planners, who may have a more holistic view of development, are responsible for administering policies and bylaws but not necessarily connecting them to infrastructure implementation (Cuthbert and Tyler 2016). This presents a challenge to professionals with a more creative and holistic approach to city planning, who recognize the value of less conventional styles of design and development that are not only more affordable, but also well-suited to conserving natural systems.

HOUSING AFFORDABILITY CONCERNS

There are two ways to accommodate a city's growing population: one is to densify the already urbanized areas and the other is to build beyond the urbanized boundary. Both require that infrastructure be adapted or extended to accommodate the additional number of households. Densifying urbanized areas makes sense until the capacity of the current infrastructure systems reaches its limits. If this threshold is crossed, then densification can become an expensive proposition since expanding infrastructure in a built-out area is onerous and disruptive. Adding new households by building new subdivisions on the outskirts of town seems to be the preferred option of developers catering to families who perceive suburban developments as being more affordable. However, the cost of extending infrastructure to these new developments is included in the final cost of the property and ultimately borne by the homeowner. Off-site levies, whereby the cost of expanding infrastructure beyond the current boundaries of an urban area is shared between the municipality and the developer, have allowed extensive greenfield development and have contributed to the decrease of affordability.

ENVIRONMENTAL IMPACTS

The built environment exerts tremendous pressure on natural systems; however, innovative design options have been devised more recently to mitigate the harmful effects of development on nature. For example, the conventional infrastructure demand for stormwater drainage can be reduced by numerous blue-green infrastructure (BGI) strategies that rely on both natural and semi-natural structures (Battemarco, Tardin-Coelho, Pires Veról, Martins de Sousa et al. 2022). BGI allows stormwater to be collected so that it can gradually be released to irrigate vegetated areas or to naturally soak into the ground to replenish local aquifers. Blue infrastructure comprises rivers, ponds, natural wetlands, constructed wetlands and naturalized retention basins that are incorporated into drainage and filtering systems. Green infrastructure includes bio-swales, rain gardens, pervious pavements, filter strips, green walls, green roofs, rain barrels and cisterns, all of which are more affordable solutions when compared to conventional infrastructure systems (Hansen and Macedo 2021).

From a sustainable urban design and development perspective, the use of blue-green infrastructure is critical for effective and efficient stormwater management and offers an affordable solution for urbanizing areas. The extensive use of green infrastructure, also known as low-impact development (LID), mitigates urbanization's environmental impacts by incorporating some of the elements mentioned above in the design of neighbourhoods and subdivisions, both new greenfield development and retrofit of established urban areas.

THE OPPORTUNITY LID OFFERS

In addition to reducing environmental impacts, incorporating strategies such as LID into land conversion processes helps preserve all the ecosystem services provided by natural systems. Ecosystem services are those produced by ecological systems that contribute directly and indirectly to human welfare and represent part of the planet's economic value (Costanza, d'Arge, de Groot, Farber et al. 1997). An important ecosystem service provided by LID practices is the reduction of runoff volumes from a catchment area, which mitigates local flooding and the potential for erosion and sedimentation, particularly along riverbanks. Allowing runoff to be naturally absorbed by pervious surfaces filters pollutants commonly found on pavements, such as oil, heavy metals and total suspended solids, protecting the entire watershed. Other advantages to urban areas that adopt LID practices include reducing ambient temperatures (urban heat island effect), filtering airborne toxins and carbon dioxide to improve air quality, absorbing noise pollution and increasing biodiversity by providing habitat for numerous species (Prince George's County, MD 2015).

The concept of integrating cities and nature is not new; its foundations date back to the 1960s in the discipline of landscape architecture (McHarg 1969). More recently dubbed biophilic urbanism (Beatley 2011; Kellert 2016), the idea that cities should be part of nature, rather than replace it, has been widely recognized and several strategies have been proposed to achieve this integration, LID among them. Inspired by biomimicry (Benyus 2002), LID and other sustainable solutions emulate natural processes. Some focus on stormwater design that replicates or maintains the natural system's hydrologic function, while others focus on renewable resources and on-site re-use and recycling to create circular, self-sustaining systems.

Expanding the ecological dimensions of land use planning can bring numerous additional benefits. For example, the installation of native landscapes and pollinator gardens increases biodiversity by attracting bees and butterflies that pollinate plants, and birds and insects that feed on mosquitoes, thus decreasing the need for pesticides. Perception and image are significant at this scale because naturalized areas are sometimes mistaken for areas with low or no maintenance. For this reason, some cities still operate under the limitations of building codes that present obstacles to the implementation of low-impact strategies. To change this paradigm, it is important to understand how LID contributes to the built environment's sustainability. Also subsumed under low-impact urban design and development (LIUDD), water-sensitive urban design (WSUD), sustainable urban drainage systems (SUDS) and the climate-proof city (CPC), LID design principles have been adopted and incorporated into development plans in several countries (Hansen and Macedo 2021).

The underlying concept of these approaches is to consider every input and output as a resource, not a disposal problem. A recent example is that of Chinese cities that have embraced a district-wide concept known as Sponge Cities (Hansen and Macedo 2021). It combines well-known LID principles into an integrated urban water management system and applies them to entire districts, some in existing urban areas like Beijing and Shanghai, most in newly planned cities and suburbs. The added advantage of this policy was to increase green space in urban areas, mitigating pollution and creating opportunities for respite and recreation. Other cities that have enacted policies and instituted programs to adapt their infrastructure include Toronto (Green Roof bylaw), Portland (Green Streets Program), New York City (Green Infrastructure Plan), Berlin (Urban Green Space Strategy), Copenhagen (Climate Resilient Infrastructure) and Singapore (ABC Waters Program). The goal is to adapt urban structures so that built environments will contribute to the restoration of, rather than replace, natural environments with no regard for what was there before development.

LID technologies are being implemented more frequently to reduce stormwater runoff resulting from an increase in impervious surfaces in urban areas, which in turn increases non-point source pollution. In addition to the immediate benefits of implementing LID features and practices, there are long-term benefits related to climate change. Many cities are using green infrastructure principles and strategies as part of their resiliency plans to future-proof themselves in the face of impending disasters due to climate change. Integrating engineered and technological low-impact solutions is necessary for the success of green infrastructure initiatives to reduce the demand for water in landscapes, filter the pollution in runoff and retain water — not only to mitigate the effects of flash floods but also to increase groundwater recharge by returning rainwater to aquifers instead of channelling it into stormwater infrastructure. Future-proofing of water and wastewater infrastructure means infrastructure has to be adapted to future risks and climate conditions. The projected changes for Alberta due to climate change include daily and seasonal temperature extremes, frequency and intensity of precipitation events and changes in stream flows (Tyler 2023). LID design could mitigate the consequences of these climatic conditions.

WHY SHOULD DEVELOPERS ADOPT LID?

There are several compelling reasons, with both short-term and long-term advantages, for developers to adopt LID strategies and integrate sustainable design principles into their projects. Conventional infrastructure is expensive, and its cost can be even higher when off-site levies are imposed on peri-urban developments, while LID techniques reduce the need for costly engineered systems. Older cities around the world are expending a large percentage of their municipal budgets on aging infrastructure repair and replacement. LID techniques greatly reduce the need for costly engineered systems, reducing the financial burden on developers. All types of green infrastructure offer added value because, in addition to performing ecological functions, they also provide ecosystem services which, along with other natural assets, should not be overlooked. They increase retention and capacity management that can be quantified and included in financial reporting as an asset class, which would be an incentive for developers (Tyler 2023; Prince George's County, MD 2015).

Developers not only save money upfront by avoiding the high cost of traditional infrastructure but also save time by using streamlined site designs with shorter planning and construction timelines. There are also marketing and commercial advantages since developments that use green infrastructure mean lower long-term costs for buyers. The housing units built in low-impact developments and conservation subdivisions are initially less costly because the overall expenditures with infrastructure are lower and developers can pass these savings on to buyers (Weitman, Weinberg and Goo 2012). In addition, municipal fees will be lower because the development will not strain municipal infrastructure systems; maintenance costs will be lower as green infrastructure requires fewer repairs and replacements; and energy usage will be lower, thus reducing utilities expenditures for homeowners. Advantages such as these would certainly enhance the value and appeal of properties and increase developers' return on investment.

WHY IS LID A SOLUTION TO HOUSING AFFORDABILITY?

LID can greatly impact development costs and thus housing affordability (Penniman, Hostetler, Borisova and Acomb 2013). Underground stormwater systems, sewage pipelines and large-scale drainage systems — all part of traditional infrastructure — are not only expensive to build, but also to maintain. In the case of developments detached from the urban core, off-site levies further increase the cost of housing. Infrastructure cost savings obtained from adopting LID techniques could be passed on to homebuyers, making housing more affordable for all. In addition to higher start-up costs, conventional infrastructure systems cost more to maintain and manage, which has a substantial long-term impact on housing affordability. Furthermore, if municipalities can lower their infrastructure maintenance and management expenditures, then property taxes and fees, which also impact housing affordability, could potentially be lowered.

As is the case with traditional infrastructure, the per-household cost of LID is reduced in denser developments with no loss of efficiency or quality. Reduced pervious surface area, typical of denser developments, is offset by the use of green walls and green roofs, even in cold climates (Macmillan and Macedo 2022). In addition, the aesthetic benefits and maintenance cost savings of LID strategies that impact the buildings themselves (as opposed to the site) are compounded in higher density developments (Perini and Rosasco 2013). LID also provides ecosystem services such as improving air quality and mitigating urban heat island effect, which tend to have a more intense effect on higher density developments.

Other benefits of LID that impact housing affordability include improved energy efficiency and reduced flood risk and related insurance costs. By increasing tree canopy and using green roofs and walls, LID models shade and insulate buildings naturally, reducing the need for heating and

cooling, thus lowering energy bills while protecting building surfaces from ultraviolet and thermal degradation. Urban flooding can be mitigated through the use of LID techniques, preventing expensive damage to both infrastructure and homes. The reduced risk of flood damage also has a direct impact on insurance premiums.

Low-cost landscaping is another LID benefit. By giving preference to native and water-wise plants, drought-tolerant landscapes are created, decreasing the need to irrigate and fertilize yards and gardens. Thus, not only do households save money by not requiring irrigation systems, but also, no water resources have to be used to maintain gardens and yards since these landscapes require little or no watering and no fertilization. In addition, tree planting in LID developments is done in such a way that the canopies of both evergreen and deciduous trees will provide shade and wind protection where and when needed, making the entire property climate resilient.

HOW CAN POLICY CONTRIBUTE TO SUSTAINABLE DESIGN?

Municipal and provincial policies can encourage sustainable design that leads to the implementation of ecological infrastructure, not only making housing more affordable, but also adding value to municipal assets and deriving significant cost savings (Gómez-Baggethun, Gren, Barton and Langemeyer 2013). Alberta's Climate Leadership Plan (2015–2019), aimed at reducing greenhouse gas emissions, encouraged green infrastructure and promoted renewable energy. Under the Water for Life Strategy (Government of Alberta 2014), governments could explore partnerships with private developers to pilot LID-based neighbourhoods in new urban developments, showcasing both affordability and infrastructure efficiency; however, this plan for action does not specifically mention LID. More recent policies have not given any incentive to developers to prioritize ecological urban systems.

The Alberta Low Impact Development Partnership Society (ALIDP), whose vision is "for land development and landscapes to co-exist in harmony" was created in 2008 (ALIDP n.d.). It continues to promote LID initiatives and practices, and more recently has been a stakeholder in Calgary's Stormwater Management Strategy (City of Calgary n.d.), which is a call to action, but does not stress the need to change the way we design our neighbourhoods. ALIDP has also led research and demonstration programs in Edmonton to fund resilient landscaping in infill developments, pilot programs to educate property owners on the value of rain gardens and other ways to collect rainwater and workshops to increase awareness of the impact of urban stormwater runoff on riparian areas in several Alberta cities.

Although Calgary's Municipal Development Plan (MDP) promotes LID practices as a means to green the city, it is not a consistent strategy. Edmonton's City Plan does not mention low-impact development either, although it addresses the city's green and blue networks (City of Edmonton n.d.). The City of Calgary's Stormwater Management Strategy and Edmonton's River for Life Initiative include some LID practices, such as bio-swales, rain gardens and permeable pavements, as isolated features. If scaled, these practices could greatly reduce the cost of stormwater management by simply mimicking natural processes.

Alberta municipalities are slowly adopting smart growth and densification strategies, which can reduce infrastructure costs by encouraging higher density and mixed-use developments; however, overloading conventional infrastructure in the urban core will not lead to more sustainable neighbourhoods. Coupling these policies with LID could further cut costs and increase affordability by reducing the need for expansive stormwater systems, sewage infrastructure and road networks. It could also greatly reduce our urban areas' ecological footprint. In addition,

replacing expensive underground stormwater systems with natural green spaces can make housing developments more cost-effective and reducing long-term infrastructure maintenance costs can keep housing prices down.

Municipal and provincial governments have the opportunity and the authority to address issues related to climate risk, vulnerability, adaptation and resilience. Climate change is already increasing the costs related to conserving terrestrial and aquatic ecosystems, maintaining water infrastructure, controlling energy use and funding infrastructure maintenance expenditures. Cost-benefit analyses show that internalizing ecosystem services in urban policy making could be advantageous from numerous perspectives.

The challenges that cities are facing today require broader policy responses. We need to start thinking about climate risk as an economic and social issue rather than simply an environmental one. We need to have a better understanding of both short- and long-term consequences, particularly the unintended ones, of allowing certain development patterns to multiply and persist. We also need policies that enable conceptual ideas and lofty goals to be translated into pragmatic action.

Municipal environmental planning should incorporate LID features and related ecosystem services into land use and development plans. Managing landscape systems through land use planning would help retain their structural and functional connectivity (Tyler 2023). For this to happen, though, we need to improve communication between researchers and policymakers so that innovative tools and techniques can be incorporated into planning strategies, land use and zoning regulations and development goals. Increasing awareness of how important sustainable urban ecosystems are for human well-being and environmental health can increase the probability that communities will choose to implement systems that benefit all.

At the municipal level, adapting codes and regulations and eliminating standards that require conventional designs; facilitating the permitting process for conservation subdivisions and developments that use LID strategies; expanding municipal LID initiatives through zoning reforms and municipal incentives; and giving tax breaks or funding support for developers using LID design, could all promote adoption of more sustainable systems. Provinces could also enable the implementation of more sustainable designs by incorporating LID principles and strategies into provincial policies and by offering incentives, such as grants and targeted funding, to municipalities and developers who integrate LID into their projects. In addition, provincial and municipal governments could explore partnerships with private developers to pilot LID-based neighbourhoods in new urban developments, showcasing both infrastructure efficiency and housing affordability.

There are numerous advantages to adopting more sustainable design practices in our urban areas, particularly those that are sprawling to their edges and beyond. Delivering infrastructure systems that use ecological processes can significantly reduce not only the demand on conventional infrastructure networks, but also the cost of housing in both newly built and retrofitted neighbourhoods. Sustainable design models that better integrate the built environment within our natural environments are the best ways to mitigate the harmful effects of development on nature, to maintain infrastructure systems at a reasonable cost, to provide affordable housing to families of all income levels and to create healthy urban environments.

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About the Author

Joseli Macedo is an educator, architect, urbanist, and leader with a wide range of experiences in the United States, Brazil, India, Australia, and Canada. Before joining the School of Architecture, Planning and Landscape at the University of Calgary, she was Dean of the Faculty of Architecture and Planning at Dalhousie University in Nova Scotia. Prior to coming to Canada, she was Head of the School of Design and the Built Environment at Curtin University in Perth, Australia. Dr. Macedo has spent most of her academic career in the U.S. teaching and conducting research on sustainable human settlements. At the University of Florida, she served as Chair of the Department of Urban and Regional Planning, Director of the Center for International Design and Planning, and Affiliate Faculty in the Center for Latin American Studies and the School of Natural Resources and the Environment. She received a Fulbright-Nehru award that allowed her to research settlements in India. Dr. Macedo has worked in the areas of sustainable cities, urban design, and international development planning for 30 years. She is the author of several publications on city design and urban form, urban ecology, land policy and land tenure, housing policy, urban planning history, and pedagogy. She has also served as an international consultant to the World Bank and to the GAIA Consortium in Brazil.

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