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SUSTAINABLE URBAN INFRASTRUCTURE TRANSITIONS IN THE ASEAN REGION: A RESOURCE PERSPECTIVE

In collaboration with:

International Resource Panel

Design and layout: Anna Mortreux
Printed by: UNESCO
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The full report should be cited as: UN Environment (2018). *Sustainable Urban Infrastructure Transitions in the ASEAN Region: a Resource Perspective*. United Nations Environment Programme, Nairobi.

DTI/2184/PA
UNEP 190

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Editorial Supervision and coordination: UN Environment, Economy Division in collaboration of the International Resource Panel with special thanks to Martina Otto, Peder Jensen, Sharon Gil, Ainhoa Carpintero and André Confiado who provided content input, conceptual direction and reviewed the document at various stages of the report

We are very grateful to the support provided by the China-ASEAN Environmental Cooperation Centre (CAEC) and the League of Cities of the Philippines, specially Peng Ning and Ma. Veronica C. Hitosis.

Peer review: This report went through a peer review process coordinated by Peng Ning with the support of UN Environment. We are very grateful to the peer review coordinator and to the reviewers who provided valuable comments to the report: Timothy Baynes (Commonwealth Scientific and Industrial Research Organisation); Virgil B. Bilaro (Bicol University); Felicity Cain (UNESCAP); Jason Cao (University of Minnesota); Lei Fang (Industrial Bank of China); Shi Han (City University of Hong Kong); Ma. Veronica C. Hitosis (League of Cities of the Philippines); Oscarlito C. Malvar (UNIDO); Esteban Muñoz (UN Environment); Abhishek Pandey (All India Institute of Local Self-Government); Shi Lei (Tsinghua University); Naylin Oo (UNESCAP); Remy Sietchiping (UN-Habitat); Marco Silvestri (UNESCAP); Jiang Yang (China Sustainable Transportation Center); Zhang Chun (Beijing Jiaotong University).

We wish to thank all the participants of the two workshops organized under this project and held on 15-17 March, 2017, Beijing, China and 24-25 July 2017, Manila, Philippines.

Foreword

Infrastructure investments made today will impact the structure of cities and determine the quality of life of their citizens for at least the next 30 years. A city, for example, can choose to build more roads for privately owned vehicles or invest in public transport, and the decision will determine how people move about, get to work and school, and socialize. The same decisions also influence the environment. The more compact and connected a city, the easier it is to implement public and non-motorized transport. More broadly, density leads to efficient use of resources and allow for green spaces that serve as carbon sinks, purify air, and help manage water.

This report comes at an important time for the ASEAN, when many decisions about infrastructure investments are being made. Southeast Asia has one of the fastest growing rates of urbanization in the world, and expects over 200 million more urban residents to be added to the 300 million current residents by the year 2050. This growth will increase the demand for basic services in places where many are already underserved. This is a challenge for leaders in ASEAN countries but it also creates a historic opportunity to plan and build infrastructure that lays the foundation for sustainable urbanization in the ASEAN region.

Leaders in ASEAN member countries have shown commitment to sustainable development. UN Environment is, in turn, committed to supporting ASEAN members at all levels in their efforts to achieve responsible growth and development. This report is one of our contributions.

Drawing from the conclusions in the forthcoming global report of the International Resource Panel "*The Weight of Cities: Resource Requirements of Future Urbanization*" this regional report aims to support policy makers by delving into the specifics of the ASEAN member countries – their dense cities, economic growth characteristics, susceptibility to climate change impacts, high informality, relative political stability, and other characteristics – and shows a way forward that speaks to the opportunities and obstacles faced by regional leaders.

The report also links ASEAN concerns to global processes, such as the Sustainable Development Goals, Paris Agreement, and the New Urban Agenda. It stresses the importance of linking global, regional, national, and local action, recognizing the role of various levels of governance in ensuring sustainable urbanization. The bottom line is that building sustainable cities is not the job of local government alone.

We hope that this report will enhance links across all levels of governance and provide ideas to ASEAN leaders on fostering urban sustainability. We also hope that the lessons from the region contained in this report will resonate with others around the world as we work towards building low-carbon, resilient, and resource efficient cities.

Ligia Noronha
Director, Economy Division
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Glossary of Terms

4th generation district energy systems	4th generation district heating systems integrate low temperature district heating networks (often circulating warm water at 40-50 °C) with energy efficient buildings, renewable energy sources and smart energy distribution systems to improve energy efficiency, system performance and cost. See also district energy systems.
Decoupling of natural resources from economic development	Natural resource use is often tightly coupled with economic growth. Decoupling represents the situation where economic activity increases without increasing natural resource use (which may remain stable and/or even decline). See also the term relative decoupling.
Articulated density	The spatial arrangements of density in a city – where density refers to the intensity of residents, jobs and services per unit geographical area and measured at the level of a city block (i.e., 1 square kilometre). Articulated density represents intentional or emergent patterns of density in a city connecting high density nodes through transit lines, along with less dense surrounding areas.
Cities	Urban settlements accommodating relatively large concentrations of people who are highly dependent on shared infrastructures, and where agriculture plays a minor role in the economy.
Densification	Refers to the average number of people, activities or interactions concentrated in a given geographical area, expressed in terms of people, jobs, or other activities per square kilometre. Density can also be represented on an average basis in a city, region or nation, to broadly represent population per unit land area. Articulated density within cities represents the arrangement of zones of varying density, typically assessed at the 1 kilometre by 1 kilometre block level within cities.
District energy systems	District energy system provide heating and cooling services to multiple buildings connected via heating or cooling pipe networks driven by a central boiler (for heat) or a central chiller (for cooling). Often water is used as a circulating fluid that distributes the heat (or cooling) in the buildings. Older second and third generation heating systems used steam (higher than 100 °C) or hot water (80- 100 °C); advanced 4th generation district heating systems circulate lower temperature warm water (40-50 °C) and are much more efficient. The heating and cooling services provide for space conditioning as well as the production of hot water or cold water for both residential and commercial uses. Often district energy systems are connected with combined heat and power plants where waste heat from electric power generation is reutilized for heating/cooling buildings.
Eco-industrial parks	Co-location of multiple industries in an area, where the industries beneficially exchange energy and materials, and utilize common water, energy and waste management infrastructures to reduce resource use and environmental pollution.
Global south	While not uncontested, the term 'global South' has come to represent countries exhibiting conditions of relative material poverty in comparison to the advanced industrialized economies of the 'global North' (Eriksen, 2015).
Governance	Governance refers to the actions and processes by which stable practices and organizations arise and persist. Governance actions and processes can occur in any social organization (businesses, communities, nations, etc.). In the context of the public sphere, governance goes beyond just the formal structure of representation, decision-making and implementation. It refers to the relational dynamics of decision-making, including representing, contesting and coalitioning and involves elected and appointed government officials along with multiple stakeholders including businesses and civil society organizations. Governance is thus more than government.

High density nodes in cities	Particular areas in cities where there is a high geographical concentration of people/jobs/amenities in the area, represented often as the (number of people or households per square kilometre) and/or a high concentration of jobs/livelihoods (per square kilometre) and typically tracked over 1 square kilometre.
Industrial symbiosis	The mutually beneficial exchange of materials, energy, water and by-products among traditionally separate industries. Typically, symbiosis is identified to occur when at least two distinct resource exchanges occur among three or more distinct industries. Industrial symbiosis borrows from the terminology of symbiosis occurring in nature wherein 'waste' or by-product from one organism serves as raw material for another. An eco-industrial park is formed when industries engaged in symbiosis are co-located and share common physical infrastructure.
Insitu slum rehabilitation	The rehabilitation of former slum residents in improved and secure housing at the same location of the original slum. See also 'slum'.
Mega block	Mega blocks, or super blocks, are oversized street blocks with long distances between intersections and are often limited in terms of land use allowances. Mega and super blocks exist in contrast to more fine-grained street grid systems with shorter distances between intersections, often characterized by a diversity of mixed land uses (commercial, residential, etc.) (ESMAP, 2014).
Micro grid for electricity distribution	Electric power generation and distribution systems (of the order of 2- 40 MW) that are smaller than conventional large scale electric power networks. Micro grids serve a group of interconnected demand points (e.g., buildings, homes and industries in a neighbourhood or in an institution such as campus or a hospital), and may be operated independent of the larger grid (fully islanded mode) or with ability to connect and disconnect from the larger grid. Micro-grids are considered to increase resilience in urban systems and have capacity to use local renewable resources in power generation.
Middle class	Generally, definitions of 'middle class' or 'middle income status' fall along a spectrum of daily household expenditures that ranges from US$10 to US$100 per person per day at 2005 purchasing power parity terms (Kharas, 2017). Alternatively, the consulting firm McKinsey & Co. has focused its analysis on the global growth of the 'consuming class' which is comprised of 'households with incomes exceeding the level at which they can begin to make significant discretionary purchases' (HV, Thompson, and Tonby, 2014). McKinsey defines members of the global consuming class as households with annual incomes over US$7,500 in purchasing power parity terms.
Mixed-use development (of land)	The fine grain intermingling of residential, commercial uses and amenities at neighbourhood, block and building level to guarantee access to amenities that are close to where people live.
Passive design of buildings	A design approach that uses building orientation, site features and natural physical processes such as trees, sunlight, shading, wind and natural ventilation to light, heat or cool a building without active use of machinery to move hot/cold air or electricity for these purposes.
PM2.5 in air	Particulate matter with a diameter of 2.5 micrometres or less, that are readily suspended in air. PM2.5 in air arise from a number of sources including fossil fuel combustion, biomass burning (from forest fires and from human activities like waste burning), through chemical reactions among chemicals in air, and, road and construction dust. High concentrations of PM2.5 in air are recognized as a major health risk factor.

Primary energy use	Primary energy refers to energy in its raw form found in nature before it is used in any human engineered conversion or transformation processes. Primary energy includes the raw energy (measured in Joules) contained in coal, oil, gas and petroleum (non-renewable) as well as renewable sources such as solar and geothermal energy, before they are converted to secondary energy sources such as electricity, heat (hot water).
Public-privatepartnership	Public-PrivatePartnership (PPP) is an umbrella term to describe cooperation between governments and private sector entities. There is no universally accepted definition. The World Bank's PPP Knowledge Lab defines a PPP as 'a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance' (World Bank, 2017). PPPs are usually distinguished from outright government procurement contracts awarded to private sector bidders. Similarly, the outright privatization of a service or facility in which there is no long-term role or involvement envisioned for the public sector is generally not described as a PPP (World Bank PPPIRC, 2015).
Relative decoupling	Natural resource use continues to be linked with economic growth, but occurs at a lower rate than the economic growth rate.
Resilience	Refers mainly to urban resilience: the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and thrive no matter what kinds of chronic stresses and acute shocks they experience.
Resource efficient urban systems or resource efficient urbanism	Sometimes used in a shorthand way as 'resource efficiency', this refers to urbanisms/urban systems where the resources required per capita to achieve a given level of human wellbeing and/or economic output are less than what is achieved in conventional resource intensive urbanisms/urban systems.
Tier 1, Tier 2 and Tier 3 Cities	Different countries often classify their cities as Tier 1, Tier 2 and Tier 3 to represent cities of the highest significance (Tier 1) to the lowest (Tier 3). Significance is measured differently in different countries in terms of varying parameters such as population size, administrative area, and political, economic and historical significance. An analogous reference to a system of cities is denoting them as primary, secondary and tertiary, with United NationsHabitat defining primary as an urban area with a population of greater than 500,000, secondary as an urban area with a population between 100,000 and 5,000,000 and tertiary as an urban area with a population of less than 100,000 in describing a global system of cities. In some literatures primary, secondary and tertiary represent the types of economic activity – with primary representing agriculture, secondary manufacturing and industry and tertiary – commercial activities. To avoid confusion, we have used the terminology of Tiers. In a study of Southeast Asian cities, those generally considered to be 'secondary' or Tier 2 might have populations of between 100,000 and 3 million inhabitants (Roberts, 2014). Examples of Tier 1 cities in the ASEAN region include Manila, the Philippines (12.9 million), Jakarta, Indonesia (10.3 million), Bangkok, Thailand (9.3 million), Ho Chi Minh City, Viet Nam (7.3 Million), Kuala Lumpur, Malaysia (6.8 million), Singapore (5.6 million), and Yangon, Myanmar (4.8 million). Examples of Tier 2 ASEAN cities include Samut Prakan, Thailand (1.8 million), Batam, Indonesia (1.4 million), and Vientiane, Laos (1 million).
Slum	An urban area which lacks one or more of the following: 1) durable housing of a permanent nature that protects against extreme climate conditions; 2) sufficient living space which means not more than three people sharing the same room; 3) easy access to safe water in sufficient amounts at an affordable price; 4) access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people; 5) security of tenure that prevents forced eviction (United NationsHabitat, 2006).

Stack ventilation	The upward movement of warm air in a vertical portion of a building (the stack), that draws in cooler air from outside through openings in the building fabric, thereby generating air flow and cooling in the interior.
Strategic intensification	The process of intensifying the number of jobs/people/amenities located within a network of primary and secondary high-density nodes that are well-connected by efficient and affordable mass transit systems (bus, rail, non-motorized).
Transit-oriented development (TOD)	Public sector development strategies aimed primarily at urban regeneration and transformation centred on public transport. Unlike transit related development (TRD), TOD uses public-private partnerships to capture a portion of the improved land values to contribute toward the costs of the public transport infrastructure.
Urban	Refers to an area where households are clustered together into coterminous neighbourhoods that together make up a recognizable socio-physical space that is distinct from the surrounding rural area, in particular they tend to have higher densities, greater access to shared services of various kinds, and are partly or wholly dependent on non-agricultural production of various kinds.
Urban-industrial symbiosis	The exchange of by-products or 'waste' between industries and urban infrastructure systems, including energy and materials.
Urbanization	The process of a territory becoming more urban, often measured nationally as the share of a country's population that is urban.
Urban form	The design and physical layout of a city.
Urban growth	The increase in the number of people who live in towns and cities. The pace of urban population growth depends on the natural increase of the urban population and the population gained by urban areas through both net rural-urban migration and the reclassification of rural settlements into cities and towns.
Urban metabolism	The flow of resources through urban systems (including sourcing, processes, and outputs into waste or re-use systems) with reference to either urban systems as a whole (globally, nationally, regionally) or individual cities or metropolitan areas (a particular area) or a particular sub-sector (e.g. transport or energy or food).
Urban settlement	Any form of settlement across a wide spectrum from small town to mega-city – at one end are settlements of roughly a minimum of 2,000 people who are relatively concentrated in a particular area where they are co-dependent on a minimum number of shared services, facilities, amenities and infrastructures (and may still be dependent on agriculture), through to large-scale metropolitan systems at the other end of the spectrum where agriculture plays a minimal economic role. All cities are urban settlements, but not all urban settlements are cities. See also Tiers of cities
Urban systems	The configuration of spaces, infrastructures, patterns of development and consumption, behaviours and movements of particular urban settlements and cities.
Vernacular design	An architectural design that incorporates local tradition, climate and availability of construction materials. Vernacular designs often use passive design features leveraging local climate characteristics.

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Executive Summary

THE IMPERATIVE FOR URBAN INFRASTRUCTURE ACTION IN THE ASEAN

The Association of Southeast Asian Nations (ASEAN) is a bloc of ten diverse nations in Southeast Asia including (from largest to smallest population) Indonesia, the Philippines, Viet Nam, Thailand, Myanmar, Malaysia, Cambodia, Laos, Singapore and Brunei. **The ASEAN region will be a hot spot for rapid urbanization over the next 30 years.** Between 2015 and 2050, ASEAN cities are projected to add 205 million new urban residents to the 300 million current urbanites in the region, creating one of the world's largest middle income emerging markets after China and India. The region's urbanized population proportion will increase from 47 per cent in 2014 to 65 per cent in 2050, with five of the ten ASEAN nations transitioning from minority urban to majority urban. This represents a significant demographic shift that will change the way people live and the way human settlements are designed and function. Simultaneously, the ASEAN region will continue to grow as an economic powerhouse, projected to become the fourth largest economy in the world by 2050 (HV, Thompson, and Tonby, 2014). **With growing wealth and urbanization, the region is projected to see one of the largest expansions in a growing urban middle class, having large implications for both sustainable urbanization and sustainable production and consumption.**

The region's new urban population growth is expected to result in the unprecedented and rapid rise of more than 200 smaller cities in just 35 years (2015-2050), in addition to continued growth in existing medium and large cities. The United Nations Department of Economic and Social Affairs estimates that fully half of future urban population growth in the ASEAN region through 2030 will occur in cities with fewer than 500,000 residents. Extrapolating to 2050, this means that the ASEAN region can expect the rise of more than 200 small cities over the relatively short period of some 35 years (2015- 2050). The region will have to plan in a concerted manner to accommodate such a large number of cities, and will need to rethink urban infrastructure planning for a diversity of city sizes (small, medium and large).

Urban population growth is likely to be very rapid in many ASEAN countries between 2014 and 2050. This means that new urban infrastructure is needed urgently and rapidly. The average expected urban population growth rate for the ASEAN region is 2.2 per cent per annum, with some countries such as Cambodia and Laos exceeding 4 per cent per annum. Population growth rates in individual cities can be even faster, exceeding 5 per cent per annum. A city with a 5 per cent annual growth rate can expect its population to double roughly every 15 years. This means that new urban infrastructure is needed urgently and rapidly. Once built, infrastructure like buildings, water treatment systems, transportation systems and power plants have decades-long life spans, often exceeding 30 years or more. **There is a once in a life time strategic opportunity for the ASEAN region to plan ahead for building sustainable, resource efficient, and inclusive infrastructures for future cities**.

THE CHALLENGE OF BUSINESS-AS-USUAL URBANIZATION

The expected increase in economy, population, urbanization, and the ASEAN urban middle class represents a positive and stable outlook for the region, yet it will also place large demand for infrastructure and associated natural resources. According to the World Energy Outlook, electricity demand is expected to triple in the ASEAN region in only 25 years (2015 to 2040). Even with currently planned renewable energy investments, the ASEAN region will be one of only a few regions globally to see an increase in the share of coal in its electricity supply mix, rising from 32 per cent to 50 per cent by 2040 (OECD/IEA, 2015). Such an increase in fossil fuel use contributes to global greenhouse gas emissions and air pollution, the latter already of concern in many ASEAN cities. The construction boom in the ASEAN region, if it develops using conventional approaches, as seen during the massive urbanization in China and India, will create high demand for cement, sand, and steel, impacting air quality where steel and cement is produced and rivers and land from which construction sand, iron ore, and coal is mined. In 2014, nearly 73 million urban residents across the region lived in slums (World Development Indicators). Slum residents are often particularly vulnerable to climate change related extreme events (typhoons, tropical cyclones, and flooding). **If the ASEAN region's projected rapid urbanization proceeds according to current business as usual practices, ASEAN cities will see existing urban challenges exacerbated and the emergence of potentially new challenges such as those already seen in fast growing cities in China and India.**

OPPORTUNITIES FOR RESOURCE EFFICIENT URBANIZATION AND AN ASEAN ROADMAP FOR SUSTAINABLE URBAN INFRASTRUCTURE TRANSITIONS

Seven key infrastructure sectors that provide buildings/shelter, public spaces, food supply, transportation, municipal water supply, waste and sanitation, and energy supply dominate both natural resource use and resulting impact on the environment and human wellbeing. These sectors, together referred to as basic infrastructure and food supply sectors, directly impact economic activity, livelihoods, access, inclusion, pollution and wellbeing in cities. These sectors also contribute to 80 per cent of global material use, more than 90 per cent of water withdrawals, and about 87 per cent of global greenhouse gas (GHG) emissions, impacting resource sustainability globally. Recent reports from UN Environment indicate that early action toward resource efficient and inclusive development of these key infrastructure sectors in cities can yield multiple sustainability benefits (IRP, 2017). **Early, inclusive and resource efficient urban infrastructure planning in diverse ASEAN cities of all sizes offers a tremendous opportunity and presents a key pathway for advancing prosperity, human wellbeing and environmental sustainability.** This opportunity assumes even greater importance as the region faces increased risk of climate related sea-rise, weather extremes, and disasters. Because the region has faced climate-induced disasters and continues to face this risk, the ASEAN urban experience could emerge as a 'resource' for disaster resilient urban infrastructure solutions and climate change adaptation strategies globally.

This report contextualizes general recommendations emerging from the global aspirational report, *The Weight of the Cities: Resource Requirements of Future Urbanisation*, to explore strategic opportunities for resource efficient and inclusive urbanization through infrastructure transitions and transformations in the ASEAN region. In this context, infrastructure transitions and transformations, should be understood as the processes by which infrastructure systems change or move toward new technical and spatial configurations that support greater resource efficiency. Transition and transformation are usually differentiated as a function of degree and pace of change, with transition representing more incremental change and transformation representing more wholesale change. The broad strategies of urban infrastructure transition and transformation covered in this regional report in many ways track those discussed in the global *Weight of Cities* report. They include:

- Reducing urban land expansion to enhance sustainability along the urban-rural continuum.
- Developing a compact, inclusive and resource efficient urban form within cities.
- Promoting diverse sustainable urban mobility and transit systems.
- Promoting energy efficient buildings and neighbourhoods.
- Integrating renewable energy generation in cities.
- Preventing slum development and promoting *in situ* slum rehabilitation of existing slums.
- Improving resource efficiency at the whole city level through integrated urban-industrial symbiosis.

The findings of this report present a roadmap for developing inclusive and resource-efficient infrastructure in both large and small ASEAN cites, potentially offering a strategic pathway to increase both human wellbeing and advance environmental sustainability, achieving multiple Sustainable Development Goals. The recommended pathways, while anchored in an explicitly focused resource-use frame, are in line with the broader goals of UN Habitat's New Urban Agenda[1] (2017) and International Guidelines for Urban and Territorial Planning (2015a). Building on the definition of urban and territorial planning as a "decision-making process aimed at realizing economic, social, cultural and environmental goals through the development of spatial visions, strategies and plans," the transition pathways presented in this report similarly take shape across a "multiscale continuum" from the neighbourhood level to the supra-national level, with city, urban-regional, and national scales in between (UN Habitat 2015a).

1 The New Urban Agenda is a global framework document that was adopted at the United Nations Habitat III convening in October 2016 hosted in Quito, Ecuador. The document represents an "urbanization action blueprint" in support of the United Nations 2030 Agenda on Sustainable Development.

SUMMARY DESCRIPTION OF RESOURCE EFFICIENT URBANIZATION AND SUSTAINABLE URBAN INFRASTRUCTURE TRANSITIONS PATHWAYS:

Managing urban growth for economic development, equity, and preservation of agricultural and ecologically sensitive resources along the urban-rural continuum.

Strategies to manage urban land expansion sustainably include actions taken by national actors and by urban-regional development agencies. First, national and/or ASEAN-level urbanization policies, in particular, strategic economic growth planning across different cities in the region, is a key strategy that can relieve growth pressure on existing primary (Tier 1) cities, and more evenly balancing development across a range of city types and sizes. Examples of urban industrial corridor planning, drawn from China, Singapore, Malaysia and India, demonstrate the benefits of developing cities with diverse and complementary economies that engage in trade. National ecological boundary requirements are a second strategy initiated by governments to sets aside valuable agricultural lands and ecologically sensitive areas around cities to improve overall sustainability along the urban-rural continuum from a larger national and regional perspective. Supported by national and international databases, such eco-preservation policies can enhance biodiversity and provide cities with resilience against natural disasters. Third, establishing urban regional development bodies to coordinate long-term urban growth and carry out the implementation of national ecological boundary policies is essential. This enables implementation of policies such as land pooling to ensure equity for rural landowners whose land is taken up by cities, provides infrastructure continuity and coordination as cities expand, while promoting compact and inclusive urban-regional master planning.

Developing compact urban form within cities in support of articulated and accessible—not average—density.

From a resource efficiency perspective, city and urban regional policy makers should foster *articulated* and *accessible* medium to high density development patterns that result in resource efficient compact urban forms that reduce motorized travel demand and associated air pollution, congestion, and traffic accidents. For planners in all city sizes, the 5D compact city framework—density, design, diversity of use/income, distance to transit, and destination access—along with the complementary Avoid-Shift-Improve (ASI) framework offer useful guidelines for fostering socially and functionally mixed neighbourhoods supported by diverse land use permissions and liveable, human-scale design principles that play a role in avoiding motorized travel. Mixed-use neighbourhoods with complete streets that provide lighting, tree cover, traffic controls, and pedestrian friendly streetscapes encourage people to make trips via walking and biking. Shifting trips than cannot be avoided to non-motorized travel or transit, and improving the efficiency of all trips, both vehicle and transit, are actions that provide resource efficiency, liveability and pollution mitigation benefits.

Customizing mobility and transit strategies to different city sizes.

In medium and large cities, investments in mass transit systems may be cost effective. However, in smaller cities of 500,000 or fewer residents, investments in active transport modes (bicycling, walking), paratransit (shared private vehicles), and traditional public bus service may be more cost effective. Preparing for a future with new vehicles and technologies, in particular electric vehicles, while being aware of transboundary and life cycle impacts of new vehicle technologies can help cities advance resource efficiency and protect the environment within cities, as well as regionally and globally.

Promoting energy efficient buildings.

From a design perspective, a few regionally developed green building standards demonstrate that strategies to reduce building energy use by as much as 30- 60 per cent are available and have been showcased in exemplar buildings. However, many ASEAN nation's building codes do not incorporate standards for energy efficiency (IEA 2015). Further, to achieve the technically feasible reductions will require broad participation across large number of buildings, attention to occupant behaviour, as well as real-time performance reporting of new energy efficient buildings compared to existing building stock. Several case studies, including Singapore's Building Energy Submission System offer models for monitoring the performance of new, high rise construction. The ASEAN region is also rich in examples of vernacular design buildings with passive design features that consume less energy and offer higher levels of occupant comfort. Going forward, combining high density, multi-storey construction with lower density, vernacular buildings is an important strategy for cities of all sizes. Vernacular buildings may offer resilience to natural disasters. An important recommendation is to develop research combining vernacular design with resilient building construction practices. Furthermore, district energy systems and micro-grids offer resource efficiency and resilience benefits as they help meet the cooling and electricity needs of neighbourhoods or institutions such as campuses and hospitals. District energy and micro-grids may be particularly suitable for use on the region's numerous small and medium-sized islands.

Integrating renewable energy generation into cities. New technologies like micro-grids can be particularly impactful in enhancing renewable electricity generation in cities. Micro-grids can operate autonomously offering greater resilience during disasters and disruptions. Rooftop solar water heaters can be incorporated into building design with district energy systems and/or used to produce hot water for domestic purposes like bathing, washing of clothes and utensils and in industries like textiles and dairy (Santra, 2015). Distributed rooftop photovoltaic (PV) systems are an attractive option for ASEAN nations due to their location in the tropics ASEAN with high solar insolation levels (1460 to 1892 kWh/square meter per year; Ismail, et al., 2014). Advanced district cooling systems that use seawater for cooling are also novel uses of renewable resources.

Slum prevention and *in situ* slum rehabilitation. Resource efficiency strategies are highly compatible with goals of developing cities without slums. Integrated urban-regional master planning and township-level planning that provide space for housing migrants and the urban poor in central urban areas or in new urban expansion development are important in preventing both slum formation and unmitigated urban sprawl. The rehabilitation of existing slum residents in multi-storey construction has seen success in recent years and, if done well, can provide basic services and economic opportunities while reducing material use per unit by 30 per cent compared to single storey rehabilitation. *In situ* and/or very nearby slum rehabilitation should be prioritized when possible in order to avoid pushing urban poor to the peripheries of cities. This should be done while acknowledging that new housing for slum residents should not be built in the same highly disaster-prone area from which a slum settlement is being relocated. Building and construction codes that institutionalize both energy efficiency and disaster risk resilience are particularly important when relocating the urban poor presently living in low-lying and coastal disaster-prone areas of ASEAN cities. Case studies of slum prevention and rehabilitation drawn from Indonesia, India and the Philippines demonstrate pathways for sustained actions that can lead to slum-free cities by 2050.

Improving resource efficiency at the whole city level through integrated urban-industrial symbiosis. Urban industrial symbiosis represents the exchange of two or more resources (materials or energy) among industries and co-located infrastructure sectors that provide, energy water, heat, and waste management services in cities. Examples include in the reuse of waste heat from industry in city district energy systems, the use of waste fly ash from power plants as a substitute for cement in urban construction, as well as systematic approaches to manage municipal solid waste by converting waste into useful by-products, including conversion of plastic waste to bricks and the conversion of organic waste to compost and liquid fertilizer. Urban industrial symbiosis is particularly viable in developing economies where manufacturing industries are located in close proximity to residential and commercial areas. Studies have shown that symbiotic exchanges of energy and materials across industry and co-located homes and businesses can offer high levels of efficiency. A case study in China demonstrates that there is sufficient waste heat from industry in Chinese cities to heat and cool buildings in more than half of Chinese cities. Several examples of urban industrial symbiosis already exist in the ASEAN nations including projects to convert waste rice husks to electricity. The two main strategies of industrial symbiosis— A) the development of eco-industrial parks and B) the establishment of urban industrial symbiosis infrastructure networks e.g. for reusing water, waste heat, and materials—can provide multiple SDG benefits including cost savings, employment, reductions in material and fossil fuel use and better management of waste and pollution.

ENABLING GOVERNANCE AND FINANCE DYNAMICS FOR SUSTAINABLE INFRASTRUCTURE TRANSITIONS

Taken together, all the strategies identified in the areas of land use planning, transportation planning, energy and buildings, and cross-sectoral urban industrial symbiosis have been estimated in the global *Weight of Cities* report to have the potential to reduce urban material use in infrastructure by 30 to 60 per cent. This technical potential however can only be achieved if several enabling factors are in place, specifically 1) institutions capable of facilitating multi-level governance and 2) financing vehicles to support investments in new and old infrastructure systems alike. Estimates suggest that the ASEAN region will require some seven trillion United States dollars in new urban infrastructure and housing investment through 2035 (Lin, 2015). Specific building blocks to deliver financing and governance solutions for urban infrastructure transitions in the region include:

1. Coordination across levels of governance identifying where national governments and the regional ASEAN bloc can provide resources and support, as well as identifying specific areas where national governments should devolve power to the local government units, while also providing financial support for needed infrastructure transformations.

2. Capacity building for local governments which can be done by leveraging international organization expertise, ASEAN Bloc level expertise, as well as local expertise at the level of individual cities through science, civil society, and business partnerships. Expertise can be mobilized to build local government capacity for advanced science-technical projects as well as for governance and management efforts like building code compliance enforcement, urban-level data collection, partnership development, and mobilization of financing.

3. Leadership training for cross-cutting sustainability resource efficiency, health and wellbeing, and disaster risk resilience is important for achieving SDGs.

4. Institutionalized best practices for urban planning, infrastructure design and building design, particularly connecting environmental sustainability, health and wellbeing, and disaster risk resilience.

The proposed strategies deliver on economic, environmental and human wellbeing outcomes, and provide a net-positive return on investment on a life-cycle basis. With land values expected to appreciate given the positive economic outlook for the ASEAN region, land value capture mechanisms emerge as a strategic vehicle for local governments to develop partnerships, including public-private partnerships, and raise the capital necessary to develop sustainable infrastructure for future ASEAN urbanization. The outlook for the future is bright and strategic infrastructure transformations initiated today can lay the foundations for a sustainable urban ASEAN in 2050.

CHAPTER 1

An Infrastructure and Resource Perspective toward Sustainable Urbanization in ASEAN Countries

BOX 1.1 Highlights of Chapter 1

1. ASEAN Cities are projected to add 205 million new urban residents by 2050 to the 300 million current urbanites in the region, creating one of the world's largest urban middle-income emerging markets after China and India. ASEAN cities are therefore a critical area of focus for achieving regional and global urban sustainability as they will be strategic sites of consumption, production, natural resource use and infrastructure development.

2. When transboundary supply chains to cities are included, urban demand for infrastructure and food supply is found to dominate global infrastructure demands and associated global natural resource requirements. Infrastructure development in cites is a key topic for considerations of resource-efficient growth as infrastructure is both a driver of materials and natural resource in and of itself, but also a key variable in shaping future patterns of resource use.

3. Developing resource-efficient and inclusive infrastructure in cities emerges as a critical pathway to achieve both resource sustainability and human wellbeing, directly linked to achieving many of the Sustainable Development Goals. Therefore, cities present a strategic and historic opportunity to reduce global material and energy flows, through transformation of urban infrastructure and food systems.

4. Resource efficiency and sustainable provision of urban infrastructure in the ASEAN region is a strategically import focus [strategically important focus? Or "is of strategic focus"] because the region: a) represents a major global emerging market, b) the region is still expected to experience substantial urbanization, presenting a chance to lock in sustainable infrastructure transitions and avoid unsustainable patterns of urban growth, c) the region will be home to a growing consumer class that can leverage present-day highly sustainable socio-cultural behaviours, and d) the region exhibits low existing energy use, but with expectations of energy demand to increase, projected to be met by coal-dominated power supply.

5. The goal of this report is to regionally contextualize the core strategies identified in the global report, The Weight of Cities: Resource Requirements of Future Urbanization (IRP, 2018), drawing on the unique characteristics of ASEAN cities, as well as the experiences of regional neighbours including India and China to offer grounded analysis of urban infrastructure provisioning, resource use, efficient urban development, and wellbeing in the context of ASEAN cities.

1.1 Introduction

By the year 2050, about 6 billion people (nearly two-thirds of the global population) are expected to be living in cities, almost doubling our current urban population of 3 billion in a short span of only 35 years (UN, 2016). Such rates of urban growth are faster than ever experienced previously in human history, and are placing enormous pressures on the local environment within cities, as well as impacting the global resource base, regional environmental quality (air and water pollution), land, and biodiversity. While the urban middle class is projected to expand, raising incomes and standards of living for millions or people, inequalities are also expected to worsen. In 2014, some 30 per cent of the developing world's urban population was already living in slums and informal settlements (United Nations Habitat 2016b), and the number of slum residents is still projected to grow, particularly in cities in Asia and Africa, where 90 per cent of future urbanization is expected to occur.

Cities in the Association of Southeast Asian Nations (ASEAN) bloc are projected to add 205 million new urban residents by 2050 to the 300 million current urbanites, creating the world's third largest middle-income emerging markets after China and India. ASEAN cities are therefore a critical area of focus for achieving regional and global urban sustainability. ASEAN nations are now developing networked trans-national infrastructures, including roads, rail, electricity and water-sharing projects that will serve the ASEAN bloc nations' growing cities (ASEAN, 2015). How and where to invest in urban infrastructure transitions that can support continued economic growth and increased standards of living, while simultaneously supporting local and global sustainability and wellbeing outcomes, is a critical challenge facing the region. To this end, the study of infrastructure trends and transformations in ASEAN cities will be a key variable affecting urban global sustainability.

1.2 The Importance of Urban Infrastructure and Food Supply

Globally, seven key sectors (combined as five in Figure 1.2) —**1)** shelter/buildings, **2)** public/green space, **3)** food, **4)** transportation, **5)** water, **6)** sanitation/waste management and 7) energy, —dominate both natural resource use and their resulting impact on the environment and human wellbeing (Figure 1.1; Ramaswami et al., 2016). These sectors, together referred to as basic infrastructure and food sectors, are essential for supporting economic activity and livelihoods. At the same time, these sectors also contribute to 80 per cent of global material use, more than 90 per cent of water withdrawals, and about 87 per cent of global greenhouse gas (GHG) emissions, impacting resource sustainability globally. **When transboundary supply chains to cities are included, urban demand for infrastructure and food supply is found to dominate global infrastructure demands and associated global natural resource requirements.** For example, energy use in cities, when including imported electricity, accounts for more than 70 per cent of global energy use and greenhouse gas emissions (Seto et al., 2014). Water supply to the 100 largest cities impacts more than 42 watersheds across the globe (McDonald et al., 2014). While cities occupy about 3 per cent of the land surface, direct urban expansion displaces valuable agricultural land and is impacting biodiversity hot spots around the world (Seto et al., 2011); while the supply chains serving cities extend many miles outside impacting land, water, air from regional to global scales.

While this report readily acknowledges that urban infrastructure systems can be thought of in terms of both 'hard' (physical) and 'soft' (social) infrastructure, it takes the role of 'hard' infrastructures in sustainability transitions as its primary point of departure. The provisioning of infrastructure and food supply profoundly shapes human health and well-being. For example, many of the world's cities are experiencing severe air pollution far exceeding healthy levels (OECD, 2016; WHO, 2016; see Appendix A). Globally, traffic accidents related to transportation infrastructures contributed to more than 1.4 million deaths worldwide, while a combination of sedentary lifestyles, undernourishment, and poor diets contribute to 14 million lives lost prematurely each year (IHME, 2015). Poor water and sanitation infrastructures contributed approximately 280,000 premature deaths annually (WHO, 2017). Further, inequalities and poor access to these infrastructure sectors results in lack of access to electricity, clean drinking water and cooking fuels, in turn contributing to illness and premature mortality in many nations. The gender dimensions of these inequalities are particularly striking (UNESCAP, 2015) – including exacerbated loss of economic opportunity for women without access to basic services, and proportionately higher exposure of women and children to health risks from poor sanitation and waste management, and increased exposure to indoor air pollution from cook stoves (WHO, 2016b). Broadly, infrastructure and environment-related risk factors have now become a leading cause of human mortality – contributing to more than 19 million premature deaths annually (Lim et al., 2010; Ramaswami et al., 2016) (see Figure 1.1). These global health risk factors are often exacerbated and/or concentrated in cities. For example, a majority of ambient air pollution related mortality occurs in cities (WHO, 2016a).

Thus resource use and basic service access in the seven key infrastructure and food supply sectors shapes resource sustainability, wellbeing of people and the planet, and affects almost all the SDGs

- By focusing on the provision of basic infrastructure and food supply in cities, particularly for the underserved, the SDGs related to water, sanitation, basic energy access, zero poverty and zero hunger can be addressed.
- By developing more resource efficient cities, and by reducing resource throughput in cities, including reducing fossil fuel use, cities can reduce local air pollution, enhancing local health and wellbeing as well as address global carbon emissions and climate goals. Likewise, by reducing land expansion and preserving ecologically valuable land and biodiversity corridors in hinterland areas, cities can play an important role in preserving biodiversity and croplands, shaping life on land. By taking a transboundary and lifecycle foot-printing approach trade-offs and co-benefits across sectors and across impacts can be quantified from local to global scales.
- Most importantly, infrastructure is essential to spur economic development and innovation. Overall, these combined linkages result in developing sustainable cities and communities and promoting sustainable consumption and production in the ASEAN region.

Given the dominant role that urban infrastructure and food systems play in shaping natural resource use and associated SDGs, developing resource-efficient and inclusive infrastructure in cities emerges as a critical pathway to achieve both resource sustainability and human wellbeing (see Figure 1.2).

FIGURE 1.1. GHG Emissions and Mortality Impacts of Key Infrastructure Sectors *(Ramaswami, 2016)*

Shown are the impacts of urban infrastructure sectors on global anthropogenic GHG emissions (20), global water withdrawals, and global disease burden.

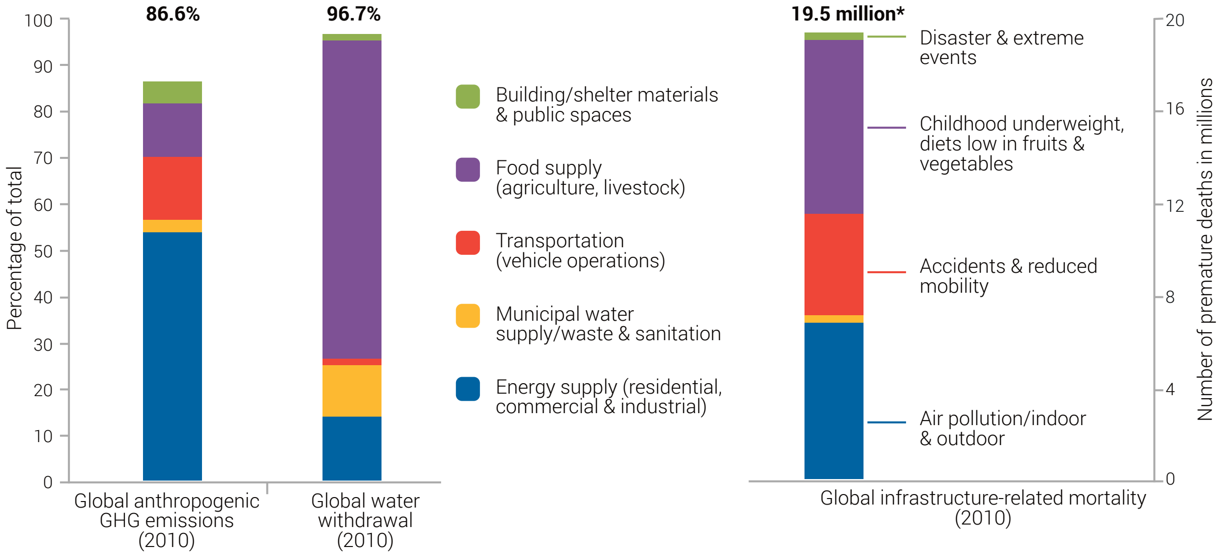


FIGURE 1.2 Connections between City-Level Action and the Sustainable Development Goals *(Un Environment, 2017)*

1.3 The Opportunity for Resource Efficient Urban Infrastructure Transformations

Cities present a strategic and historic opportunity to reduce global material and energy flows, through transformation of urban infrastructure and food systems. In this context, infrastructure transitions and transformations, should be understood as the processes by which infrastructure systems change or move toward new technical and spatial configurations that support greater resource efficiency. Transition and transformation are usually differentiated as a function of the degree and pace of change involved, with transition representing more incremental change and transformation representing more wholesale change. The United Nations Environment Programme's International Resource Panel (IRP) was launched in 2007 to build and share the knowledge needed to improve our use of resources worldwide, through dialogue and synthesis of science-policy experts. The IRP has developed two major reports on cities, resources and sustainability. The first report titled: *Cities and Decoupling* (UNEP, 2013) reports that 60 per cent of the urban area required to accommodate the world's urban population by 2050 has yet to be built, providing a strategic opportunity to build 'better' infrastructure from the start (UNEP, 2013). Infrastructure for new cities will last for 30 years or more, creating a lock-in that affects environmental and human wellbeing well into the future. Hence it is imperative to get it 'right' now, when new cities and new urban infrastructure systems are being planned. Simultaneously, existing cities in advanced economies are replacing aging infrastructures, with similar implications for locking in sustainability advances (or not) for years to come. The report highlights that several infrastructure innovations are on the horizon in both developed and developing countries and underscores the strategic importance and the historic opportunity to focus on these innovations as critical pathways to sustainability. Cities around the world are engaging in experimentation around infrastructure – involving technology, human behaviours, financing and novel governance arrangements. These innovations include new strategies for shared mobility, *insitu* slum rehabilitation, a One Water approach to urban water management, urban-industrial symbiosis, electric and autonomous vehicles, and, distributed solar energy to achieve a decarbonized grid.

A second city-focused IRP report titled *The Weight of Cities: Resource Requirements of Future Urbanization* (IRP, 2018) seeks to estimate the future material requirements for urbanization, and outlines a suite of strategies, that when implemented together, demonstrate a pathway to promoting high levels of resource efficiency in cities (Salat & Bourdic, 2012.) Specifically, the *Weight of Cities* report is built on the assumption that a factor of ten reduction in energy and resource use from an original 'business as usual' (BAU) scenario (representing 100 per cent resource use) is possible through four inter-related and multiplicative levers of change: **1)** compact urban growth, **2)** liveable, functionally and socially mixed neighbourhoods, **3)** resource-efficient buildings and urban systems, ad **4)** the promotion of sustainable behaviours. When implemented together, these levers of change have the potential to yield cascading resource reductions, building on each other as shown below (IRP, 2018):

- Spatial restructuring of the urban morphology to reverse the century-long trend towards de-densification and to instead achieve much greater densities – and a richer mix – of housing, jobs and amenities at the neighbourhood level; *Weight of Cities* assumes that strategic land use intensification leading to more compact forms with higher densities can reduce infrastructures and GHG emissions by a factor 2 or higher (yielding 50 per cent of resource use compared to the original BAU scenario) (Salat, Bourdic, and Kamiya, 2017).
- Human-scale sustainable planning and design to create liveable, functionally and socially mixed neighbourhoods, with a dense urban fabric made of small scale urban blocks and dense street patterns; *Weight of Cities* assumes a reduction in energy consumption by a factor of 2 or higher (yielding 25 per cent resource use compared to the original BAU scenario).
- Energy-efficiency strategies in the buildings sector (includes retrofitting buildings to limit thermal losses, creating synergies between buildings, etc.) and enhanced efficiency strategies for energy systems (including renewable energies, demand-side management, etc.); *Weight of Cities* assumes building energy efficiency strategies can reduce energy consumption by a factor of two (yielding 12.5 per cent resource use compared to the original business as usual case) and energy system efficiency strategies can reduce use by an additional 20 per cent (yielding 10 per cent of resource use compared to the original BAU scenario).
- The promotion of sustainable behaviours (i.e. conserve energy); *Weight of Cities* assumes that behavioural change can further reduce energy and resource use by another factor of 2 (yielding 5 per cent of total resource use compared to the original business as usual scenario) (Salat, 2009).

The *Weight of Cities* report is global and aspirational in nature, and is therefore necessarily broad. **It aims to lay out a pathway to systemic change that could yield more than a factor of ten reduction in resource use.** One of the key uncertainties of the global analysis is whether the magnitude of assumed sequential factor reductions are achievable and multiplicative in all contexts. There is also uncertainty as to what measures, policies, activities and other parameters are already included in a generalizable business-as-usual scenario and thus that may not, in practice, characterize some regionally specific urbanization contexts. Nevertheless, these recommendations provide an important starting point and offer guiding principles for considering how best to deliver sustainable, resource efficient urban development in cities around the world.

Specifically, the *Weight of Cities* report recommends five broad strategies including:

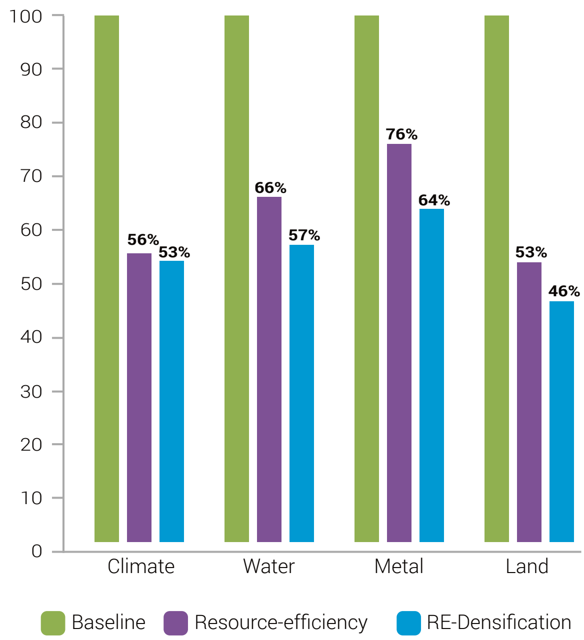
- Avoiding urban area expansion to agricultural lands and lands that provide high value ecosystem services, such as flood protection.
- Planning for strategic intensification and limit urban sprawl with higher density and mixed use development around transit access, developing human-scaled urban form, and encouraging non-motorized travel.
- Promoting energy efficiency strategies in single sectors – e.g., high efficiency buildings, district energy systems, and transit.
- Supporting cross-sectoral efficiency across urban areas and infrastructure systems, for example, reusing waste heat in district energy systems, beneficial exchange of materials across industry sectors, and waste-to-energy.
- Advancing urban experimentation to innovate on urban finance and multi-sector governance.

IRP's scenario analyses indicate that three infrastructure systems level strategies have the potential to achieve a 36 to 54 per cent reduction in resource use, in diverse world cities (see Figure 1.3; IRP, 2018), when applied in conjunction to strategic densification in cities (see Figure 1.3). The three systems level interventions included: Green buildings that assumed 100 per cent adopted 100 per cent by 2050; Bus rapid transit; and District Energy. The impact of these three resource efficiency (RE) interventions was estimated theoretically on a per unit basis (i.e., per unit building square area or per unit per person-kilometre travelled) and were than mapped to travel and buildings data obtained for a sample of 84 global cities for which data on all the relevant sectors were available or could be estimated for the BAU case through various correlations and assumptions. The BAU case was modelled separately from the interventions and the reductions shown in Figure 1.3 are assumed likely to apply, in line with the factor of 10 cascading reductions framework.

Additional studies are assessing the significant health and wellbeing co-benefits that can also accrue from resource efficiency strategies, particularly when those strategies are cross-sectoral, spanning entire urban areas and infrastructure systems. For example, a study that considered the application of circular economy policies in Chinese cities shows substantial potential to reduce air pollution, reduce material use, create economic savings and avoid premature mortality of more than 45,000 people annually (Ramaswami et.al. 2017; Tong et al., 2016). Studies of eco-industrial parks in China are estimating material and energy savings along with employment benefits and monetary savings (Tian et al., 2016). These areas are topics of emerging research – aimed at linking the impact of strategic infrastructure transformations on a number of SDGs, as illustrated conceptually in Figure 1.3.

FIGURE 1.3 Reduction potential of system level transformation strategies (buildings, district energy & transit) *(IRP 2018)*

Aggregate change in resources consumption for each socio-technical system for 84 cities combined under resource-efficient scenarios in 2050 (compared to forecasted baseline in 2050).



1.4 Report Goals

The overarching goal of this report is to regionally contextualize the core strategies identified in the global report, *The Weight of Cities: Resource Requirements of Future Urbanization* (IRP, 2018), drawing on the unique characteristics of ASEAN cities, as well as the experiences of regional neighbours including India and China. This report takes the specific strategies outlined in the *Weight of Cities* report as a starting point for analysing future urbanization processes in the ASEAN region. Where possible, we additionally incorporate linkages to health, wellbeing and the SDGs through the framework noted in Figure 1.2.

The purpose of this report is to offer grounded analysis of urban infrastructure provisioning, resource use, efficient urban development, and wellbeing in the context of ASEAN countries. The process amounts to the regional ground-truthing of findings and recommendations taken from the *Weight of Cities'* aspirational global document for the ASEAN context, taking into account the unique population, economic, infrastructure, socio-cultural and governance contexts of the ASEAN nations and cities. This report takes a regional view of the ASEAN nations as they, together, represent some 625 million people, just under half of whom live in cities spread across national contexts with diverse economies, levels of development and governance structures that in many ways represents the diversity of urbanization experiences happening across much of the global south. Some of the important and unique features of ASEAN urbanization that motivates the analysis conducted in this report are shown in Box 1.2 below and are detailed in the following section.

1.5 Importance of ASEAN Urbanization

1.5.2 Substantial urbanization still to occur

Substantial future urbanization s still projected to occur. About 205 million new urban residents are expected to be added to cities across the ASEAN through 2050, with a substantial portion of those new urban residents concentrated in small, emerging ASEAN cities. The total urban expansion of the region represents the third largest bloc of global urban population expansion, behind India and China. In 2014, the ASEAN region as a whole, with an urban population of some 294 million people, was only 47 per cent urbanized. In 2050, that proportion is projected to jump to nearly 65 per cent urbanized with a total urban population of some 506 million people. Indonesia alone is expected to see 94 million new urban residents between 2014 and 2050. The Philippines will see almost 44 million new urban residents during that time period. While Indonesia and the Philippines will see the largest absolute increase in their urban populations, Cambodia and Laos will see the fastest growing urban populations, each with annual average urban population growth rates of more than 4 per cent between 2014 and 2050 (UNDESA Population Division, 2014). That so much urbanization still has yet to occur in the ASEAN region presents an opportunity to strategize and plan for how best to accommodate this future urban population growth with the goal of getting resource efficient urban development 'right' at the outset, thereby avoiding the need to retrofit and mitigate the consequences of urban infrastructure system development that gets it 'wrong.'

The pace and total scale of urbanization in the region will require trillions of dollars of infrastructure investment. The consulting firm McKinsey estimates that the region will require seven trillion US dollars in investment to meet demand for new urban infrastructure and housing stock through 2035 (Lin, 2015). This figure does not include investments that will be needed to maintain existing infrastructure or building stock. Where this total level of investment might come from is not fully clear. For all infrastructure invetsting needs across Southeast Asia from 2016 to 2030, the Asian Development Bank estiamtes that the region faces a financing gap of more than US$2.7 trillion (ADB, 2017).

1.5.3 A growing global 'consumer class'

The ASEAN region is an important collection of emerging markets to watch, not just because of the population concentration in those markets, but also because large portions of those populations are increasingly members of a growing global middle class, also often referred to as a global 'consuming class' (Dobbs et.al. 2012; see Box 1.3). This is significant because of the influence that rising household incomes have on purchasing, consumption, and mobility patterns. As incomes rise, households generally increase their resource use footprints as they purchase washing machines, refrigerators, air conditioners and even personal vehicles. **McKinsey has identified consumers aged 15-59 in Southeast Asia as one of nine global consumer groups to watch, with expectations that this group alone will drive 3 per cent of global consumption growth between 2015 and 2030 (Dobbs et.al., 2016).** Many urban areas in the ASEAN region will face challenges that emerging markets across the global south will be grappling with: how to accommodate urban middle class consumption habits and standards of living without dramatically increasing natural resource use.

BOX 1.2 Why ASEAN? Strategic Implications for Future Urbanization and Sustainable Resource Use in Southeast Asia

- A major global emerging market behind China and India
- Substantial urbanization still to occur, a chance to lock in sustainable infrastructure transitions and avoid unsustainable patterns of urban growth
- A growing consumer class that can leverage present-day highly sustainable socio-cultural behaviours
- Low existing energy use, expectations of energy demand to increase, projected to be met by coal-dominated power supply

BOX 1.3 Defining Global Middle- and Consuming Classes

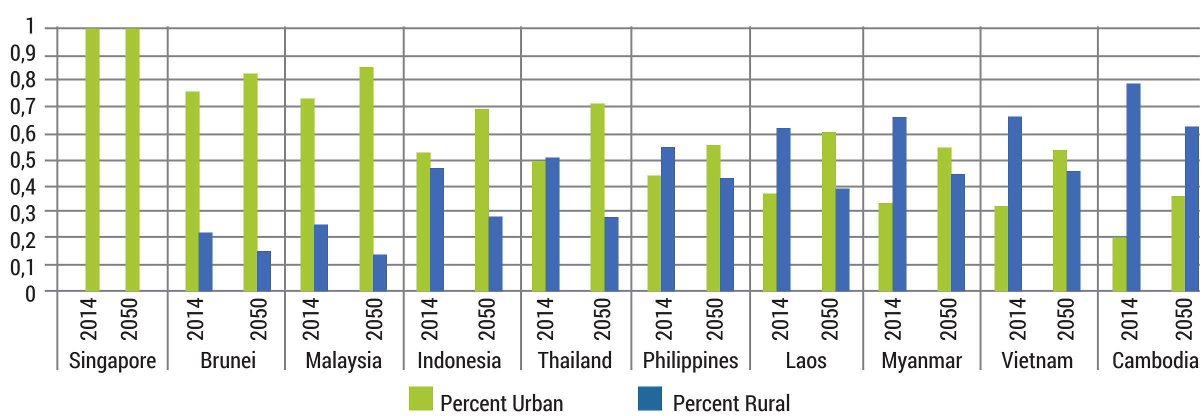
Definitions of middle class or middle-income status fall along a spectrum of daily household expenditures that ranges from US$10 to US$100 per person per day at 2005 purchasing power parity terms (Kharas, 2017). Alternatively, the consulting firm McKinsey & Co. has focused its analysis on the global growth of the 'consuming class,' which is comprised of 'households with incomes exceeding the level at which they can begin to make significant discretionary purchases' (HV, Thompson and Tonby, 2014). McKinsey defines members of the 'consuming class as households with annual incomes over US$7,500 in purchasing power parity terms'.

FIGURE 1.4 Population, GDP and Map of the ASEAN Region *(World Development Indicators; Map Credit ASEANup.com)*

Country	2015 Population (millions)	2016 GDP (trillions)
Indonesia	257.56	3.032
Philippines	100.70	0.807
Viet Nam	91.71	0.596
Thailand	67.96	1.165
Myanmar	53.90	0.305
Malaysia	30.33	0.863
Cambodia	15.58	0.059
Laos	6.80	0.042
Singapore	5.54	0.493
Brunei	0.42	0.033

2016 GDP figures presented at purchasing-power-parity rates in current international dollars. The map shown above is used to illustrate countries in the ASEAN region.

FIGURE 1.5 Per cent Urban-Rural ASEAN Countries, 2014 and 2050 *(UNDESA Population Division, 2014)*



1.5.4 Low existing energy use, expectations of substantial growth

The ASEAN region is a critical arena in which energy use, while currently at relatively low per capita levels, is expected to rise along with incomes and standards of living as the population increasingly urbanizes. Given the existing low levels of energy use, relative to global averages the challenge will be to ensure access to energy while reducing the carbon footprint associated with that modern energy access. **Overall, the region is expecting to triple its electricity use, triple its GDP and increase its primary energy use by 80% over the same period. Focusing on urban metabolic efficiencies, particularly with regard to energy use, will be important in the ASEAN region as it is expected to be heavily reliant on coal in meeting future demand.**

1.6 Drawing upon Experiences from China and India

While ASEAN countries are the core focus of this report, lack of consistent urban scale data across multiple sectors necessitates drawing more broadly on urbanization experiences and urban sustainability analysis from regional neighbours such as China and India, where quantitative data, case studies and scenarios at the city-scale are available to provide added insights. While the scale of both the Chinese and Indian urbanization is larger than the ASEAN context, at the level of individual urban areas, there is an opportunity to learn from the successes (and failures) of Indian and Chinese cities. This broadening of scope is not to suggest to that ASEAN, Chinese, and Indian urban contexts are interchangeable. Rather, China and India might be closer in context and relatability to the ASEAN context than those drawn from more western and northern contexts, while also providing very different national political systems that book-end the diversity of governance structures observed in the ASEAN region. **Indian and Chinese contexts are diverse enough to provide examples and experiences that speak to many of the general governance environments and urbanization characteristics present in cities across the ASEAN region.**

1.7 Methodology

To contextualize the global analysis of the *Weight of Cities* report for ASEAN nations, it is necessary to build a regional understanding of the resource, infrastructure, and wellbeing dynamics that undergird the *Weight of Cities'* resource-infrastructure-wellbeing framework. Regionally, this report considers broad topic areas that encompass many of the resources and infrastructure systems identified as relevant in the *Weight of Cities* analysis. The basic infrastructure sectors explicitly considered in this report include: energy, buildings, transportation and their interactions. While less explicitly addressed, the additional infrastructure sectors of water supply, food supply, and sanitation/waste services should be read as being at least partially embedded in the cross-sector industrial symbiosis discussion in Chapter 5. The resource and environmental impact discussion included in this report are focused on energy, urban land, materials and air pollution. A socio-technical approach is taken that seeks to first understand the population-economy, land, and urban form relationship in cities, followed by a closer look at energy, buildings and transportation sectors using a systems based life cycle perspective on single-sector opportunities in Chapter 4, followed by exploration of cross-sectoral industrial symbiosis opportunities in Chapter 5. Contextualization was conducted in three steps: an initial experts workshop, 2) literature and case study analysis, and 3) a second experts workshop to solicit comments and input on early findings.

1. Workshop in March 2017

A workshop was held in March 2017 in Beijing with a panel of experts drawn from the ASEAN nations, China, and USA, including both researchers and practitioners. The workshop attendees reviewed the general framework for the project, which matches the key interventions studied at the global scale in the *Weight of Cities* report. Their insights and experiences were recorded and provided the basis for the next step, which was a literature review and collection of case studies on the proposed infrastructure interventions. At the March workshop, the attendees discussed the challenge of obtaining secondary data for ASEAN cities. Data covering all infrastructure sectors, along with details of use, air pollution and other impacts, were not readily available for any single ASEAN city on a consistent basis for the same year (See Appendix A for the available data gathered in the *Weight of Cities* report). Such data would have to be available for several diverse ASEAN cities to draw meaningful conclusions.

2. Literature and Case Study Analysis

Given the paucity of bottom up city level data for the resource use and outcomes in relevant infrastructure sectors for a consistent year, the project focused on gaining insight through a review of the literature to first understand national trends, We first develop the national context around these topics, building upon population and economic projections provided by the International Energy Agency in its World Energy Outlook: ASEAN report (OECD/IEA, 2015). We then developed an understanding of the broad national trends in the energy, buildings and transportation sectors followed by sector specific city case studies from cities in the ASEAN bloc, India and China. The policy relevant insights emerging from the case studies are summarized in this report organized as:

- ASEAN Context (Chapter 2)
- Strategic Land Use Intensification and Transportation Planning (Chapter 3)
- Buildings and Energy (Chapter 4)
- Slum Prevention and Rehabilitation: A Resource Perspective (Chapter 5)
- Cross Sectoral Urban Industrial Symbiosis (Chapter 6)
- Governance and Finance (Chapter 7)

The major topic areas and key resources consulted to develop a profile for the ASEAN region are listed below table 1.1. These sources provide a broad mix of contextual information at both national and urban-levels.

3. Workshop 2: July 2017

A second workshop was held in July 2017 in Manila in conjunction with the ASEAN Mayors Forum to engage with urban management professionals and city representatives to test and receive feedback regarding the early findings of the report. The Manila workshop provided an opportunity to test the assumptions, findings, and analysis presented in this report in front of an audience of city leaders, technical urban managers, and policy experts from across the ASEAN region.

1.8 Available ASEAN City-Level Data

Very few cities in ASEAN nations have data on land use, energy use, water use, and material use linked with infrastructure development and air pollution for the same year. Data that do exist are only available for 4 large cities (Bangkok, Ho Chi Minh City, Manila, Singapore) and are relatively old, from the years 1995-2005 (see Appendix A). Furthermore, except for Bangkok in 2005, the material and energy flow data that are available have been downscaled from other levels of analysis, rather than having been calculated from bottom up measures which would better reflect actual city character and conditions. Such data are only now emerging for cities such as Delhi. Therefore, in this report, the *Weight of Cities* findings are contextualized not by analysing whole cities but rather by focusing on individual sectors such as land-use, transportation, and buildings while drawing on comparative case studies from ASEAN countries as well as from China and India.

TABLE 1.1 Summary of Key Resources Consulted for ASEAN Regional Profile

Topic Area	Key Data Resources
Population and Urbanization Statistics (national data)	World Urbanization Prospects 2014, 2015, 2016, United Nations Population Division; World Development Indicators, World Bank
Economic Development Data and Projections (national data)	World Energy Outlook Southeast Asia, International Energy Agency, 2015; World Development Indicators, World Bank; Urban World: Global Consumers to Watch, McKinsey Global Institute, 2016
Urban Land Expansion and Agglomeration	East Asia's Changing Urban Landscape: Measuring a Decade of Spatial Growth, World Bank, 2015
Poverty and Lack of Infrastructure	World Energy Outlook Southeast Asia, International Energy Agency, 2015; World Development Indicators, World Bank; ASEAN Statistical Yearbook 2014, ASEANstats, 2014
Energy Use and Supply: Trends and Outlook	World Energy Outlook Southeast Asia, International Energy Agency, 2015; Energy Outlook for the Asia-Pacific, Asian Development Bank, 2013
Material Use	Wiedmann et.al., The Material Footprint of Nations, Proceedings of the National Academy of Sciences, 2015; World Energy Outlook Southeast Asia, International Energy Agency, 2015
Air Pollution and Health	Global Urban Ambient Air Pollution Database, World Health Organization, 2016a; Global Health Data Exchange, Institute for Health Metrics and Evaluation, 2015
Water and Climate Change	Urban Poverty in Asia, Asian Development Bank, 2014; The State of Asian and Pacific Cities 2015, United Nations, 2015.

CHAPTER 2

ASEAN Context Urbanization Patterns, Infrastructure Trends, and Governance

BOX 2.1 Highlights of Chapter 2

1. Cities in the Association of Southeast Asian Nations (ASEAN) bloc are projected to add 205 million new urban residents by 2050 to the 300 million current urbanites.
2. In the ASEAN region 61 per cent of the urban population will be living in cities with fewer than 500,000 residents by 2030, and half of all urban population growth through 2030 will occur in cities of fewer than 500,000 residents. If these trends hold through 2050, the ASEAN region can expect the rise of more than 200 small cities in the next 30 years.
3. As the region's cities grow, they generally appear to be densifying in contrast to global trends of de-densification. The challenge for ASEAN cities will be to better manage existing levels of high density development to minimize the negative effects of urban density (pollution, congestion, environmental degradation of air, land, rivers and sea) while maximizing the most important co-benefits of urban density (resource efficiency, transit mobility and economic opportunity).
4. In 2017, the ASEAN region collectively represents the seventh largest economy in the world and is projected to represent the fourth largest economy in the world by 2050. It represents one of the largest emerging market economies behind China and India.
5. Demand among electricity consumers already connected to the electricity grid is only expected to grow as incomes, urbanization and standards of living rise. Demand will also rise as new urban residents connect to the grid for the first time. The region's total primary energy demand is projected to rise by 80 per cent by 2040 over 2013 levels, during which time the region's economy is expected to more than triple (OECD/IEA, 2015).
6. Even with expanded renewable energy investments, the ASEAN region will be one of only a few regions globally to see an increase in the share of coal in its electricity supply mix, rising from 32 per cent to 50 per cent by 2040 (OECD/IEA, 2015).
7. Personal vehicle ownership is low in the region, but is rising, while household saturation of two-wheelers (bicycles and motorcycles) is high.
8. Industrial growth sectors in the ASEAN are high users of fossil fuel and hence also produce substantial waste heat and materials that are particularly suited for urban industrial symbiosis.
9. The region faces substantial existing natural disaster risk as well as substantial climate change exacerbated natural disaster risk in the form of rising seas and increasingly intense and frequent storms. These risks are particularly dangerous for the region's urban areas given the stronger concentration of major population centres in low-lying coastal areas across the region.
10. Economic development, governance dynamics and control over infrastructure sectors vary substantially across national contexts in the region.

In order to translate the global findings of the IRP's *Weight of Cities* report, it is necessary to build a regional understanding of the population, economy, natural resource use patterns, infrastructure trends and links to wellbeing in the regional context. It is also important to understand the different governance contexts of both city administrations and national governments across the ASEAN, recognizing the role that policy and governance play in shaping the implementation of proposed interventions in the ASEAN cities. The objective of this chapter is to provide a high-level overview of the ASEAN context in the following broad topic areas: 1) demographics and urbanization trends at the national level, 2) patterns of urban growth across cities of different size; 3) economic development and market opportunities, 4) urban expansion and demand for land, 5) poverty and lack of infrastructure, 6) energy resources, 7) transportation, 8) air pollution, health and wellbeing, 9) climate change and water, 10) local and national governance.

BOX 2.2 The Strategic Importance of Looking at Sustainable Infrastructure Transitions in the ASEAN

- The ASEAN region is diverse and substantially varied when it comes to the level of existing (2014) urbanization levels and project future urban population growth.

- Collectively, the ASEAN region is slated to undergo significant additional urban population growth between 2015 and 2050, adding 205 million new urban residents to the present 300 million people in its cities, a 68 per cent increase from 2015 levels.
- Half of future urban population growth in the ASEAN region will occur in cities with a population of less than 500,000 people. **This indicates the likely rise and growth of more than <u>200+ cities</u> smaller than half a million in population, over the next 30 years.**

2.1 Urban Population Growth and Urbanization Trends

Overall, from 2015 to 2040, the ASEAN region is expected to see its population increase by some 135 million residents (from 633 million to 768 million, a 21 per cent increase). . Over that same period, the region's urban population is expected to increase by some 158 million new residents (from 301 million to 459 million, a 52 per cent increase), meaning that functionally all new growth will be concentrated in urban areas and that millions of currently non-urban residents will become urban residents. By 2050, that urban population will grow by another 47 million to reach 507 million, a 68 per cent increase over 2015 levels. As these population changes take place, the region's economy and energy use profile will also change rapidly. By 2040, the region's GDP is projected to triple, primary energy use will increase by 80 per cent, and electricity demand is expected to more than triple (OECD/IEA, 2015).

Data from the UNDESA Population Division indicates that substantial urbanization in the ASEAN region is still yet to occur given that the present average level of urbanization across the ASEAN bloc is just below 50 per cent (UNDESA, 2014). Across the ASEAN region, cities are expected to see their populations grow by some 205 million new urban residents through 2050. **The region's urbanized population proportion will increase from 47 per cent in 2014 to 65 per cent in 2050, with five of the ten ASEAN nations transitioning from minority urban to majority urban. This represents a significant demographic shift that will change the way people live and the way human settlements are designed and function.**

It is important to note however, that classifications of "urban" vary substantially across national contexts in the ASEAN region resulting in substantial heterogeneity in the settlement patterns reflected within this aggregate number for total urban population in the region (see Box 2.3). The urban population growth will occur across a variety of differently situated national contexts and will occur at a variety of speeds. ASEAN countries like Brunei, Malaysia and Singapore are already highly urbanized at present, with 70 per cent or more of their populations living in urban areas in the year 2014. The seven remaining ASEAN nations exhibit urbanization levels ranging from a low of 21 per cent urban in Cambodia to an upper limit of 53 per cent urban in Indonesia. Going forward, relatively slow urban population growth, on par with annual urban growth rates observed in advanced industrial economies of approximately 1 per cent or less, will characterize urban population growth rates in Brunei, Singapore and Thailand. Faster annual national urban population growth rates between 1.5 and 3 per cent are projected for Indonesia, Malaysia, Myanmar, the Philippines and Viet Nam. The highest levels of annual urban population growth of more than 4 per cent are expected in the ASEAN countries of Cambodia and Laos.

Fast urban population growth can result in infrastructure deficits as urban areas face the possibility of falling behind with infrastructure investment and provisioning for their rapidly expanding populations. The inability of fast growing cities to make infrastructure investments that keep pace with population growth is a key factor behind slum formation, crowded and overburdened transportation systems, and insufficient delivery of basic services.

TABLE 2.1 ASEAN Region Current and Future Urban Population Trends across ASEAN Nations *(UNDESA, World Urbanization Prospects: 2014 Revision)*

Country	Per cent Urban 2014	Per cent Urban 2050	Absolute Urban Population Growth 2014-2050 (million)	Annual Urban Population Growth Rate 2014-2050
Brunei	77%	84%	0.1	1.14
Cambodia	21%	36%	5.0	4.40
Indonesia	53%	71%	93.8	1.94
Laos	38%	61%	3.8	4.13
Malaysia	74%	86%	13.8	1.72
Myanmar	34%	55%	14.2	2.19
Philippines	44%	56%	43.8	2.74
Singapore	100%	100%	1.5	0.78
Thailand	49%	72%	11.3	0.95
Viet Nam	33%	54%	25.2	2.30

BOX 2.3 Defining 'Urban' in the ASEAN Context

The definition of 'urban' varies from country to country. Definitions generally hinge on factors including administrative categories, total population count, population density levels, and/or the predominance of non-agricultural economic activity. Some national definitions are premised on only one of these factors, while others may be premised on a combination of these factors. UNDESA Population Division"s World Urbanization Prospects reports the definitions of 'urban' used by each national census administration. The available definitions for all ten ASEAN nations, plus China and India, are included below.

- **Brunei** - Municipalities and areas having urban socio-economic characteristics.
- **Cambodia** - Since the 2008 census, every commune that meets at least one of the following criteria: a) population density exceeding 200 persons per square kilometre, b) percentage of male employment in agriculture below 50 per cent, or c) total population exceeding 2,000 inhabitants. To improve time trend comparability, the urban proportion for the 1998 census was recalculated based on the revised classification of urban areas adopted in the 2008 census. For the 1962 and 1980 censuses, municipalities of Phnom Penh, Bokor and Kep and 13 additional urban centres.
- **China** - For up to 1982, total population of cities and towns. Cities had to have a population of at least 100,000 inhabitants or command special administrative, strategic, or economic importance to qualify as cities. Towns were either settlements with 3,000 inhabitants or more, of whom more than 70 per cent were registered as non-agricultural or settlements with a population ranging from 2,500 to 3,000 inhabitants of whom more than 85 per cent were registered as non-agricultural. For the 1990 census, the urban population included: 1) all residents of urban districts in provincial and prefectural-level cities; 2) resident population of 'streets' (jiedao) in county-level cities; 3) population of all residents' committees in towns. For the 2000 census, the urban population was composed of population in City Districts with an average population density of at least 1,500 persons per square kilometre, other population in suburban-district units and township-level units meeting criteria such as contiguous built-up area, being the location of the local government, or being a Street or having a Resident Committee. For the 2010 census, urban population included all urban residents meeting the criterion defined by the National Bureau of Statistics of China in 2008, i.e., the criterion used in the 2000 census plus residents living in villages or towns in outer urban and suburban areas that are directly connected to municipal infrastructure, and that receive public services from urban municipalities.
- **India** - Statutory places with a municipality, corporation, cantonment board or notified town area committee; and places satisfying the following three criteria simultaneously: (a) a minimum population of 5,000 inhabitants, (b) at least 75 per cent of male working population engaged in non-agricultural pursuits, and (c) a density of population of at least 400 per square kilometre.
- **Indonesia** - Municipalities ('kotamadya'), regency capitals ('kabupaten') and other places with urban characteristics.
- **Lao** - For the 2005 census, areas within municipal vicinity with the centre of that municipality having more than 600 inhabitants or more than 100 households. Further, the areas must have certain urban characteristics (roads, electricity, market function, tap water supply).
- **Malaysia** - Gazetted areas with their adjoining built-up areas and with a combined population of 10,000 persons or more. Built-up areas were areas contiguous to a gazetted area and had at least 60 per cent of their population (aged 10 years and over) engaged in non-agricultural activities. Areas had also modern toilet facilities in their housing units.
- **Myanmar** - No official definition available.
- **The Philippines** - Cities and municipalities with a density of at least 1,000 persons per square kilometre; administrative centres, 'barrios' with 2,000 inhabitants or more and 'barrios' with 1,000 inhabitants or more which are contiguous to the administrative centre, in all cities and municipalities with a density of 500 persons or more per square kilometre and all other administrative centres with 2,500 inhabitants or more.
- **Singapore** - Entire population.
- **Thailand** - Municipalities. In 1999, 981 districts were reclassified as 'Tambon' municipalities and data for proportion urban were adjusted retrospectively.
- **Viet Nam** - Places with 4,000 inhabitants or more.

FIGURE 2.1 **Absolute urban population growth (between 2015 and 2030) projected to occur in Small (<0.5 million residents) and Medium/Large Cities (>0.5 million residents)** *(UNDESA Population Division, 2014)*

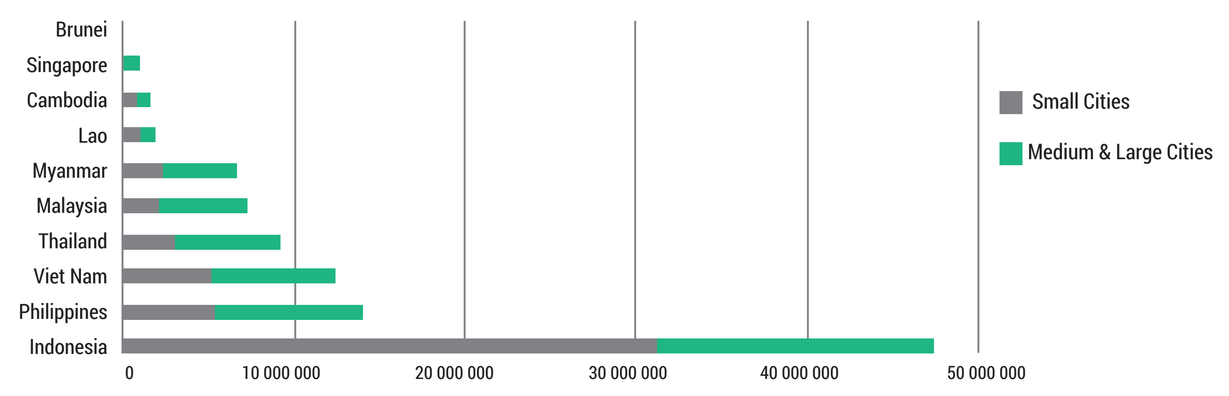


FIGURE 2.2 **Percentage of urban growth (between 2015 and 2030) projected to occur in small cities (<0.5 million residents) and medium/large cities (>0.5 million residents)** *(UNDESA, Population Division 2014)*

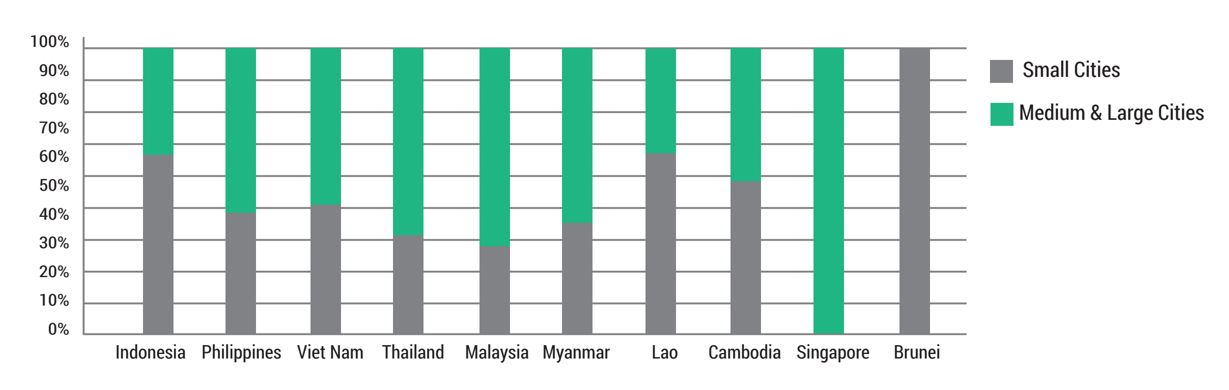


TABLE 2.2 **ASEAN Urban Population Change by Urban Settlement Class between 2015 and 2030: Small, Medium, and Large Cities. The Breakpoint of 500,000 was chosen because of United Nations emphasis that significant growth with will occur in cities of less than 500,000** *(UNDESA Population Division, 2014)*

	Settlement Class: Small Cities (Tier 3)			Settlement Class: Medium to Large Cities (Tier 1 and Tier 2)				
	Total Urban Population Growth (millions)	Population Change in Cities <0.5 Million Residents (millions)	**Share of Overall Urban Growth in Small Cities**	Population Change in Cities 0.5 to 1 Million Residents (millions)	Population Change in Cities 1 to 5 Million Residents (millions)	Population Change in Cities 5 to 10 Million Residents (millions)	Population Change in Cities +10 million residents (millions)	**Share of Overall Urban Population Growth in Medium to Large Cities**
Brunei	**0.07**	0.07	**100%**	0.00	0.00	0.00	0.00	**0%**
Cambodia	**1.65**	0.80	**48%**	0.00	0.85	0.00	0.00	**52%**
Indonesia	**47.50**	31.20	**66%**	-0.68	13.44	0.00	3.49	**34%**
Lao	**1.77**	0.98	**56%**	-1.00	1.78	0.00	0.00	**44%**
Malaysia	**7.28**	2.03	**28%**	1.42	1.25	2.59	0.00	**72%**
Myanmar	**6.63**	2.28	**34%**	1.71	-3.9	6.58	0.00	**66%**
Philippines	**14.05**	5.31	**38%**	1.75	3.18	0.00	3.81	**62%**
Singapore	**0.96**	0	**0%**	0.00	0.00	0.96	0.00	**100%**
Thailand	**9.18**	2.94	**32%**	2.66	1.33	-9.27	11.53	**68%**
Viet Nam	**12.37**	5.06	**41%**	-1.27	0.2	-1.80	10.20	**59%**
ASEAN	**101.46**	**50.67**	**50%**	**4.59**	**18.13**	**-0.94**	**29.03**	**50%**

2.2 Patterns of urban growth; the rise of 200+ small cities

Worldwide, urban population growth will be concentrated in cities with fewer than 500,000 residents. By 2030, of the world's 5 billion projected urban residents, nearly half (2.25 billion) are estimated by the United Nations to be living in urban areas of less than 500,000 residents. This is in contrast to the 730 million people who are expected to live in megacities of more than 10 million residents. Across Asia, the number of small cities (fewer than 500,000 residents) is expected to grow to by 30 per cent between 2016 and 2030. In the ASEAN region specifically, in 2030, the bulk of urban populations—some 61 per cent—will be living in cities with fewer than 500,000 residents. What is more, between 2015 and 2030, fully half of the urban population growth in the region will occur in cities with 500,000 residents or fewer (UNDESA Population Division, 2014; see Figure 2.1, Figure 2.2 ; Table 2.2).

Extrapolating these estimations out to 2050 (i.e., 50 per cent of new urban population growth—2015 to 2030 trend—concentrated in cities of less than 500,000 people) for the 205 million new urban residents expected to be added to cities across the ASEAN region, indicates that at a minimum, the region can expect the rise of more than 200 small cities in the next 30 years. Globally, the story of fast growing small cities will be relevant for understanding future urbanization and sustainable infrastructure development trends. **The ASEAN region will be a global hotspot for this type of fast-paced urban growth in small cities with populations of less than half a million people.**

While future urban growth is expected to predominantly occur in the smaller cities (<500,000 people), some of the existing medium and large cities in the ASEAN will also see very rapid population growth rates, including the Tier 1 cities (Manila, Jakarta, Bangkok Ho Chi Minh City, Kuala Lumpur, Singapore, and Yangon), as well as Tier 2cities shown in Table 2.3. **Taken together, both the anticipated 200+new small cities (<500,000) and existing medium and large cities will exert a tremendous demand for new urban infrastructure.**

TABLE 2.3 Population of Example Tier 1 and Tier 2 cities across the ASEAN bloc of nations *(ASEANup.com)*

Tier 1 (Large) Cities and their populations in 2015	Examples of Fast Growing Tier 2 (Medium) Cities and their populations in 2015 and 2025 (population growth expected from 2015-2025)
• Manila (Philippines): 12.9 million • Jakarta (Indonesia): 10.3 million • Bangkok (Thailand): 9.3 million • Ho Chi Minh City (Viet Nam): 7.3 million • Kuala Lumpur (Malaysia): 6.8 million • Singapore: 5.6 million • Yangon (Myanmar): 4.8 million	Samut Prakan (Thailand) will grow from 1.8 million inhabitants in 2015 to 2.9 million in 2025 (62.3 per cent growth) Batam (Indonesia) will grow from 1.4 million inhabitants in 2015 to 2.2 million in 2025 (60.8 per cent growth) Vientiane (Laos) will grow from 0.99 million inhabitants in 2015 to 1.6 million in 2025 (54.5 per cent growth) Denpasar (Indonesia) will grow from 1.1 million in 2015 to 1.7 million in 2025 (51.9 per cent growth)

2.3 Regional Economic Development

The economic development statuses of ASEAN countries are as varied as their urbanization levels. Singapore and Brunei exhibit per capita GDP levels (at purchasing power parity rates) on par with, or surpassing, advanced industrialized economies of East Asia, Western Europe, and the United States. As such, the World Bank categorizes them as high-income countries. Malaysia and Thailand are both categorized as upper middle-income countries while the rest of the ASEAN region including Cambodia, Indonesia, Laos, Myanmar and the Philippines are all categorized at the lower-middle income level.

Economic growth in the ASEAN region has been robust over the past two decades, with the region as a whole seeing real GDP grow by 5.1 per cent annually between 2000 and 2013. This level of growth is below China's rate of 10 per cent annual growth and India's rate of 7 per cent annual growth, but well above the economic growth rates seen in the United States or Western Europe. Much of this growth has been premised on productivity gains across the labour market in the region. **The region collectively represents the seventh largest economy in the world, and is projected to represent the fourth largest economy in the world by 2050 (HV, Thompson, and Tonby, 2014).**

Substantial economic growth in the ASEAN region has also been driven by an expanding labour force and a structural shift in the economy toward higher productivity activities including manufacturing and the services sector. Continued economic growth in the region is expected to yield average per capita incomes that are equal to a quarter of per capita income levels of OECD countries by 2040 (OECD/IEA, 2015).

The region's economic growth potential has led the global consulting firm McKinsey to identify working age consumers (ages 15-59) in Southeast Asia as one of nine global consumer cohort groups to watch, with expectations that this group alone will drive 3 per cent of global consumption growth between 2015 and 2030 (Dobbs et.al., 2016). **The ASEAN region as a whole has experienced and is expected to continue to experience steady economic growth that will raise average per capita incomes and standards of living, likely driving increased household consumption habits and resource requirements.**

TABLE 2.4 Per Capita GDP (PPP) in ASEAN Countries, 2015 *(World Development Indicators)*

Country	GDP Per Capita (PPP) 2015	Income Category
Brunei	US$78,369	High
Cambodia	US$3,490	Lower-Middle
Indonesia	US$11,058	Lower-Middle
Laos	US$5,691	Lower-Middle
Malaysia	US$26,950	Upper-Middle
Myanmar	US$5,250	Lower-Middle
Philippines	US$7,387	Lower-Middle
Singapore	US$85,382	High
Thailand	US$16,340	Upper-Middle
Viet Nam	US$6,034	Lower-Middle

Source: GDP (PPP) figures are for 2015, sourced from the World Development Indicators data series from the World Bank; Income status classifications are based on GNI per capita income categories assigned by the World Bank, current as of FY2018.

2.4 Urbanization, Urban Density, and Correlates with Air, Land and Ocean Pollution

The ASEAN region may be one of only a few regions globally where current urbanization trends point towards continued levels of high density growth (2000-2010). A comprehensive study conducted by the World Bank found that in 34 large urban areas of more than 1 million in population across the ASEAN region, average city-wide density in 2010 ranged from a floor of 3,100 people/square kilometre to a ceiling of 24,700 people/square kilometre, with a mean average density of just under 9,300 people/square kilometre (World Bank, 2015).[2] For all 34 cities, the annual rate of urban land expansion from (2000 to 2010) was slower than the annual rate of urban population growth (2000 to 2010), indicating that the population is growing faster than the physical city is expanding. Independent of density considerations, urban land expansion relative to population growth is important for understanding how a city's physical footprint is growing and the rate at which it is spilling on to valuable agricultural land or otherwise ecologically sensitive hinterlands that can provide important ecosystem services to the urban region as a whole including regional food security, water supply provisioning (McDonald et al., 2014), urban watershed drainage, as well as functioning as important bio-diversity hotspots (Seto et al., 2012). In addition to direct land expansion, cities also impact natural resources (the use of land, water, energy, and materials) well beyond their boundaries because the supply chains that serve cities extend well beyond administrative urban boundaries.

The general trend that cities over 1 million in population in the ASEAN region have a population growth rate that exceeds their urban land expansion rate indicates that these are cities are not dealing with the generalized de-densification challenges that other global urban cohort groups are experiencing, whereby the rate of urban land expansion is happening faster than the rate of urban population growth. The same study of urban areas over 1 million in population across the ASEAN region found that these densification trends--whereby population growth outpaces urban land expansion—hold true for smaller urban areas between 100,000 and 1 million in population. Specifically, small cities in Myanmar, Indonesia, Viet Nam and the Philippines, especially, have added population without much physical land expansion (Schneider et. al. 2015).

Because ASEAN urban areas already demonstrate densifying trends (Table 2.3), the challenge, broadly speaking, is not about raising densities. Instead, the challenge is to 1) maintain trends of high density urbanization by limiting urban boundary spill over, sprawl and the proliferation of enclave townships, and 2) to better manage current patterns of high density as "accessible" and "articulated" densities that bolster environmental sustainability, human wellbeing, and liveability for all residents within the city and surrounding peri-urban and rural areas.

2 High average densities are not a goal unto themselves and say nothing about the quality of life of the residents who live at those average levels of density. That said, average densities do provide an important starting point for understanding existing urban development patterns, allowing urbanization observers to understand, directionally, whether a city as a whole is densifying or de-densifying. See Chapter 3 for a more detailed discussion of density generally and the concepts of articulated and accessible density specifically.

TABLE 2.5 Urban area and population in 2010, change in area and population from 2000 to 2010, and administrative boundary arrangement for ASEAN cities *(World Bank Group, 2015)*

Urban area	Country	Urban land 2010 (sq. km)	Average annual rate of increase in urban land, 2000–10 (%)	Urban population, 2010	Average annual rate of change of urban population 2000-2010 (%)	Average urban population density, 2010 (persons/sq. km)	Administrative boundary arrangement
Jakarta	Indonesia	1,600	1.8	23,431,674	3.7	14,643	Fragmented
Manila	Philippines	1,275	2.2	16,521,948	3.1	12,958	Fragmented
Subtotal		2,875	2.0	39,953,622	3.4	13,801	
Bangkok	Thailand	2,126	1.1	9,555,372	2	4,495	Fragmented
Ho Chi Minh City	Viet Nam	815	4	7,761,835	3.9	9,528	Fragmented
Bandung	Indonesia	512	1.7	6,946,592	3.8	13,571	Spillover
Surabaya	Indonesia	726	1.2	6,104,808	3.3	8,410	Fragmented
Kuala Lumpur	Malaysia	1,739	1.2	5,750,078	3.8	3,306	Fragmented
Hanoi	Viet Nam	851	3.8	5,642,882	4.8	6,634	Fragmented
Subtotal		**6,769**	**2.2**	**41,761,567**	**3.6**	**7,657**	
Medan	Indonesia	456	0.4	3,929,132	3.1	8,624	Fragmented
Yangon City	Myanmar	390	0.5	3,416,962	2.6	8,771	Fragmented
Singapore	Singapore	404	1.8	3,412,239	3	8,457	Contained
Semarang	Indonesia	365	1	2,857,742	3.5	7,832	Fragmented
Malang	Indonesia	265	0.6	2,242,804	3.2	8,463	Spillover
Surakarta	Indonesia	379	0.1	2,125,451	3	5,615	Fragmented
Tegal	Indonesia	248	1.4	2,106,735	3.9	8,480	Fragmented
Yogyakarta	Indonesia	234	0	1,799,090	2.9	7,701	Fragmented
George Town	Malaysia	396	2	1,682,629	4.3	4,253	Fragmented
Cirebon	Indonesia	171	1.4	1,656,403	3.9	9,683	Spillover
Palembang	Indonesia	205	0.3	1,602,228	3	7,806	Spillover
Tasikmalaya	Indonesia	93	1.8	1,594,737	4.2	17,090	Spillover
Makassar	Indonesia	139	2.1	1,591,997	3.8	11,464	Spillover
Cebu	Philippines	161	2.8	1,527,407	4.1	9,461	Fragmented
Denpasar	Indonesia	227	0.8	1,473,252	3.2	6,488	Fragmented
Phnom Penh	Cambodia	164	4.3	1,405,381	4.4	8,596	Fragmented
Jember	Indonesia	231	0.1	1,358,347	2.9	5,890	Spillover
Sukabumi	Indonesia	96	2.3	1,357,948	4.2	14,201	Spillover
Johor Bahru	Malaysia	416	4.4	1,297,170	4.7	3,116	Contained
Kediri	Indonesia	274	1	1,256,399	3.3	4,586	Spillover
Hai Phong	Viet Nam	199	2.1	1,221,115	4.1	6,144	Fragmented
Garut	Indonesia	46	3.1	1,136,920	5.5	24,749	Contained
Mandalay	Myanmar	130	1.5	1,130,511	3.2	8,709	Fragmented
Cikampek	Indonesia	106	1.4	1,116,340	3.9	10,556	Contained
Cianjur	Indonesia	69	1.4	1,066,550	4.1	15,415	Contained
Cilacap	Indonesia	101	0.7	1,007,170	3.4	9,978	Contained
Subtotal		**5,965**	**1.5**	**46,372,659**	**3.7**	**9,313**	

Urbanization and density considerations are not just factors linked to the expanding physical footprints of cities, but also the intensity of transboundary flows of waste and pollution that stem from urban areas and spill into hinterlands and hinter-seas, as well as reverse pollution flows, for example air pollution from surrounding crop burning that flows into cities.

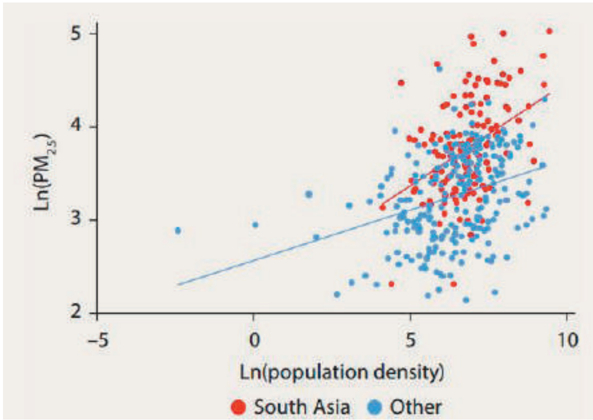
If poorly managed and untreated, urban waste and pollution flows can result in the degradation of both freshwater resources and seas (Jalilov, 2016). The effect of land-sourced marine pollution is especially dramatic in the ASEAN region. Indonesia, the Philippines, Viet Nam, Thailand, and Malaysia are all among the top ten contributors of plastic debris pollution to global oceans (Jambeck et.al. 2015). The impacts of urban land-sourced marine pollution from ASEAN nations has global implications for bio-diversity. The coastal waters of South East Asia are home to some 34 per cent of the world's reefs and between a quarter and a third of the world's mangrove forests. The discharged sediment loads and pollution associated with rapid urbanization in the region directly threaten these natural assets (Todd, Ong, & Chou, 2010).

In cities of developing countries, air pollution in the form of PM2.5 concentration is positively and significantly correlated with increased city size and population density when controlling for climate and geographic variation (World Bank, 2016b; see Figure 2.3). The analysis in Figure 2.3 shows a correlation for developing country cities globally, with an even stronger correlation for South Asian cities specifically, although the scatter is large, indicating a high degree of variability.

Air pollution and density are related not just as a result of higher concentrations of people living in an area, but also as a function of urban form and the ability of high-density cities with closely packed buildings to easily ventilate. The "urban permeability" and "building geometries" of high density urban environments become important design variables for either exacerbating or mitigating air pollution concerns (Yuan, Ng, & Norford, 2014).

The better management of environmental and human health dis-benefits of urban density and urbanization through engineered waste management and control systems (solid waste management, sewage treatment, air pollution controls) is critical not just for its impact on immediate human health along the urban rural-continuum, but also for its impact on pollution and waste flows into both hinter-lands and hinter-seas. Reducing the throughput of natural resources like fossil fuels, etc. into the economic system through resource efficient urban infrastructure systems in conjunction with end of pipe control infrastructure (e.g. waste management infrastructure) is essential to support high-density human settlement and environmental sustainability, hence the emphasis of this report on urban infrastructure systems (see well-being and infrastructure discussion in Chapter 1). **While by some estimates ASEAN urban areas appear to be bucking the global trend of general de-densification, the immediate challenge is to ensure that already dense settlement patterns are viable moving forward by having the appropriate infrastructure systems in place to minimize the negative effects of urban growth and density (pollution, congestion, environmental degradation of air, land, rivers, and seas) while maximizing the most important co-benefits of urban growth and density (resource efficiency, transit mobility, and economic opportunity).**

FIGURE 2.3 Relationship between Annual Mean Concentration of PM2.5 and City Population Density for 381 Developing-country Cities *(World Bank, 2016b)*



Calculations based on analysis of World Health Organization ambient (outdoor) air pollution in cities 2014 data and other sources of data on city population levels, densities, and climate; and geographical-related determinants of air pollution levels. Source: Leveraging Urbanization in South Asia: Managing Spatial Transformation for Prosperity and Livability, World Bank, 2016.

BOX 2.4 Global Perspectives on Measuring Urban Built-Up Areas and Density

Global urbanization experts have been working since the early 2000s to understand whether cities are densifying or de-densifying as they grow, all the while experimenting with technological methods for assessing the expansion of urban built environments. Remote sensing has emerged as a critical tool for evaluating urban expansion globally. Aerial remote sensing of built up urban areas (central cities and their surrounding urban and peri-urban areas) allows for a more complete picture of actual urban density rather than simply comparing the formal land area of a given jurisdiction and comparing that value to its population count. Below is a brief summary of paraphrased and excerpted key findings and caveats taken from influential studies that inform the discussion of urban land expansion and density trends considered in this report.

Schneider and Woodcock 2008 - An examination of 25 cities globally that identifies four city types: “low-growth cities with modest rates of infilling”; “high-growth cities with rapid, fragmented development”; “expansive-growth cities with extensive dispersion at low population densities”; and “frantic-growth cities with extraordinary land conversion rates at high population densities.” The authors note that, “although all 25 cities are expanding, the results suggest that cities outside the United States do not exhibit the dispersed spatial forms characteristic of American urban sprawl.”

Angel et al. 2010 - An examination of 120 cities globally that uses satellite imagery, census data and historical maps to report that average built-up area density in cities in land-rich developed countries was 34±7 persons per hectare (p/ha) in 1990 and 28±5 p/ha in 2000; that the average built-up area density in cities in other developed countries was 86±9 p/ ha in 1990 and 70±8 p/ha in 2000; that average built up area density in cities in developing countries was 174±14 p/ha in 1990 and 135±11 p/ha in 2000. In all categories, average built-up area densities in cities declined between 1990 and 2000. Specifically, the authors note that “average built-up area densities declined in 75 out of the 88 developing country cities in the global sample between 1990 and 2000.”

Schneider et al. 2015 - A sample of 1,000 cities in East and Southeast Asia using consistent methodology, satellite imagery, and census data reports that urban land increased >22 per cent between 2000 and 2010 while urban populations climbed >31 per cent. The authors state that: “Although urban land expanded at unprecedented rates, urban populations grew more rapidly, resulting in increasing densities for the majority of urban agglomerations, including those in both more developed (Japan, South Korea) and industrializing nations (China, Viet Nam, Indonesia). The results contrast previous sample-based studies, which conclude that cities are universally declining in density.” Specifically, the results contradict previous studies modeling results using static c. 2000 urban maps. The Schneider et.al. 2015 study relied on data developed from the MODIS 500m urban extent map, which the authors cite as having “the highest local accuracy of available maps and a zero-omission rate for cities globally.” The authors note that their measurement of “urban extent does not include low-density settlements (e.g. 30–40 per cent built-up), although these areas may function as urban space. If we relax the 50 per cent threshold built-up, higher rates and amounts of urban land would be likely.”

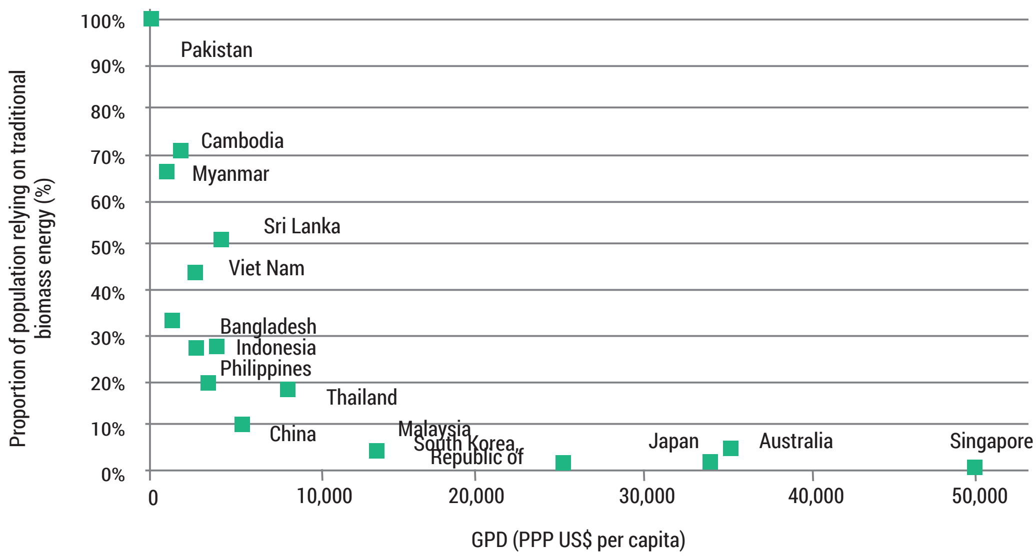
Taken together, and considering the large sample of 1,000 cities reported by Schneider et al. (2015), the scientific evidence points toward rapid urban land expansion in ASEAN cities, yet at rates slower than population growth indicating densification on average in urban built up areas. Densification, on average, would be a positive development to reduce land expansion, to preserve agricultural lands and to enhance biodiversity along the urban-rural continuum. However, average urban densification alone does not necessarily address resource efficient urbanization within cities where compact urban form and strategic intensification has the potential to reduce material and energy use in both transportation and buildings sectors.

TABLE 2.6 Per cent Urban Population Living in Slums, and per cent Urban Population with Access to Basic Services *(World Development Indicators)*

Country	Share of Urban Pop. Living in Slum Settlements	Share of Urban Pop. Access to Electricity	Share of Urban Pop. Access to Improved Sanitation Facilities	Share of Urban Pop. Access to Improved Water Source
Brunei	No data	100.0%	No data	No data
Cambodia	55.0%	96.9%	88.0%	100.0%
Indonesia	22.0%	99.7%	72.0%	94.0%
Laos	31.0%	94.7%	95.0%	86.0%
Malaysia	No data	100%	96.0%	100.0%
Myanmar	41.0%	85.5%	84.0%	93.0%
Philippines	38.0%	97.3%	78.0%	94.0%
Singapore	No data	100.0%	100.0%	100.0%
Thailand	25.0%	100.0%	90.0%	98.0%
Viet Nam	27.0%	99.9%	94.0%	99.0%

Source: Figures sourced from the World Development Indicators data series published by the World Bank; data presented is based on the latest year available, all data from either 2014 or 2015.

FIGURE 2.4 Trends in Proportion of Population Using Traditional Biomass Energy (%) and GDP (PPP US$ per Capita) in Selected ASEAN and Non-ASEAN Countries *(Anbumozhi and Han, 2015)*



Source: The World Bank, World Development Indicators.

2.5 Slum Development and Access to Basic Services via Infrastructure

Significant gains in poverty reduction and the provisioning of infrastructure and basic services have been made in the ASEAN nations. The total number of people in the ASEAN region without access to electricity was more than 410 million in 2000. By 2016, the International Energy Agency estimates that number had fallen more than 75 per cent to just over 100 million (OECD/IEA, 2016a). However, 120 million people across the ASEAN region still lack access to electricity and 280 million lack access to clean cooking facilities (OECD/IEA, 2015). Nearly 73 million people across the region lived in urban slums in 2014 (World Development Indicators). While slums and informal settlements across the region take many different forms and are characterized by different levels of poverty, built environments, and infrastructure systems, urban settlements that lack secure land tenure and access to basic infrastructure are a common feature in cities across the region, with the notable exceptions of Brunei, Singapore, and to a lesser extent, Malaysia. **Excluding the higher income nations of Singapore and Brunei, the median share of urban population living in slums for nations in the ASEAN region is 31 per cent.** Country by country, that share ranges from 22 per cent in Indonesia to a high of 55 per cent in Cambodia.

Access to the different infrastructure services in cities varies across the nations (as seen table 2.6) with more work needed to provide better housing (alleviate slum conditions) and improve sanitation. With the exception of Laos and Myanmar, all countries in the ASEAN region exhibit an urban electricity access rate of 95 per cent or greater. Rates of access to improved sanitation facilities among urban residents are more varied than rates of access to electricity. Six of the ten ASEAN countries exhibited national urban rates of access to improved sanitation levels of less than 95 per cent, dipping to 72 and 78 per cent respectively in the cases of Indonesia and the Philippines. For comparison, 87 per cent of China's urban population and 61 per cent of India's urban population have access to improved sanitation facilities. National urban access rates to improved water sources across the ASEAN region was slightly higher with only four countries exhibiting an access rate of less than 95 per cent, with only one country dipping below 90 per cent.

While the region as a whole and individual countries have experienced strong levels of economic growth over the past two decades, that growth has not translated into prosperity for all (Anbumozhi & Han, 2015). The relationship between per capita income levels and lack of access to basic modern infrastructure services like electricity and clean cooking fuels can be seen when comparing income and use of traditional biofuels within the home (see Figure 2.4), which incidentally, cause substantial health consequences particularly for women and young children who may spend more time in the home.

BOX 2.5 Defining Slums and Informal Settlements

Slums
An urban area which lacks one or more of the following: 1) durable housing of a permanent nature that protects against extreme climate conditions; 2) sufficient living space which means not more than three people sharing the same room; 3) easy access to safe water in sufficient amounts at an affordable price; 4) access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people; 5) security of tenure that prevents forced eviction (United Nations Habitat, 2006).

Informal Settlements
Residential areas where 1) inhabitants have no security of tenure vis-à-vis the land or dwellings they inhabit, with modalities ranging from squatting to informal rental housing, 2) the neighbourhoods usually lack, or are cut off from, basic services and city infrastructure and 3) the housing may not comply with current planning and building regulations, and is often situated in geographically and environmentally hazardous areas. In addition, informal settlements can be a form of real estate speculation for all income levels of urban residents, affluent and poor. Slums are the most deprived and excluded form of informal settlements characterized by poverty and large agglomerations of dilapidated housing often located in the most hazardous urban land. In addition to tenure insecurity, slum dwellers lack formal supply of basic infrastructure and services, public space and green areas, and are constantly exposed to eviction, disease and violence (United Nations Habitat, 2015c).

2.6 Electricity and Primary Energy Demand

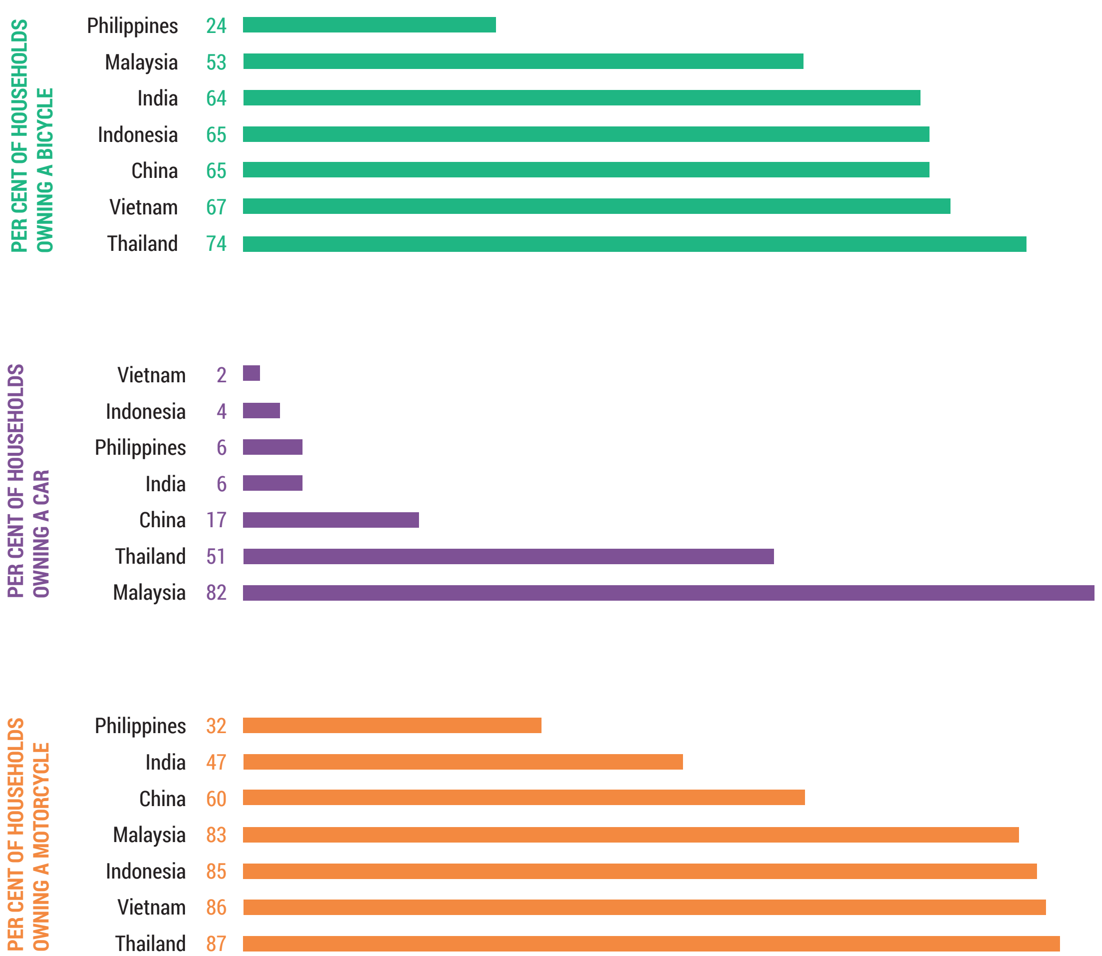
Substantial investments in energy infrastructure will be needed to ensure basic levels of electricity access across the region. **Demand among electricity consumers already connected to the electricity grid is only expected to grow as incomes, urbanization and standards of living rise. Demand will also rise as new urban residents connect to the grid for the first time (see Section 2.5).** Industrial production of iron steel, cement, wood, pulp and paper in the region are also expected to increase dramatically to support new urban demand, further fueling industrial demand for electricity. Even after taking into account existing resource efficiency policies proposed by ASEAN

FIGURE 2.5 **ASEAN Regional Electricity Supply Mix by Fuel Type** *(OECD/IEA, 2015)*

	1990	2013	2020	2040	Shares		CAAGR*
					2013	2040	2013-2040
Fossil fuels	**120**	**648**	**925**	**1699**	**82%**	**77%**	**3.6%**
Coal	28	255	482	1097	32%	50%	5.6%
Gas	26	349	406	578	44%	26%	1.9%
Oil	66	45	36	24	6%	1%	-2.2%
Nuclear	**-**	**-**	**-**	**32**	**-**	**1%**	**n.a.**
Renewables	**34**	**141**	**180**	**481**	**18%**	**22%**	**4.7%**
Hydro	27	110	119	255	14%	12%	3.2%
Geothermal	7	19	27	58	2%	3%	4.2%
Bioenergy	1	10	22	75	1%	3%	7.7%
Other**	-	2	12	93	0%	4%	16.0%
TOTAL	**154**	**789**	**1104**	**2212**	**100%**	**100%**	**3.9%**

**Coumpound average annual growth rate. ** Includes wind and solar PV.*

FIGURE 2.6 **Car, Motorcycle, and Bicycle Ownership Rates in Select ASEAN Countries** *(Pew Research Center, 2015)*



nations, **the region's total primary energy demand is projected to rise by 80 per cent by 2040 over 2013 levels, during which time the region's economy is expected to more than triple (OECD/IEA, 2015).** Only about 18 per cent of primary energy use goes toward electricity generation, indicating a vast majority (>80 per cent) of energy use occurs in ASEAN industries, addressed further in Chapter 6. Electricity demand in both the residential sector and in commercial/institutional buildings will be largely driven by increased use of appliances and demand for cooling.

While per capita direct energy use in ASEAN nations is low and projected to remain low compared to other regions of the world, the increased energy supply needed to meet increased demand in ASEAN nations will come predominantly from coal. **Even with expanded renewable energy investments, the ASEAN region will be one of only a few regions globally to see an increase in the share of coal in its electricity supply mix, rising from 32 per cent to 50 per cent by 2040 (OECD/IEA, 2015).** Coal demand is projected to triple to become the largest fuel source of the region's primary energy demand followed closely by oil. Coal will similarly be the largest source in the region's electricity supply mix. The share of cleaner burning natural gas supplies in the region's electricity mix is actually projected to decrease from 44 per cent in 2015 to 26 per cent by 2040 (OECD/IEA, 2015; see Figure 2.5). The predominance of coal and oil reflects the importance of these sectors to the ASEAN national economies, e.g., with Indonesia being a major coal supplier globally and Malaysia a leader in petroleum production. **Decisions made today about what types of infrastructure will be installed to meet future demand have the power to lock in decades-long dependence on a particular fuel source. As demand for electricity is heavily concentrated in urban areas, energy efficiency and renewable energy interventions in cities present an opportunity to make gains in reducing the region's reliance on coal.**

2.7 Industrial Growth and Resource Use

Significant amounts of construction materials, electricity, oil and gas are expected to be required in the ASEAN nations to meet demand generated by future growth, and projections indicate that many ASEAN nations will likely produce a vast majority of that coal, oil, cement, steel, pulp and paper. For example, the World Energy Outlook found that in Southeast Asia, cement and chemicals are the largest industrial energy consumers in 2013, but energy demand from the iron/steel sub-sector grows an average 5.6 per cent per year, and by 2040 is the largest energy consumer, followed by chemicals, with oil as the predominant feedstock (OECD/IEA 2015). Cement, iron and steel factories, and coal production is expected to grow in Indonesia, while Malaysia will significantly grow its petrochemical industries given its strong role in this industry. The pulp/paper sub-sector is also expected to see large increases - particularly in Thailand, Malaysia, Viet Nam and Indonesia. **Industrial growth sectors in the ASEAN are high users of fossil fuel, and hence also produce substantial waste heat and materials that are particularly suited for urban industrial symbiosis.**

2.8 Vehicle Ownership and Transportation Patterns

The ASEAN region is characterized by existing low rates of household-level personal vehicle ownership, and high rates of household bicycle and motorcycle ownership (Pew Research Center, 2015; see Figure 2.6 below). Data detailing the mode share of trips taken by non-motorized means are not widely available for the ASEAN bloc nations or individual cities. While it can be assumed that the overall share of trips that rely on personal cars or trucks may be relatively low due to low ownership rates, the high rate of motorcycle ownership and the general ubiquity of motorized taxis and paratransit vehicles (mini-buses, jeepneys, etc.) in cities across the region suggests that the overall mode share of trips that rely on some form of motorized transport is likely substantial.

Despite relatively low levels of personal car or truck ownership in the region, vehicle sales have increased significantly over the past several years as economic growth has driven rising incomes. Between 2006 and 2014, vehicle sales increased 21 per cent in Laos, 18 per cent in Indonesia, 16 per cent in Viet Nam, and 11 per cent in the Philippines (PwC, 2015). **ASEAN cities could see rising vehicle ownership rates accompanying further economic growth, as has been the case in many Chinese cities. Or they could potentially leap-frog past car-centric urbanization phases by investing in public and non-motorized mobility options, leveraging existing travel behaviours that do not rely extensively on private cars.**

The exiting culture of relying heavily on shared modes of transportation, even if still motorized, means that there is an opportunity for ASEAN cities to leverage this culture of shared mobility and potentially avoid overly car-centric future urbanization patterns, at least with respect to

FIGURE 2.7 **Annual average PM2.5 concentration in ASEAN cities year 2013-14** *(WHO, 2016a)*

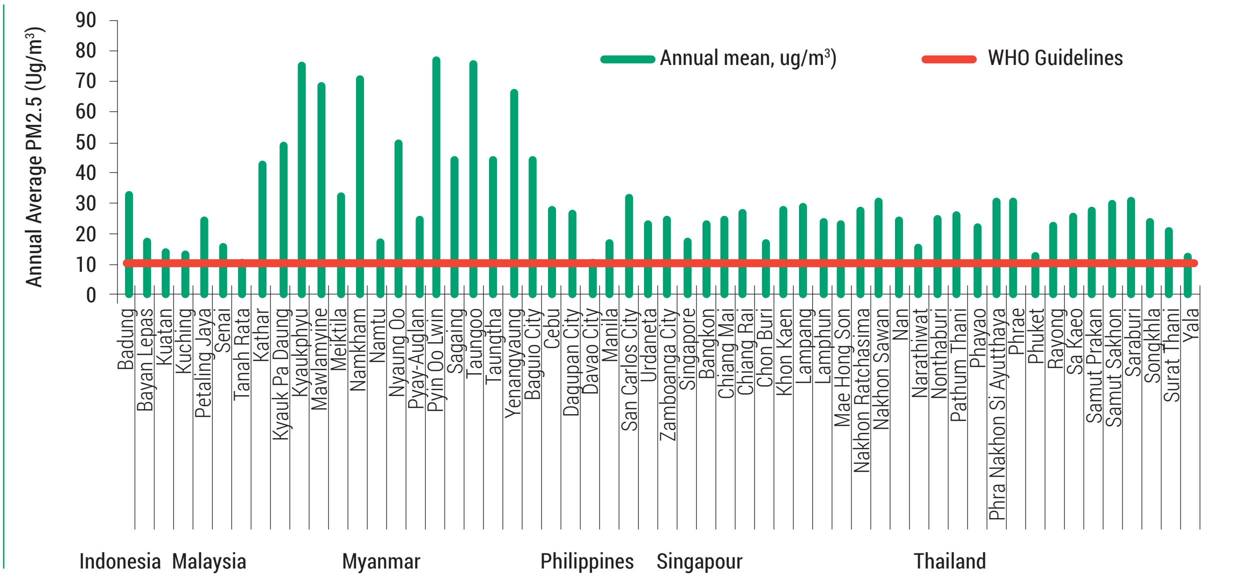


TABLE 2.7 **Top health risk factors for ASEAN countries in 2015 and years of life lost per 100,000 people standardized by age (World Bank Group, 2015). Years of life lost are calculated by starting with the highest achievable life expectancy in a given year for a given age group, then subtracting the age at which a person in that age group dies.**

	Average Years of Life Lost per 100,000 for 2015 by 17 Various Risk factors (rank is shown from 1-17 for each country)									
Top ten risk factor in alphabetical order	**Brunei**	**Cambodia**	**Indonesia**	**Laos**	**Malaysia**	**Myanmar**	**Philippines**	**Singapore**	**Thailand**	**Viet Nam**
Air pollution	141 (10)	2369 (3)	1347 (6)	3388 (2)	726 (7)	2793 (3)	2019 (4)	588 (7)	1384 (6)	1276 (5)
Alcohol and drug use	447 (7)	1328 (6)	574 (12)	865 (9)	707 (8)	1339 (6)	910 (9)	245 (10)	2398 (3)	1561 (4)
Child and maternal malnutrition	46 (13)	1376 (5)	903 (9)	3846 (1)	89 (15)	1336 (7)	1021 (8)	11 (17)	40 (17)	276 (12)
Dietary risks	2095 (1)	3108 (1)	3952 (1)	2905 (3)	2750 (1)	3063 (2)	3382 (1)	1986 (1)	3156 (1)	2701 (1)
High body-mass index	932 (5)	684 (11)	1610 (5)	830 (10)	1248 (6)	1331 (8)	1173 (7)	670 (6)	1366 (7)	460 (9)
High fasting plasma glucose	1344 (3)	817 (10)	2200 (4)	1292 (7)	1253 (5)	1585 (5)	1529 (5)	715 (5)	1708 (5)	1086 (6)
High systolic blood pressure	1472 (2)	2123 (4)	3562 (2)	2543 (5)	2500 (2)	2749 (4)	2581 (3)	1772 (2)	2257 (4)	2359 (3)
High total cholesterol	765 (6)	1014 (7)	1199 (7)	1000 (8)	1444 (4)	654 (12)	1290 (6)	869 (4)	910 (9)	650 (7)
Impaired kidney function	420 (8)	640 (12)	683 (10)	723 (11)	440 (10)	678 (11)	827 (10)	464 (8)	991 (8)	482 (8)
Low bone mineral density	36 (15)	45 (17)	58 (16)	45 (17)	55 (16)	83 (16)	30 (17)	30 (16)	138 (15)	141 (15)
Low physical activity	420 (9)	261 (14)	616 (11)	270 (14)	448 (9)	294 (14)	223 (14)	374 (9)	357 (11)	190 (14)
Occupational risks	90 (12)	355 (13)	243 (14)	322 (13)	333 (11)	545 (13)	263 (13)	123 (11)	352 (12)	407 (10)
Other environmental risks	19 (17)	63 (16)	139 (15)	58 (16)	34 (17)	165 (15)	121 (15)	85 (14)	63 (16)	93 (16)
Sexual abuse and violence	46 (14)	170 (15)	36 (17)	147 (15)	96 (14)	68 (17)	75 (16)	87 (13)	155 (14)	91 (17)
Tobacco smoke	1096 (4)	2425 (2)	2326 (3)	2895 (4)	1958 (3)	3129 (1)	2701 (2)	1199 (2)	3152 (2)	2569 (2)
Unsafe sex	136 (11)	856 (9)	412 (13)	322 (12)	166 (13)	877 (10)	288 (12)	72 (15)	890 (10)	287 (11)
Unsafe water, sanitation, and handwashing	29 (16)	863 (8)	952 (8)	1926 (6)	233 (12)	1006 (9)	660 (11)	90 (12)	305 (13)	265 (13)

personally owned cars and trucks. The growth of personal vehicle sales and increased reliance on personal vehicles for daily transportation needs could exert adverse effects on both local air pollution and traffic congestion, as it has in many cities across China and India.

While other forms of transportation beyond personal vehicle ownership are relevant for ASEAN region-wide and inter-urban connectivity dynamics—including rail, sea, and air transportation—resource efficiency in these sectors is beyond the scope of this report. However, as inter-urban connectivity both nationally and regionally is prioritized as a strategy for balancing urban growth and economic opportunity across a system of cities, resource efficiency in these transport sectors will become an increasingly important concern and should be the subject of future research.

2.9 Air Pollution, Health and Wellbeing

Air pollution ranks among the top ten risk factors causing premature mortality in all ten ASEAN nations (See Row 1 in Table 2.7). World Health Organization (WHO) data show that annual average urban air pollution levels across cities in ASEAN countries for which data are available range from 16 ug/m^3 for cities in Malaysia to a high of 53 ug/m^3 for cities in Myanmar. Two cities in Myanmar surpass levels of PM2.5 concentration of more than 70 ug/m^3 (See Figure 2.5). The lower end of this range of national averages for urban area pollution is already above what the WHO considers a safe level of air pollution at 10 ug/m^3 or below. The upper figure, while concerning and well beyond what the WHO standard presribes, is still currently below the level of severe pollution experienced in some cities in China and India, both of which have multiple cities with PM2.5 concentration levels exceeding 100 ug/m^3 (see Figure 2.7). In Cambodia, Laos, Myanmar and the Philippines, national figures for average years of life lost per 100,000 people due to air pollution in 2015 totalled more than 2,000 in each country. Indonesia, Thailand, and Viet Nam, each had national air pollution health risk figures that surpassed 1,000 average years of life lost per 100,000 people (see Table 2.7). **Economic growth and urbanization, if poorly managed, have the potential to increase ambient air pollution in ASEAN cities, indicating that ASEAN cities will need to be vigilant in protecting against a dramatic increase in air pollution levels as seen elsewhere in India and China as incomes and rates of urbanization increase.**

2.10 Water and Climate Risks

The ASEAN region has a complex relationship with water resources. Broadly speaking, freshwater scarcity is not a dominant resource concern across the region as a whole (albeit an acutely felt concern in the areas of the region where it is a concern).The largely coastal location of urban areas in the region presents an opportunity to leverage proximity to the ocean in developing sea water-fed district cooling systems. Similarly, the natural wind and breeze patterns of coastal locations can be leveraged for maximizing the passive cooling capacity of urban structures.

However, the region's strong concentration of cities in low-lying coastal areas also presents substantial risks as residents and infrastructures are exposed to the risks of rising sea levels and increasingly intense and frequent coastal storms (ADB, 2014; UNESCAP, 2015). These climate-change driven coastal vulnerabilities are compounded by the pre-existing risks of tsunamis in many coastal locations. Globally, of the ten most affected countries by climate change related extreme weather loss events between 1996 and 2015, four are ASEAN nations: Myanmar, the Philippines, Viet Nam, and Thailand (Germanwatch, 2017). That slum communities are often built in the lowest-lying and most vulnerable land of costal urban areas presents an additional challenge when considering the risk that water and climate change pose to general urban wellbeing (UNESCAP, 2015).

The water-climate adaptation link is a relevant factor to urbanization and infrastructure dynamics when considering the construction of damns, floodwalls, and regional storm surge and watershed protection systems for low-lying regions, as well as the potential need to resettle the residents of low-lying areas elsewhere in the urban region and the need to accommodate climate-change driven migrants arriving in a given city. Disaster-resilient urban construction, and better support of ecosystem services around urban areas that offer climate resilience, including the preservation of beaches and wetlands, become paramount needs in the context of increased urbanization and resource use in areas threatened by climate change. There are additional disaster risks in the region—including earthquakes and volcanic eruptions—that should similarly be taken into account when designing disaster resilient infrastructure systems. Because the region has faced climate-induced disasters in urban areas and continues to face this risk, the ASEAN experience could emerge as a 'resource center' for disaster resilient infrastructure solutions and global climate change adaptation strategies, specifically in urban areas.

2.11 Local Government Authority

Local governance authorities vary both across and within ASEAN nations. Questions of which level of government has the legal authority and/or the practical capacity to influence the governance and future development trajectories of specific infrastructure sectors of a city as a whole are highly relevant to considerations of how resource efficient urban development might be realized across the region. Based on interviews with mayors and representatives of local government associations representing perspectives from Cambodia, Malaysia, the Philippines, and Viet Nam, the study team developed a regional sample of local government authorities over broad clusters of infrastructure services and urban governance functions (see Table 2.10). While not a comprehensive sampling, the countries surveyed cover a range of development types and national political configurations revealing broad trends in infrastructure-related local authority and governance dynamics.

Cambodia

Structures are in place for collaboration between neighbouring urban areas on infrastructure projects that span administrative boundaries; local administration has control over a local pool of resources to use at its discretion to support local infrastructure projects; public private partnerships are common in the water and energy sectors; concessions for private corporations to engage in the provision of basic infrastructures services are granted at the national level; building construction and regulation is based on the physical size of a project, with projects falling to the responsibility of local, provincial and national authorities respectively as building projects graduate in size from one level to the next; technical offices for the support of infrastructure generally are operated at both the city and provincial level, with provincial authorities maintaining offices in most large cities; areas of infrastructure-relevant authority most under the control of local administrations include general planning support, municipal development, clean air, and green spaces; areas of infrastructure-relevant authority most under the control of provincial authorities include agriculture, land, and health.

TABLE 2.8 **Governing Authority and Infrastructure Sectors. Qualitative insights from survey/interviews of select government officials and multi-city representatives from ASEAN cities and nations conducted by the authors in July 2017.**

Infrastructure Sector	Local or Urban-Regional Government Responsibility (including with Public Private Partnerships-PPP)	National or Provincial Government Responsibility (including with Public Private Partnerships-PPP)
Solid Waste Management	Local authority responsibility in Cambodia, Malaysia, Philippines, and Viet Nam	National level regulation mandates solid waste management facilities in the Philippines, mandate carried out by local authorities
Public Space/Green Space	Local authority responsibility in Cambodia, Malaysia, Philippines, Viet Nam	N/A
Water/Wastewater	Local authority responsibility in Cambodia (with PPP participation), Philippines, Viet Nam	National authority responsibility in Malaysia
Buildings (construction and regulation)	Local authority responsibility in Cambodia, Malaysia, Philippines, and Viet Nam for building projects under a certain size or significance threshold	National and provincial authority responsibility in Cambodia, Malaysia, Philippines, and Viet Nam for projects above a certain size or significance threshold
Transportation (road construction and transit/ paratransit)	Local authority responsibility in Cambodia, Malaysia, Philippines, and Viet Nam for transit/ paratransit (with PPP participation) and local road construction	National and provincial authority responsibility in Cambodia, Malaysia, Philippines, and Viet Nam for inter-urban road and other transportation connection projects that cross provincial lines
Electricity (generation/distribution, or regulation of generation distribution)	Local authority responsibility in Malaysia to affect demand side consumption and conservation	Cambodia, Malaysia, Philippines and Viet Nam.
Information and Communications Technology	N/A	National and/or provincial level responsibility in Cambodia, Malaysia, Philippines, and Viet Nam (heavy reliance on PPP participation)

Malaysia
Collaboration among nearby cities is common on infrastructure projects; national and state plans are responsible for guiding large infrastructure projects that span or connect multiple cities, local governments are responsible for smaller road and infrastructure projects often requiring collaboration with neighbouring jurisdictions; there are no formal metropolitan governance structures, but the national physical committee is formally responsible for coordinating inter-city projects; the national government is responsible for provision of electricity and water supplied but local governments are directly involved in efforts to reduce consumption of each; local governments have authority to approve and regulate building projects, but other levels of government are often directly involved in carrying out building projects; local governments have authority over the rezoning of agricultural land under their jurisdiction; telecommunications infrastructures are provided by private companies, which are licensed to operate by the national government; local governments have authority over green/public spaces in urban areas and can require that certain percentages of overall floor area in a large development are dedicated to green or public space; there is generally strong local planning control but much of the local government's urban development work requires coordinating efforts across state and national level agencies.

The Philippines
Local governments can turn to national level agencies to seek funds for projects that surpass local fiscal capacity; general resources at the local level cover infrastructure concerns including roads and potable water; many smaller municipalities now feel the pressure to create programmes for urban land and housing development whereas previously it might not have been a core responsibility of theirs; electricity provision is often the responsibility of a government cooperative that operates at the provincial level serving multiple municipalities or cities; large-scale construction and building projects are often carried out by the national government but with local government counterpart support; largely private companies provide transportation services in the city, especially in smaller cities; water supply infrastructure is managed by city-specific public corporations chartered directly by local government authorities; solid waste is regulated at the national level, but local governments are responsible for carrying out the mandates in those regulations; telecommunications infrastructures are provided by private companies that are licensed to operate by national authorities; parks and green space are generally the responsibility of local governments.

Viet Nam
Established norms exist for collaboration between neighbouring urban areas on projects that span urban administrative boundaries within the same province; projects that span cities within the same province generally require provincial involvement, the Ministry of Construction at the national level is responsible for projects that span provincial boundaries including those that connect cities across provincial lines; large infrastructure projects that surpass the local government's financial resources can variously be supported by national funds, international development assistance funds, or investment from the private sector; city authorities have the authority to borrow money for investment in critical local infrastructures including water and sewer systems; responsibility for the management of electricity infrastructures services depends on the fiscal strength and overall capacity of the city; some large cities with strong local revenue streams manage their own electricity infrastructures; for cities in poorer fiscal health, provincial or national authorities need to at least partially support local electricity infrastructures; in some particularly remote and poor urban areas, the national government assumes virtually full control of providing essential services; local authorities are increasingly inviting private investors to develop key community amenities that previously would have been publicly controlled for instance commercial centres, hotels, and theatres; telecommunications infrastructures are provided by private companies; parks and green spaces within urban areas are the local government's concern; provincial authorities have to be involved for most rezoning of agricultural or forest land for industrial or urban development, national authorities will weigh in on particularly large or sensitive agricultural rezoning decisions.

CHAPTER 3
Urban Expansion, Land Use Planning, and Transportation

BOX 3.1 Highlights of Chapter 3

1. Urban land-use has two major implications for sustainable development: 1) urban land expansion overtakes rural, agricultural and ecologically sensitive areas and shapes sustainability at the level of the urban-rural continuum; 2) strategic land-use intensification and coordinated transportation planning *within cities* has the potential to substantially reduce resource use and simultaneously contribute to inclusive development within city boundaries, in turn helping to reduce pressure for outward urban expansion.

2. Strategies to manage urban land expansion include actions at multiple levels of government. National level urbanization planning and ecological boundary setting can help establish the wider contours in which more compact urban forms take shape. Economic and transportation planning across national urban systems can relieve growth pressure on existing primary (tier 1) cities and more evenly balance development across a range of cities. National governments can initiate ecological boundary setting to protect agricultural lands and ecologically sensitive areas around cities, improving sustainability along the urban-rural continuum.

3. Action at the level of an urban region should focus on anticipatory coordination of urban growth to ensure that urban land expansion is planned for rather than responded to in an ad hoc manner, in turn helping to minimize inequities borne by rural landowners in the development process, maximizing infrastructure continuity and ease of management in support of compact urban form, and providing secure and affordable housing for migrants and low-income residents in an effort to avoid peri-urban slum development.

4. For planning both within the city and at the level of the urban-region, it is important to recognize that high average density is not a meaningful policy goal unto itself, especially in the ASEAN context where average densities are already high relative to global norms. Instead, policy makers at the city and urban-regional level should foster principles of *articulated* and *accessible* medium to high density development patterns that result in resource efficient compact urban forms while mitigating negative effects of uncontrolled densification including air pollution, congestion, and traffic accidents.

5. For city-level planning actions the 5D compact city framework—density, design, diversity of use/income, distance to transit, and destination access—along with the complementary Avoid-Shift-Improve (ASI) framework offer useful paradigms for achieving articulated and accessible density. Both frameworks rely on socially and functionally mixed neighbourhoods supported by diverse land use permissions and liveable, human scale design principles emphasizing complete streets that provide lighting, tree cover, traffic controls and pedestrian friendly streetscapes. Both also rely on the availability of transit and active mobility options to access key destinations including housing, jobs centres, and educational institutions.

6. Customizing mobility and transit strategies for different city sizes is important. In medium and large cities—tier 1 and tier 2—investments in mass transit systems may be cost effective, however in smaller cities of 500,000 or fewer residents, investments in active transport modes (bicycling, walking), paratransit (shared private vehicles), and traditional public bus service may be more cost effective.

7. New vehicle futures including electric, shared and autonomous vehicle technologies have the potential to minimize growth in private automobile ownership and provide new options for sustainable mobility. Preparing for a future with new vehicle technologies, in particular electric vehicles—while being aware of the transboundary and life cycle impacts and underlying electricity grid dynamics that affect those technologies—can help cities advance resource efficiency.

3.1 Rationale and *Weight of Cities* Findings for the Global Case

The globally-oriented *Weight of Cities* report discusses two aspects of urban land expansion:

a) Urban land expansion as cities grow within a larger region, overtaking agricultural and ecologically sensitive lands and biodiversity hotspots (Seto et al., 2012), shaping sustainability and equity across the urban-rural continuum, and,

b) Strategic land use intensification within cities, to achieve compact, inclusive and resource efficient urbanization.

While distinct, both aspects are closely linked and impact resource use and sustainability both within and around cities.

Strategies to manage urban land expansion and foster compact urban form through land use and transportation planning can take shape at multiple levels of government. **National governments can take planning actions to support the broad contours in which urbanization takes shape, setting the stage for urbanization futures in which land expansion is controlled and in which compact, liveable urban forms are more readily achievable.** This can include national urbanization planning across urban systems to relieve intense growth and development pressure on primary cities, more evenly distributing that pressure across a range of cities. Investments in inter-city connectivity can also yield balanced growth benefits by reducing the importance of migration to Tier 1 cities as a necessary strategy for accessing livelihoods that revolve around commerce, trade routes, and export channels. National level action can also include efforts to set ecological preservation and urban development boundaries to protect strategically important agricultural land and ecologically sensitive areas, supporting sustainability along the urban-rural continuum. An important role of national governments is to develop institutional frameworks that enable urban regional authorities to undertake and implement master planning.

Urban-regional planning authorities can help ensure coordinated growth and urban expansion at a metropolitan scale, including developing master-planning and implementing micro or township planning schemes integrated with the master plan. Actions at this level often rely on land pooling and other mechanisms to help minimize inequities borne by rural landowners in the urban development process, maximize infrastructure continuity and ease of management in support of compact urban form, and provide secure and affordable housing for migrants and low-income residents in an effort to avoid peri-urban slum development.

Within a city, actions can be taken to support compact urban form premised on building socially and functionally mixed neighbourhoods that comprise a larger urban fabric in which key sites including housing, jobs, commerce, and education are accessible via public transit or active modes of transportation. This chapter will explicitly consider these strategies broken out according to levels of government action. All of these actions can be implemented in concert to help more sustainably manage urban growth and associated land use, looking at both trends in the outward expansion of cities as well as internal development patterns within cities.

3.1.1 Three Frames for Considering Urban Land Expansion and Compact City Development

Balanced Development across the Urban-Rural Continuum

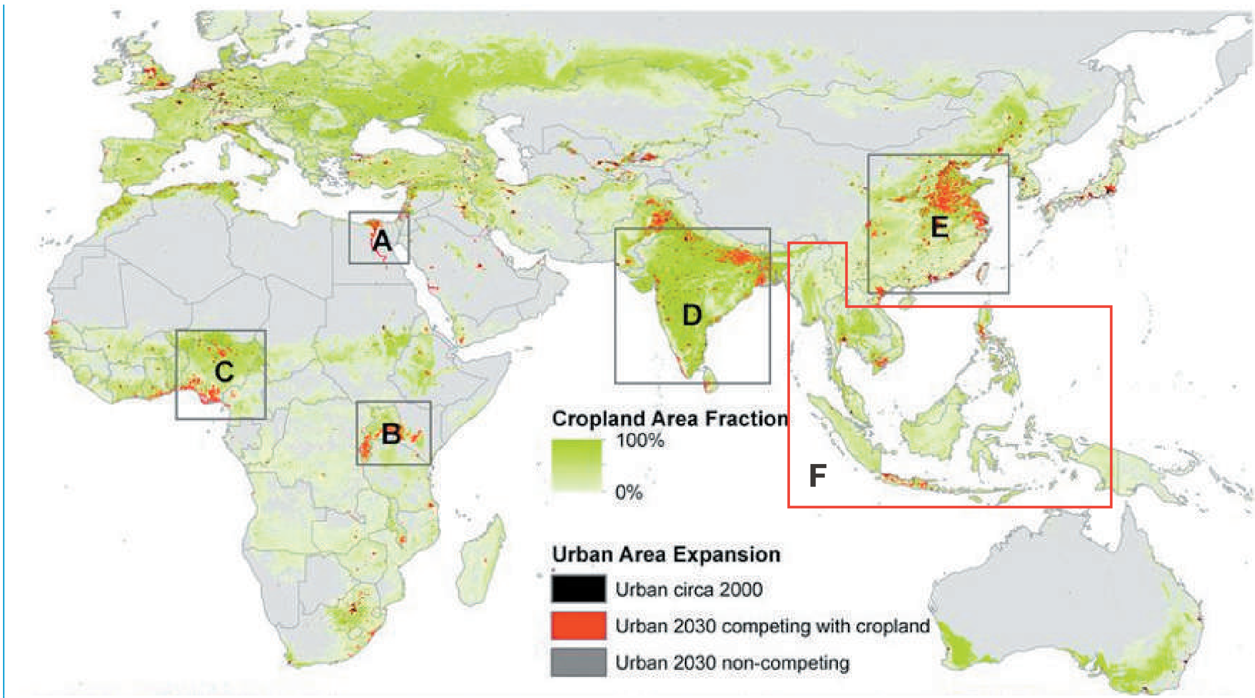
A first frame for considering compact urban form is in relation to its capacity to minimize urban land expansion impacts on rural and hinterland areas. Several studies have documented the patterns and the impacts of urban land expansion, regionally and globally. First, a number of studies have tried to assess the rate of urban land expansion compared to the rate of population growth in major urban areas (see box 2.4 for summaries of the Schneider and Woodcock 2008, Angel et al., 2010 and Schneider et.al 2015 studies), and have concluded that globally, urban land expansion is occurring rapidly, in some instances even faster than a given urban area's rate of population growth. Where this latter trend is occurring suggests patterns of *de-densification*, or less people living on more urban land per capita. In other instances, particularly in urban areas of Southeast Asia and many developing country contexts, growth patterns suggest that while land expansion is occurring at a rapid pace, it is not outpacing urban population growth, meaning that more people are living on less urban land per capita (World Bank, 2015). Here concepts such as the increase in average density help inform an understanding of the rate of urban expansion onto surrounding hinterlands. But even cities that are densifying on average as they grow, can still rapidly expand the footprint of their built up urban areas. The densification aspect of growth in these cities simply means their footprints of built up urban area are expanding less rapidly than they would be otherwise under circumstances of de-densifying growth.

Other studies have assessed the impacts of such urban land expansion specifically on agricultural lands and on biodiversity hot spots. Recent studies by Seto et al. (2012) and d'Amour et al. (2017) conclude that urban land expansion, particularly in Asia and Africa where 80 per cent of cropland loss to urbanization is expected to occur, is poised to occur over prime agricultural land, ecologically sensitive regions such as mangroves and wetlands that can provide resilience to disasters, as well as biodiversity hotspots. For example, biodiversity hot spots, particularly on island nations across the ASEAN are at risk (Seto et al, 2012), and agricultural lands in Java, India and China are at risk, in turn stressing food supplies. In the Philippines, some 4 per cent of biodiversity hot spots are at risk from land expansion. As a result of prime agricultural lands being overtaken by urban expansion, losses of over 2 per cent of total crop production in Indonesia and nearly 16 per cent in Viet Nam are anticipated. The livelihoods of rural farmers who lose land to urban expansion is also of concern, raising double-sided equity concerns, i.e. the loss of agricultural livelihoods due to rural-urban land conversion *and* the prospect of being cut out of full profit sharing in the increased value of their land as it appreciates post-urbanization. **For all these urban-hinterland challenges, understanding the *rate at which urban land expansion* is occurring (measured in the context of average densities or de-densification), as well as *where such expansion* is occurring (the location of prime agriculture and biodiversity hot spots), and *how it is occurring* are all critical to adequately managing expansion and preserving social equity along the urban-rural continuum.**

TABLE 3.1 Regional and national implications of urban area expansion on croplands and crop production
(adapted from d'Amour et.al. 2017)

Region or country	Expected cropland loss, Mha	Relative cropland loss, % of cropland	Production loss, Pcal y-1	Production loss, % of total crop production	Productivity compared to domestic/regional average
World	30 (27–35)	2.0 (1.8–2.4)	333 (308–378)	3.7 (3.4–4.2)	1.77
Asia	18 (16–21)	3.2 (2.9–3.7)	231 (214–264)	5.6 (5.1–6.3)	1.59
Africa	6 (5–6)	2.6 (2.4–3)	49 (45–52)	8.9 (8.3–9.4)	3.32
Europe	2 (2–3)	0.5 (0.5–0.9)	17 (16–23)	1.2 (1.1–1.5)	2.18
Americas	5 (4–5)	1.2 (1.1–1.4)	35 (32–40)	1.3 (1.2–1.5)	1.09
Australasia	0.1 (0–0.1)	0.2 (0.1–0.3)	0.3 (0.1–0.3)	0.2 (0.1–0.3)	0.94
China	7.6 (7.1–8.6)	5.4 (5–6.1)	137 (128–153)	8.7 (8.2–9.8)	1.53
India	3.4 (3.3–3.7)	2.0 (1.9–2.2)	34 (32–38)	3.9 (3.7–4.3)	1.61
Nigeria	2.1 (1.8–2.5)	5.7 (5–6.9)	16 (15–17)	11.7 (10.7–12.6)	1.82
Pakistan	1.8 (1.7–2)	7.6 (7.2–8.6)	9 (9–10)	8.8 (8.4–9.9)	1.22
United States	1.5 (1.4–1.6)	0.8 (0.8–0.9)	11 (11–12)	0.7 (0.7–0.8)	0.9
Brazil	1.0 (0.9–1.2)	2.0 (1.7–2.4)	10 (9–12)	2.4 (2.1–2.8)	1.22
Egypt	0.8 (0.7–0.8)	34.1 (31.6–35.8)	25 (23–26)	36.5 (34–38)	1.07
Viet Nam	0.8 (0.7–0.8)	10.3 (9.3–11.2)	15 (15–17)	15.9 (15.2–17.2)	1.41
Mexico	0.7 (0.6–0.8)	1.9 (1.7–2.3)	4 (4–5)	3.7 (3.2–4.4)	1.91
Indonesia	0.6 (0.5–0.7)	1.1 (0.9–1.3)	10 (8–11)	2.3 (2–2.7)	2.03

FIGURE 3.1 **Locations where projected urban expansion through 2030 is expected to result in cropland loss**
(adapted from d'Amour et.al. 2017)



Box A: Egypt; Box B: Uganda – Kenya; Box C: Nigeria; Box D: India; Box E: China; Box F: ASEAN (in red)

The 5D Framework for Articulated and Accessible Density

A second frame for considering compact urban form is in relation to its capacity to transform areas within cities and larger urban areas, both to reduce outward land expansion, and to enable resource efficient and equitable medium to high density urban living within cities. Achieving medium or high *average* densities, by itself, will not be sufficient to yield sustainable urbanization outcomes from either a social of resource-use perspective, taking into account connectivity, liveability, resource efficiencies and social equity objectives. Instead, the global *Weight of Cities* report emphasizes *articulated* and *accessible* density rather than *average* density. Articulated and accessible density are terms used to refer to strategic intensification efforts that emphasize high-rise, multi-use construction around transit nodes, surrounded by a density-gradient of mid-rise buildings organized in "leaf-like" street network patterns that result in human scale blocks that facilitate walking and diverse travel modes (ESMAP, 2013).

However, as the *Weight of Cities* report points out "an increase in average densities across a given space-economy may be the outcome of successful strategic intensification, but it should not be the analytical and policy focus of those intensification efforts, nor the key metric by which success is judged. Increases in density should be balanced by the need in some excessively dense cities in the developing world (e.g. Indian cities) to provide enough land per capita to achieve sustainability goals regarding issues like adequate living space per capita, connective streets, and social infrastructure".

The 5D framework for compact cities—**d**ensity, **d**iversity of use and income, **d**esign, **d**istance to transit, and **d**estination access—represents a paradigm for encouraging articulated and accessible medium to high density development patterns that are expected to reduce motorized travel demand, congestion and air pollution emissions while providing access to destinations and enhancing the liveability of cities (Cervero and Kockelman, 1997; Cervero, 2013; IRP, 2018 ; see Box 3.2). In particularly large cities, using the 5D framework to foster accessible and articulated density patterns may require poly-centric development, where one city has multiple high density 'centres.' **While density is a critical enabling component of the 5D framework, achieving high average density alone, without any integration of the other "D"s of the 5D framework, is not expected to yield sustainable urbanization outcomes.**

To help guide strategic intensification for compact urban form, UN Habitat has set a broad density target of 15,000 persons/km^2 for central city areas surrounding high-density transit nodes as a density benchmark that will help cities deliver the fullest economic, social, and environmental benefits afforded by compact urban development (UN Habitat, 2014). Across the city as a whole, at the metropolitan scale, the *Weight of Cities* report assesses the benefits of medium to high densities of 7,500 -10,000 persons/km^2 that are complemented by high integration of mobility and accessibility efforts. This aspirational articulated density target for high-density transit nodes in the central city surrounded by medium to high-density gradients across the rest of the metropolitan built up area has been incorporated into the *Weight of Cities* analysis when considering the resource reduction potential of strategic land use intensification and transportation planning for compact urban form (IRP, 2018).

The *Weight of Cities* analysis is in part responding to global de-densification trends—particularly in urban areas of advanced industrialized countries—of cities that are exhibiting density levels well below this threshold (Angel, 2010). For example. Across the 282 metropolitan areas in OECD countries for which the OECD keeps statistics, the average population density in 2014 was 711 persons/square kilometre. Only six of the 282 metropolitan areas had densities of more than 3,000 persons/square kilometre (OECD, 2014).

Considerations of urban density, strategic intensification, and compact urban form have direct consequences for sustainable urban development from a resource-use perspective. Studies in the United States show that a doubling of the 5Ds through strategic intensification can, in the best case, result in up to a 25 per cent reduction in motorized travel demand in the affected built up zone (NRC, 2009). **The global study initiated in the *Weight of Cities* report suggests that there is potential for a 50 per cent reduction in motorized demand and personalized vehicle ownership by doubling the 5Ds, however, recognizing that comparing diverse global cities is challenging (Salat, Bourdic, and Kamiya, 2017).**

While transit mobility solutions are already a core pillar of the strategic intensification and articulated density principles explored in the global *Weight of Cities* analysis, future vehicle and fuel technologies overlaid on top of compact urban forms are expected to yield even more urban resource efficiencies. The *Weight of Cities* report studied bus-rapid-transit (BRT) as one of three key socio-technical systems—in addition to district energy and efficient buildings (see Chapter 4)—that could be deployed to help enhance resource efficiency in a sample of 84 global cities. The three-system approach evaluated in the *Weight of Cities* analysis, of which bus rapid transit is a part, is estimated to result in resource use reductions between 24 and 47 per cent over a business as usual scenario. Coupling enhanced transit solutions with strategic intensification of land use yields further resource-use reductions, ranging from between 36 and 54 per cent reduction over a business as usual scenario (IRP, 2018).

The Avoid-Shift-Improve Framework for Sustainable Mobility

A third frame developed in Asia for thinking about compact urban form as it relates to transportation planning is the avoid-shift-improve (ASI) framework. The “avoid” pillar of the ASI framework is about avoiding vehicle-dependent trips in the first place by designing neighbourhoods that both enable (make it possible) and encourage (make it desirable) to access services, commerce, and other basic daily needs via walking. For destinations that cannot be reasonably accessed by walking, the second pillar of the ASI framework—“shift”—is premised on shifting those trips to public transportation or active transport modes like bicycling, rather than relying on a personal or shared motorized vehicle. Finally, the “improve” pillar of the ASI framework is concerned with improving the efficiency of motorized vehicle trips that cannot be avoided entirely or shifted to public or active transportation modes by relying on strategies such as coordinated signalling, the deployment of intelligent transportation systems, and new vehicle/fuel technologies (UNESCAP, 2012b). The “improve” pillar is also relevant to public transportation systems vis-à-vis the integration of green transit and efficiency technologies. Multiple “travel demand management” strategies can be deployed in support of the ASI framework, particularly

BOX 3.2 The 5D Framework for Compact Urban Form and Strategic Intensification *(adapted from Cervero and Kockelman, 1997; Cervero 2013)*

Density (Articulated and Accessible) - High density nodes (15,000 persons/km^2) built around transit centres in the central city surrounded by high and medium gradient densities throughout (7,500-10,000 persons/km^2) throughout the rest of the built-up metropolitan area. (United Nations Habitat 2014a; IRP, 2018).

Diversity of Use and Income - compact liveable neighbourhoods—in which people can walk or take transit to key destinations—are socially and functionally mixed neighbourhoods with a variety of income groups living in areas with diverse opportunities for jobs, commerce, leisure, and education all located nearby (IRP, 2018).

Design - the design of neighbourhood layouts and streetscapes will influence the liveability and compactness of an areas. Safe and lively streets with short distances between intersections, tree cover, accessible pathways for pedestrians and cyclists and strong traffic safety controls will encourage people to walk and cycle rather than drive (ESMAP 2014; United Nations Habitat, 2014a).

Distance to Transit - when people live within convenient walking distance to transit—1 km or less, but ideally 400-800m (Pongprasert and Kubota, 2017)—they are more likely to use it; making sure that residents throughout a city have convenient access to sustainable mobility options is a key strategy for delivering compact urban form.

Destination Access - making sure that sustainable transportation modes (mass transit, traditional bus routes, cycling and pedestrian paths) take people where they want to go is an important part of encouraging people not to drive. Jobs, commerce, housing and education are all strategic destinations that should be accessible by sustainable mobility options.

for the "avoid" and "shift" pillars of the framework (see Table 3.2).

How to best deliver the ASI framework in any given ASEAN city will depend on the characteristics (both strengths and weaknesses) of the city in question. There is no one-size fits all approach to transportation planning for compact urban form. While mass transit solutions are appropriate for many large cities, they may be out of reach or simply not cost effective for many small cities. **While the general principles of strategic intensification and articulated density continue to apply for small cities—i.e. the interconnection of high density nodes via multiple sustainable mobility options—it may be advisable for small cities to explore alternative mobility solutions in contrast to mass transit. Urban planning for complete streets and the emergence of new vehicle and fuel technologies are likely to drive many of those alternative mobility solutions.**

The purpose of this chapter is to discuss the challenges and opportunities presented by urban land expansion patterns, land use and transportation planning efforts, and future vehicle/fuel technologies for shaping the trajectory of future urban expansion, compact urban form, resource efficiency, and human wellbeing in ASEAN cities. The remaining sections of the chapter will 1) consider the existing ASEAN context with respect to urban land expansion, land-use planning, and transportation futures and 2) consider potential strategies for managing urban land expansion and encouraging compact urban form at various levels of government: national, urban-regional, and intra-city (see table 3.2). Finally, the chapter will discuss transportation planning and new vehicle futures as a relevant and inter-dependent topic intersecting with considerations of land use planning for strategic intensification in pursuit of compact urban form.

TABLE 3.2 Policy Tools for Delivering on the Avoid, Shift, Improve (ASI) Framework *(adapted from UNESCAP, 2012b)*

Policy Priorities	Type of Policy	Key Actors
AVOID		
Integrated transport and land use plans	Planning	Local, National
Managed parking	Economic, Planning, Regulation	Local, Private
Congestion/road pricing	Economic	Local
Restricted license plates	Regulation	Local
Car-free, low emissions zones	Planning, Regulation	Local
Vehicle registration tax	Economic	National
Fuel taxation/removal of subsidy	Economic	National
Removal of vehicle subsidies	Economic	National
Distance-based car insurance	Economic	National, Private
SHIFT		
Footpaths, cycle-paths, pedestrian zones	Planning	Local
Bike sharing programmes	Planning	Local, Private
Public transportation	Planning	Local, Private
Priority signalling for public transport	Planning, Technology	Local
Dedicated lanes for buses	Planning	Local
Marketing for transit and active transport	Information	Local
IMPROVE		
Vehicle efficiency standards	Regulation	National
Fuel standards	Regulation	National
New Vehicle Technology and Infrastructure	Planning, Technology	Local, National, Private
New fuel research and development	Technology	National, Private
Intelligent Transport Systems	Planning, Technology	National, Private

The authors of the table considered spheres of local, national, and private actors. Depending on the specific authorities granted to them, urban-regional governing bodies discussed in this chapter may have analogous powers to the "local" actors identified in this table.

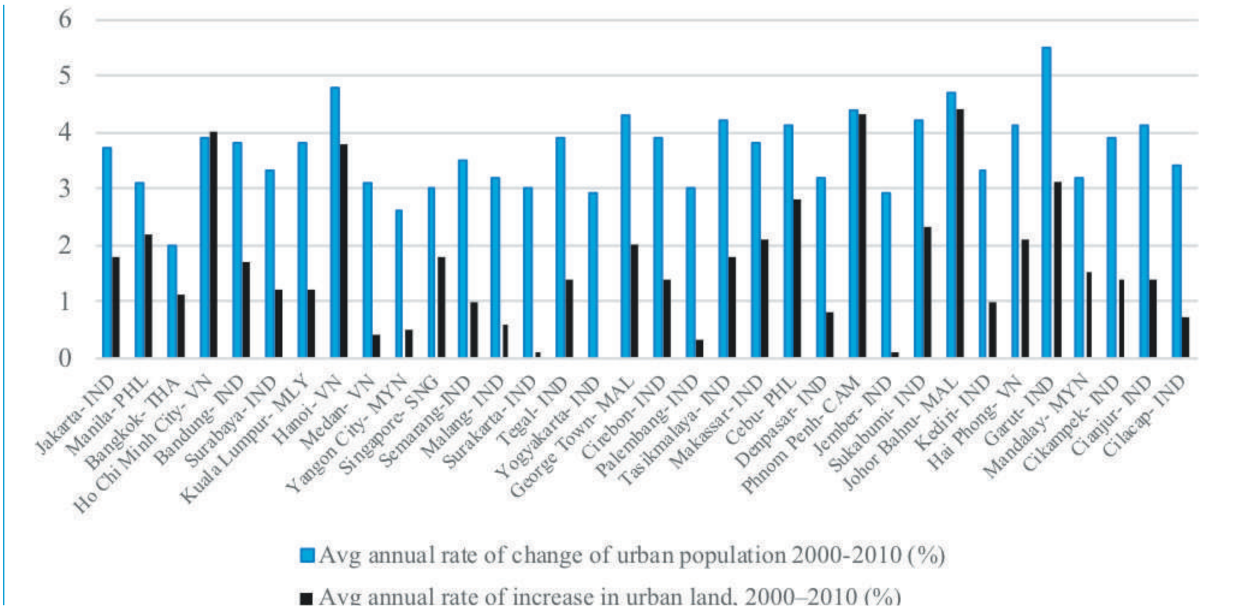
TABLE 3.3 Strategies for Urban Land Expansion Management and Compact Urban Form at Various Levels of Government

Level of Government	Strategy	Desired Impact
NATIONAL	National urbanization planning—including economic development, industrial, and inter-city transportation planning—across national urban systems of cites	• Reduced development and growth pressure on primary cities • Balanced development and growth across a national urban system made up of cities of varying size
	Ecological protection and urban development boundary setting (supported by national level data resources and/or mandated by national policy directive but often implemented by urban-regional authority)	• Reduced outward expansion of urban and peri-urban development onto rural and agricultural land • Designation of strategically important ecological sites to be protected against development
URBAN-REGION	Land pooling and readjustment for guided urban development and common infrastructure development	• Better managed urban land expansion onto rationalized and contained land parcels for more efficient development and on-going management of common infrastructure • Minimization of low-density sprawl • Decreased inequities borne by rural land owners faced with speculative development offers
INTRA-CITY	Planning for accessible and articulated density through the development of interconnected high-density nodes around transit stations surrounded by medium- to high-density and mid- and low-rise development	• Avoidance of mono-centric urban forms with ultra-high density centre surrounded by low-rise sprawl • Reduced traffic congestion • Improved access and efficiency of wide-coverage transit system
	Planning for diversity of use and income to support functionally and socially mixed neighbourhoods	• Inclusion of economically weaker sections in central urban fabrics rather than in peripheral slum settlements • Increased opportunities to live near work, commerce, education and recreation opportunities • Reduction of trips that require leaving the neighbourhood
	Leveraging neighbourhood and streetscape design for liveability, active mobility, and human scale development	• Increased desirability and feasibility of using active modes of transport—walking and biking—to complete local trips • Increased first-mile/last-mile connectivity of transit stations and surrounding medium density neighbourhoods via active transport modes

3.2 ASEAN Context Land Use and Transportation

Current urban expansion trends in ASEAN cities appear to be bucking global trends of urban de-densification. A 2015 World Bank study indicates that ASEAN cities are urbanizing rapidly, and in doing so are densifying (rather than de-densifying) relative to their population growth (See details in Chapter 2; World Bank, 2015; Schneider et al., 2015). Comparing urban population growth rates against urban land expansion rates across 34 ASEAN cities shows that in all but one city population is growing faster than urban land expansion is happening (See Figure 3.2). Instances in which urban land is expanding at a rate faster than the urban population is growing would indicate that an urban area is de-densifying. Whether these past expansion and growth trends will hold consistent moving forward is an unanswered question.

FIGURE 3.2 **Population Growth vs. Urban Land Expansion Rates for ASEAN Cities >1,000,000 in population, 2000-2010**
(World Bank, 2015)



The density of ASEAN cities is already quite high, ranging from 3,100 to 24,000 people per/km² in cities with over 1 million inhabitants (see Chapter 2, Table 2.5). Of the 34 cities in the ASEAN region with a population of more than 1 million inhabitants, 21 showed average density levels of more than 8,000 people per/km². The largest cities in the ASEAN region, Jakarta and Manila, had densities of 14,600 and 13,000 people per/km² respectively. Recent research on Chinese cities reveals that average city density may be correlated with city size as well as city typology by economic structure. For example, classifying cities by the proportion of local GDP arising from secondary versus tertiary activities, highly industrial cities (>60 per cent GDP arising from the manufacturing sectors in China were found to exhibit an apparent population cap (i.e., they did not grow larger than 2 million in population) and also had lower densities compared with highly commercial and mixed-economy cities (Ramaswami et al., 2016). Density, in general, also increased with city population within each typology: highly industrial cities, mixed economy cities, and highly commercial cities. **However, the general trends in density discussed here do not speak to the liveability or quality of life for residents living in the range of dense urban conditions represented across the ASEAN. Specifically, it is important to acknowledge the potential negative effects of poorly managed high density urban environments including: air, land, and water pollution; congestion; and traffic accidents (see Section 2.4 for a specific discussions on the potential consequences of poorly managed high densities).**

For these reasons, and to better address the broader land use and planning challenges associated with ASEAN urbanization, the recommendations of this chapter are focused on delivering *articulated* and *accessible* density, rather than simply high *average* density. The principles of articulated and accessible density provide a path forward for addressing concerns of rapid urbanization and land use as they intersect with broader challenges of liveability, air pollution, adequate infrastructure development and avoidance of slum development in ASEAN cities. In particular, as ASEAN urbanization is expected to result in the potential emergence or expansion of more than 200 new, smaller cities (<0.5 million population), the challenge of providing infrastructure in small cities and towns with little existing infrastructure becomes increasingly important as a tool for maximizing their compactness. **Thus, the recommendation for ASEAN cities is that they should not focus exclusively on high density per se, but rather on addressing the challenges caused by rapid urbanization by promoting articulated and accessible density, leveraging key strengths including an existing baseline of high density development trends and relative compactness.**

Smaller ASEAN cities and towns also offer several assets regarding vehicle use and travel behaviours. The region presently has very low automobile ownership rates (See Chapter 2). Further, as the ASEAN nations have become wealthier, the ownership of bicycles and motorcycles has increased, while automobile ownership remains very low (except in Malaysia, Brunei and Singapore). **These patterns suggest that – with the right urban planning and transit design strategies and policies – new ASEAN cities may be able to leapfrog over the current car-congested and polluted urban development patterns seen in other parts of urbanized Asia.** However, urgent and immediate actions are needed to suppress the growth of private automobile ownership by providing viable and attractive alternatives. Such measures taken early – can avoid the measures now required in many large Asian cities that are trying to reduce driving by personal vehicles. Such actions include, introducing quotas on new automobile purchases as has been rolled out in China, charging high license plate registration fees as is done in Singapore, implementing odd-even license plate number driving days as was experimented with in Delhi to combat extreme air pollution.

New and emerging fuel-vehicle technologies on the horizon—such as electric motorcycles, shared and autonomous electric vehicles, as well a new vehicle light-weighting technologies—offer compelling options for increasing mobility while decreasing resource consumption and air pollution. Currently, no city in the ASEAN region for which data are available has achieved low air pollution levels that meet the WHO PM standard for safe air, and all are grappling with transportation as a major source of pollution (see discussion in Chapter 2). **New vehicle and fuel technologies have the potential to enable different transportation and vehicle pathways than those followed by other fast-growing emerging market economies, which have often seen stark increases in personal ownership of motorized vehicles as incomes rise.**

Moreover, the cultural norms that preserve the sense of smaller communities and active transport in ASEAN cities offer examples of sustainable consumption. Preserving and replicating these sustainable transportation practices—such as low rates of personal vehicle ownership (see Chapter 2), the sharing of taxi and paratransit vehicles, patterns of bicycle usage, and large volume transit systems in the largest urban areas—offers residents a clear pathway toward sustainable mobility, thereby helping urban authorities leap-frog over car dominated cities that have proven to be so problematic in many of the larger cities across Asia.

The Asian experience clearly illustrates the interconnectedness of rapid rates of urban in-migration, land use and infrastructure planning, inclusive development, slum avoidance and rehabilitation, transportation, and air pollution (see Box 3.3). Solutions to these are all rooted in the pace of urbanization, the use of land and the design of the built environment – including the density and form of buildings, the design of transportation systems and the provision of green infrastructure such as trees and parks to enhance the liveability of cities, small and large.

Urban planning for compact form and sustainable mobility, however, requires engagement with the private sector (e.g., developers and construction industry), understanding of consumer behaviours, and efforts across multi-level government – from the national, to the urban-regional and

BOX 3.3 Key Inter-Related Challenges of Rapid Urbanization in ASEAN Countries *(World Bank, 2015)*

1. As urban populations grow, **economic opportunities need to grow to accommodate expanding labour pools**. National-level planning and coordination for economic development across a range of cities in a nation can alleviate the migration-driven job pressures, particularly in large cities that often are unable to cope with the very rapid population expansion and attendant infrastructure needs.

2. Unplanned and **unmanaged urban land expansion can reduce total availability of agricultural land** and degrade the critical ecosystem surrounding non-urban land functions can offer cities. As seen in recent flooding events in Chennai, infilling of natural water bodies and loss of wetlands contributes to the intense flooding events that resulted in loss of life and economy. Such ecosystem services are particularly relevant to ASEAN urban contexts given their water-related risks.

3. **Urban land expansion onto peri-urban and rural agricultural land can also impact rural livelihoods and drive urban-rural inequity**. New approaches like land pooling and town planning have emerged in India to address this challenge, a challenge that ASEAN urban areas are also likely to face.

4. Development of **urban infrastructure often cannot keep up with the pace of population growth** in the fastest growing cities, resulting in uncoordinated or insufficient infrastructure provision that drive the prevalence of:

    a. Large informal settlements and slums that provide shelter (often of poor quality) to the urban poor and to migrant workers;

    b. Segregated and wealthy gated townships develop outside of the city's boundaries, increasing inequality, spill over, and fragmentation while still drawing upon and benefitting from the core city's infrastructure base.

5. **Infrastructure-environmental risk factors such as pollution and climate-change are correlated with increased density**. Air pollution not only arises from human driven sources within the city (transportation, cooking, waste burning, industrial burning and construction), it also is wind-blown transport from PM2.5 from agricultural waste burning, forest fires and other sources outside cities.

6. **Governance challenges across sectors and geographical scale arise** both in financing new infrastructure and managing infrastructure, as well as in the provision of environmental and urban services.

intra-city planning levels. Thus, the next section organizes case study discussions as:

a) National Urbanization and Ecological Protection Policies
b) Urban-Regional Long-Term Planning
c) Intra-city Planning for Compact City and Liveable Streets
d) Customizing Transit for Different Cities
e) Travel Behaviours, New Technologies and Vehicle Futures

The case studies draw upon examples from ASEAN nations, and analyses of best practices emerging from China and India.

3.3 National Urbanization and Ecological Protection Policies

There are policy actions that national government authorities can take to help shape the general urban system of cities and the larger national context in which the urban development of individual cities takes shape. Because cities are nodes in larger national systems of primary, secondary and tertiary cities, and as their futures are often intimately tied to the fortunes of the peri-urban and rural land that surrounds them and provides them with critical ecosystem services, often national authorities are well positioned to provide macro-level data guidance and framing to help ensure that urbanization dynamics across a nation are sustainable. **National economic development and corridor planning across cities of different sizes and policy directives (with the provision of accompanying resources) for urban-regional development authorities to establish urban development boundaries to protect ecologically important land are two key examples of national policy actions that can help shape sustainable urban forms and economies**.

By coordinating urban economic development policy at a national level and pursuing strategic inter-urban infrastructure connectivity investments, policy makers can help promote balanced urban growth and the development of industries that are the most appropriate in a given urban area. National urbanization plans should incorporate policies that promote the growth of industries best suited for the city size and include a portfolio of activities suited for larger cities, given the plans will need to adapt as the cities grow. **Yet, planning economic development of cities can be challenging and national authorities should be conscious of avoiding investment strategies that result in 'ghost cities', or urban areas in which substantial investments in infrastructure and industry are made, but which never result in the development of local industry or strong urban population growth.** Similarly, national urban economic development planners should be wary of strategies that encourage excessive competition and "race to the bottom" dynamics between cities as they compete for private development interest.

3.3.1 Economic Development Planning Across Cities of Different Size

Rapid urban population growth rates place immense pressure on infrastructure and often cities facing very rapid growth rates are unable to cope, resulting in inadequate infrastructure and slums to house poorer migrant labour. In such cases, an economy may not be well positioned to absorb substantial growth in the urban labour market. National urbanization plans can incorporate policies that promote the growth of urban industry best suited for particular city sizes and types. Such plans should account for the fact that the portfolio of economic activity and industry best positioned to support a regional urban economy will vary, at a minimum, based on the location, size, and physical configuration of the city in question. **Generally speaking, large cities tend to be more economically efficient if they focus on services and high-technology manufacturing. Small and medium-sized cities tend to be more economically efficient when they specialize in lower-technology manufacturing and agriculture-related industries (Lall and Wang, 2012).**

3.3.2 National Ecological Preservation and Urban Boundary Setting Requirements

Unplanned urban growth and expansion beyond urban boundaries generally does damage to all residents of the urban area and the region, although to varying degrees, as it encourages sprawl and resource use inefficiencies. Economies of scale dissipate with respect to infrastructure investments and maintenance costs when de-densification occurs. Allowing growth to occur outside of urban boundaries becomes an especially damaging concern when that growth takes the form of wealthy enclaves that are allowed to benefit from the urban-regional economy and the effects of agglomeration, but are allowed to disconnect themselves from the urban systems and structures of service provision that support that larger regional economy.

National authorities can work to establish policy directives and place a national cap on the total area of land that can be urbanized. Regional or national caps on urbanization can then be coupled with individual urban development boundaries and limits implemented by urban-regional development authorities that correspond to the needs and conditions of specific urban areas. **National policy-makers can require that urban-regional authorities set urban boundaries and ecological red-lines, which can be powerful policy tools for promoting guided urban development at a macro scale. However, the specific limits and boundaries that eventually take shape around cities need to be based on rigorous analysis and consideration of the spatial and economic development realities of the individual cities that will be affected by such boundaries or caps.** Robust national databases of city and urban area-specific statistics regarding population growth, economic development, physical expansion patterns, surrounding high value lands and other data points can help inform a process of setting urban boundaries that strikes a balance between compact urbanization—thereby protecting agricultural and ecological lands—and allowing for necessary flexibility in terms of both accommodating population growth and economic development.[3]

BOX 3.4 Economic Development Corridor Planning in Singapore and Johor, Malaysia

The South Johor region of Malaysia has emerged as an important electronics manufacturing hub over the last several decades as national economic development authorities in Malaysia have invested in local industrial infrastructure and stronger linkages with nearby Singapore. Johor has benefitted from this proximity to Singapore and has attracted lower-wage electronics manufacturing functions that the substantially higher waged economy of Singapore is no longer well positioned to support. The two economies complement each other and form the basis of a strong global centre of electronics development and manufacturing. Malaysian authorities have been investing in this outcome over decades to develop industrial manufacturing capacity in the Johor region, **to create special trade conditions that facilitate cross-border exports and to establish physical road and rail linkages to encourage connectivity between the two hubs**. The 'symbiotic' relationship between Singapore and Johor is an example of cross border economic planning and coordination that takes advantages of the relative strengths that each urban area has to offer, recognizing that urban areas of different size and development status have different assets and opportunities to leverage (Best, 1999; Ho, 2011; Yusuf, 2007).

BOX 3.5 Urban Development Boundary Policies in China

To ensure valuable agriculture land is not depleted during urban expansion, national authorities in China are working with specific cities to implement urban development boundary (UDB) policies or 'red line' policies. The red line policy limits the amount of agriculture or cultivated land that may be urbanized. The purpose of the policy is to protect ecologically fragile regions and important agricultural production areas, and to limit unplanned urban sprawl. New data tools are emerging to support the delineation of city-specific urban development boundaries in ways that are consistent with agricultural and ecological preservation needs as well as housing and urban development needs (Zhuang, 2017). The UDB policy tool defines three controlling boundaries: ecological protection lines, permanent basic agriculture/farmland protection areas and urban development boundaries. China's red line policy limits the total amount of cultivated or agricultural land that can be urbanized by 2020 to 1.2 million square kilometres (Tan et al., 2014), which is considered to be the minimum necessary standard to ensure food security. In addition, starting in 2009, the policy limited the amount of agriculture land that could be converted to urban developments to 1,152 square kilometres a year. While the policy is incorporated into China's planning system, **the UDB as a policy tool is still in the trial period**. Its implementation requires substantial coordination at both local and national levels to ensure that the appropriate balances are struck.

Starting in 2014, the UDB policy was piloted in 14 Chinese cities, including Beijing, Guangzhou, Shanghai and Xiamen. The UDB policy for Xiamen City was implemented as part of a larger plan for economic growth, social development, urban and land development. Xiamen City delineated boundaries between ecological zones, **a buffer to the ecological zones and urban spaces. China is planning on continuing to use red line and UDB policies for urban planning**. An April 2015 report entitled 'Opinions of the CPC Central Committee and the State Council on Accelerating the Ecological Civilization Construction' stated there was a further need for UDBs and a need for more stringent rules for the supply of urban land for development.

3 Urban development boundary (UDB) policies are an example of a policy that can take shape across multiple levels of government. In some instances, they may be nationally mandated and locally implemented. In other instances, they may be locally mandated ***and*** locally implemented. While UDBs are just one example, across the ASEAN region, specific policy responsibilities and relevant jurisdictions may vary by level of government from country to country. The analysis presented in this document regarding the relevance of specific policy tools to specific levels of government should be read as illustrative, rather than definitive across all contexts.

3.4 Urban and Regional Long-term Planning

Urban-regional authorities—governance bodies that span the multiple city-level jurisdictions of a metropolitan area—have a key role to play in coordinating growth and development trajectories at the level of urban agglomerations. These bodies should be equipped to take a larger urban-regional view of an urban area, effectively examining the component parts of that urban area and their collective impacts. Where such urban-regional planning authorities do not currently exist, they should be established, and where they do exist, they should be empowered and strengthened with additional formal authority and resources. Specifically, urban-regional bodies are well positioned to think proactively about how best to guide future development in a way that benefits not just the interests of a single municipal jurisdiction but rather the urban-region as a whole. For example, urban regional authorities can use land pooling and other tools for guiding development to ensure early infrastructure and inclusive development planning, improving standards of living across the region through enhanced service provision, while also ensuring that uncoordinated urban expansion does not unnecessarily threaten agricultural and other natural resources that support the security and resilience of the urban area as whole. Guided development at this level helps avoid infrastructure and service provision deficits and can dramatically reduce the need to undertake costly remediation efforts to undo the consequences of unguided, haphazard development patterns and overburdened infrastructure systems.

3.4.1 Land Pooling for Guided Development

Taking an 'urban-region' approach to development planning can allow for a higher-level consideration of how best to maintain workable equilibriums between urban land expansion and rural land absorption and degradation. This type of approach is also often referred to as guided urban development planning and can be aided by an instrument known as land pooling. Generally speaking, **urban expansion and infrastructure development can be more efficiently coordinated and contained within defined expansion corridors or zones when developers and planners can be certain that that they have a large and dedicated contiguous parcel of land to work with**. In contrast, uncoordinated development and expansion into rural areas can lead to sporadic, opportunistic, and unconnected urban development pockets that emerge based on where developers are able to find individual land-owners willing to sell parcels for development.

Land pooling is a mechanism by which local governments can work with peri-urban and rural land owners to aggregate land parcels, with individual property owners sacrificing as much as 40 per cent of their overall land holding for the purposes of supporting the development of common infrastructure. In exchange, landowners retain ownership of their remaining share of land and and are able to share in the profits of rising land values as infrastructure is installed, making development more valuable. The process provides a more attractive and profitable overall parcel for development, while containing urban development and infrastructure development to confined zones and helping rural land owners maximize the profits they gain from guided urban expansion. The process also avoids local governments having to rely on contentious eminent domain processes for acquiring land. More specifically, the benefits of land pooling include: (1) rural land owners do not lose the value of their property; (2) more efficient infrastructure can be built; (3) the cost of the infrastructure reconfiguration is recouped through the sale of land, typically for commercial use or residential development; and (4) additional land is made available for urbanization. Land pooling schemes have faced challenges and criticism over lengthy project processes, a lack of transparency that can lead to a gaming of the system, unmet landowner expectations, and lack of recourse for informal settlers who are unable to lodge claims if they are settled on land this is slated to be pooled (IDFC, 2010; Sanyal and Deuskar, 2011). Land pooling is already being used in urban contexts across Asia, including in India, Japan, Korea, and Thailand (see Box 3.6 for an example from the Indian context).

3.4.2 An Urban-Regional View of Slum Avoidance and Upgrading

Planning for the resettlement or upgrading of existing slums (mitigation) and planning to create the necessary infrastructure and housing resources to avoid slum development in the first place (avoidance) are fundamentally different tasks, as the former is based on retrofitting, while the latter is based on prevention. However, from a urban-regional strategic planning perspective there are key choices that will have to be made in either type of project about their location within the metropolitan area and their degree of connectivity with important assets within the city—services, job centres, commerce, education etc.—that have implications for urban form, material and natural resource use, and social inclusivity. **As a first principle, from an urban-regional planning perspective, policy makers should avoid programmes and policies that push economically weaker sections and new migrants to the periphery of urban areas.**

Slum resettlement and avoidance efforts (in contrast to *insitu* slum upgradation) should take into account the location of new sites relative to the layout of key assets across the metropolitan area, with a specific focus on access to employment centers for the poor and working

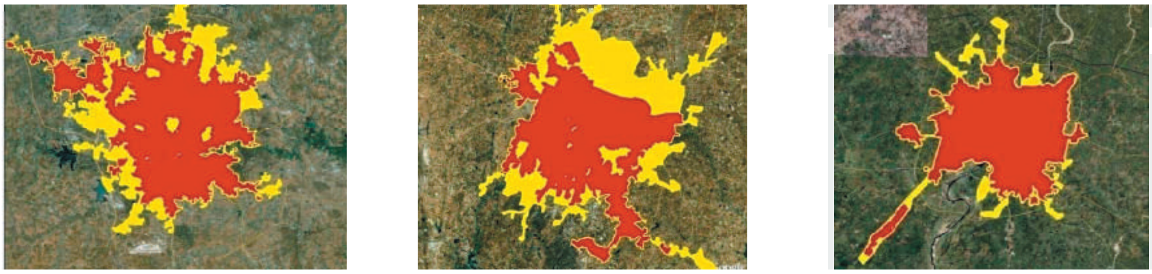
BOX 3.6 Land Pooling and Town Planning Schemes in India

The Ahmedabad Urban Development Authority (AUDA) of Ahmedabad, India, has been proactive about incorporating land pooling as part its long-standing town planning schemes to guide urban development and expansion. The Gujarat Town Planning and Urban Development Act of 1976 is the relevant state-wide urban development statute governing town planning schemes in Ahmedabad and it includes specific provisions for land pooling practices in the state. The process ensures that property owners continue to own the land and thus are able to share in subsequent increases in the land's value. This is in contrast to land acquisitions for which property owners are directly compensated by the state, either through willing sale or eminent domain proceedings (Rasheed and Parambath, **2014). The results of Ahmedabad's efforts to use land pooling as part of larger town planning schemes are evident in the relatively compact urban form the city has achieved when compared to other cities in India (see Figure 3.4)**. Ahmedabad has minimized sprawl and driven higher relative densities even in areas that are considered outside of the built up urban area of the city as shown in the images below.

In a variation on traditional land pooling practice, the Delhi Development Authority (DDA) has assumed the role of facilitator for land pooling arrangements that match private sector developers with groups of landowners in designated urban expansion zones (KPMG, 2013). In 2017, **the DDA designated 89 'villages' on the periphery of the city as 'urban zones' that will be targeted for infrastructure development under the DDA's land pooling policy**. The move is being billed as a way to accelerate efforts to meet housing demand, help correct for basic infrastructure deficits, prevent the development of 'unauthorized colonies,' and to grant farmers and rural landholders greater flexibility in land dealings (Times of India, 2017).

FIGURE 3.3 Urban Form across Indian Cities *(used with permission, Munshi, 2015)*

HYDERABAD (760 sq.km)	BANGALORE (853 sq.km)	AHMEDABAD (344 sq.km)



	HYDERABAD	BANGALORE	AHMEDABAD
Population Density (Urban Built in persons/sqkm)	10526	9378	17441
Population Density (Urban Sprawl in persons/sqkm)	6265	5869	15574
Compactness index	0.60	0.63	0.90
POPULATION (MILLION)	**8.0**	**8.0**	**6.0**

class. The relocation of existing slum settlements or the construction of new social hosing on the far outskirts of a city where land might be cheaper, is not a viable solution for resource efficient infrastructure provision. Such efforts drive patterns of sprawl and place costly time and financial burdens on the poor in terms of commutes they are forced to undertake to access livelihoods. A large literature has shown that when slum residents are resettled on the periphery, they often re-migrate to the city centre and end up living in highly vulnerable and disaster-prone areas, in many instances in more vulnerable conditions than prior to resettlement. The dynamics of peripheral sprawl and longer commute times associated with social housing that is constructed in the far reaches of an urban area have explicit resource use implications for the urban area as whole, before even considering the negative social and economic consequences of such development patterns. For these reasons, ***insitu* rehabilitation or resettlement of slum residents at very nearby sites already within the city centre are more desirable outcomes than peripheral accommodation of both new social housing and resettlement efforts for existing .**

However, efforts to accommodate new economically weaker sections or the resettlement of existing slum residents in the central urban fabric, generally require turning to multi-storey high-rise housing development given high demand for land in city centres. These types of centrally positioned new social housing and resettlement efforts can be supported by entering into developer rights agreements that use land pooling and readjustment to allow for the redevelopment of very valuable centrally located land currently occupied by low-rise slum settlements in exchange for providing housing to the residents of those slum settlements within the new development. In India, examples of this approach have taken shape in which the onus is put on developers to work with local civil society organizations to reach a threshold of community consent before development can proceed, ensuring a certain degree of community buy-in and enhancing the political viability of the project. This type of arrangement works best when a developer is able to accommodate residents on a relatively small portion of the total land that was previously occupied by the slum settlement (usually by means of relocation into multi-storey housing) and is allowed to profitably redevelop the rest of the valuable land for market-rate commercial and residential purposes (Zhang, 2013). **Multi-story construction not only frees up centrally located land that can be used to finance *insitu* or very nearby slum-rehabilitation, but it is also estimated to be some 30 per cent more resource efficient than single-story housing construction, when considering material requirements for initial construction (Nagpure et. al. 2018).**

3.5 City-level Planning for Compact Urban Form and Complete Streets

Investments inside the city that enhance the liveability of high-density, resource efficient environment are key to not just making those urban forms more sustainable with respect to resource use, but are also key to making them desirable, healthy, and inclusive places to live. **Planning for compact cities and complete streets requires making investments in the 5Ds discussed earlier—density (people, housing, and jobs), diversity of use, multi-modal design, distance to transit, and destination access. Similarly, planning for compact urban form can help advance the ASI framework for sustainable mobility: Avoid, Shift, Improve.** The "avoid" pillar of the ASI framework is directly impacted by intra-city planning for compact urban form and complete streets.

3.5.1 Planning for Accessible and Articulated Density

With respect to the first "D"—density— of the 5D framework, simply concentrating more people in less area will not provide a solution to the concerns of resource inefficient urbanization. Part of the challenge of developing more compact urban forms is to make life at relatively high densities fundamentally desirable, mitigating the negative effects of urban density including air pollution, congestion, and traffic accidents. Achieving a high level of average density does not tell an observer anything about what life is like at a given level of density. The goal instead should be to strive for accessible and articulated high and medium density urban forms: with 15,000 persons/km^2 representing a minimum density target for central city transit oriented development nodes, surrounded by lower-rise medium to high density areas of 7,500 to 10,000 persons/km^2 (IRP, 2018). In addition to population density, planners should be cognizant of jobs and housing density as well. In urban areas with one central area of high density development surrounded by large swathes of low-density development, commute times are longer, congestion in the central area can be substantial, and there can be a general imbalance or lopsidedness in the distribution of residences, places of employment, etc. **Articulated density makes reference to the idea of multiple nodes of high density development interspersed throughout a city, also referred to as poly-centric development, connected via transit lines and surrounded by various gradients of medium and low density, as being a more efficient and liveable urban configuration.** Accessible density is premised on the easy availability and accessibility of services, employment, commerce, and amenities within walking or transit distance. **Accessible density has the power to influence resource efficiency and liveability in cities by creating urban environments in which the logical and desirable choice is to walk, bike, or travel by transit to reach amenities, services, jobs, commerce, etc. (ESMAP, 2014).**

3.5.2 Planning for Diversity of Use and Income: Making Room for Socially and Functionally Mixed Neighbourhoods

The second "D" –diversity of use— of the 5D framework helps ensure that density is not simply articulated but also that it is accessible by ensuring a mix of uses and affordability in any given ward, district, or neighbourhood of a larger urban area. Policies that zone central city areas for multiple uses and mixed affordability can encourage a robust mixed-use district that is home to a variety of housing stock types, businesses, service providers, and employment opportunities. **Specific floor area ratios requiring that shares of an overall development are dedicated to different uses and affordability thresholds can help provide formal development requirements that ensure a diversity of uses and incomes in different neighbourhoods across a city (ESMAP, 2014).** Similarly, land pooling and town planning urban expansion schemes, as used in Ahmedabad (see Box 3.6), can be used to specifically designate portions of an overall development for economically weaker sections, ensuring their partial inclusion in all new development.

Across much of the ASEAN context, there already exists an established pattern of urban life characterized by mixed use environments. In many instances, it is more a question of improving the connectivity and liveability of mixed use spaces in ASEAN cities. **The challenge will be to encourage**

development patterns that maintain this existing culture of mixed-use urban development in which people live and work in relatively close proximity and are able to access basic services and commerce in their immediate vicinity. Being able to find economic opportunity and work close to where one lives is particularly important for the urban poor and those who live in informal settlements or slum communities. The urban poor are disproportionately affected by high daily commuting costs relative to their incomes. For this reason, efforts to undertake *insitu* slum upgrading and rehabilitation—as opposed to the relocation of economically weaker sections to the periphery of an urban area where land might be cheaper—pay both social and environmental/resource-use dividends as sprawl and daily commutes are limited and as travel burdens on the working poor are lessened (see Box 3.7).

3.5.3 Leveraging Neighbourhood and Streetscape Design

The third "D"—design— of the 5D framework is a critical building block for the 5D framework as it directly enhances the ability of urban residents to benefit from the advantages of dense areas that are characterized by a diversity of uses. Specifically, design of the streetscape can be used to influence the level of pedestrians and other non-motorized modes of transportation. **Bad design can act as significant barrier to accessible density if the existing streetscape makes accessing the benefits of diverse, mixed use areas difficult. Design barriers include poor connectivity of sidewalks, long intervals between intersections, no traffic control measures, lack of tree cover, the presence of imposing super blocks, and excessively set back buildings, among others (ESMAP, 2014; UN Habitat, 2014).** Design is often the linchpin that makes realizing principles of "accessible density" possible. Thousands of people may live in a high rise, but if it is isolated from its surrounding urban fabric as a function of bad site or street-network design, the density gains that such development represents for overall compactness of urban form, sustainable mobility, and resource efficiency will be substantially negated.

The goal of using design to enhance accessible density is to yield similar levels of population density, while avoiding the phenomenon of isolated super blocks. To this end, urban areas can implement complete street policies and design guidelines to ensure that liveability and resource efficiency considerations are taken into account when developing new—or retrofitting old—building sites and streetscapes. **Traditional "old city" neighbourhood layouts and streetscape characteristics that were designed around vernacular building architectural styles (rather than contemporary glass and steel high-rise construction) may offer important design cues about how best to foster culturally and climatically appropriate**

BOX 3.7 Modal Share and Distance of Urban Work Commutes in India

Traditional urban development patterns in cities across India have supported conditions under which walking to work is feasible, **as average distances to work are relatively short (less than 5km)**. There is a concern that North American models of single use, suburban style sprawl are now being adopted, resulting in urban expansion in Indian cities. The cost of commuting is a particularly important consideration for the urban poor, who, in Indian cities tend to live closer to where they work than the non-poor as a way to minimize that cost burden. In this light, efforts to resettle the poor to the urban edges places additional burdens and costs on an already vulnerable population (The Hindu, 2015).

In India's **five largest cities, with the exception of Mumbai, walking is the** most common way to commute to work. In Mumbai, walking is tied with taking the train as the most common mode for work commutes, with each travel mode representing 31 per cent. Kolkata is the city with the largest share of workers who commute to work by walking, at 39 per cent. Nationwide, nearly a quarter of non-agricultural workers walk to work. What is more, regardless of mode, over half of all non-agricultural workers have a commute that is less than 5 km (Census of India, 2011). Compact and mixed-use urban design can maximize the nearby co-location of housing and jobs, thereby laying the foundation for the possibility of walking to work. Complete street design principles are an additional factor that affect the desirability and feasibility of walking to work.

BOX 3.8 Regulated Mixed Use and Mixed Income Development in Singapore

Singapore urban development authorities have taken a hands-on approach to ensuring that new development within the city, **especially when it comes to the development of new 'townships' or dense wards of mid and high-rise tower blocks in the city, adhere to mixed use development principles**. Authorities have prescribed highly specific design guidelines that dictate variation of building heights, housing supply variety across affordability categories and a 400 metres radius in which certain basic amenities and services ought to be made available, including: markets, schools, clinics, eating establishments and restaurants. The goal of such effort is to develop 'self-sufficient' districts in which residents have easy walking access to shared amenities and basic services. This approach has resulted in the development of compact urban forms, highly walkable neighbourhoods with strong amenity access, and a reduction of traffic congestion in central areas of the city (Centre for Liveable Cities, 2013).

BOX 3.9 Regulated Mixed Use and Mixed Income Development in Singapore

Mega blocks, **or super blocks, are oversized street blocks with long distances between intersections and are often limited in terms of land use allowances**. Mega and super blocks exist in contrast to more fine-grained street grid systems with shorter distances between intersections, often characterized by a diversity of mixed land uses (commercial, residential, etc.) (ESMAP, 2014).

configurations of compact urban form for a given ASEAN city (ESMAP, 2014).

TABLE 3.4 Articulated and Accessible Density Urban Design Guidelines for Avoiding Mega Blocks

Feature	Characteristics	Minimum Parameters
High Density Transit Nodes	Immediately surrounding transit station	15,000 persons/km^2
Mid to High Density Neighbourhood Gradient	Neighbourhoods areas interspersed between high density transit nodes	7,500 – 10,000 persons/km^2
City-Wide Transit Access	Widely available transit station access throughout city linking housing, jobs, education, and commerce.	<1km distance, preferably 400-800m
Green Space Access	Neighbourhood parkland and open space	0.5-2 hectare site within 300m
Human Scale Blocks (No Mega Blocks)	Block design that is walkable, proportionally scaled, with frequent intersections and reasonable building setback in contrast to mega block design	<150 m between intersections, 100+ intersections per km

Sources: United Nations Habitat 2014, WHO 2016c, Pongprasert and Kubota 2017, ESMAP 2014

3.6 Customizing Transit and Mobility for Compact Urban Form in Different City Types

A key feature of future ASEAN urbanization is the potential emergence and growth of 200+ small cities, along with growth in existing Tier 1 and Tier 2 cities (see ASEAN context discussion in Chapter 2). In addition to size, cities may also be classified in terms of their economic structure as highly industrial, highly commercial and mixed-economy. Based on studies of Chinese urbanization, industrial cities are likely to be smaller in size (Ramaswami et al., 2016). Smaller cities are also less likely to have a large revenue base to finance large transportation projects, and, they may not be needed, either. Table 3.5 illustrates the various ways for understanding the costs and capacity benefits of various forms of transportation infrastructure investments (ADB, 2010). Figure 3.7 illustrates the level of investments per kilometre of mass transit type (United Nations Habitat, 2013), indicating that Metro projects are by far the most expensive. The cost-benefit calculation for specific transportation and mobility investment strategies should realistically take into account both city size and economic development status (UNESACP 2012; see Figure 3.6).

Keeping these considerations in mind, transportation planning across diverse ASEAN cities will require differentiated strategies appropriate for cities of different size and function. While mass transit investment in medium and large cities is often cost-effective, it may not be in smaller cities where a combination of traditional public bus service, active transportation modes, and para-transit through shared vehicles could provide widely accessible sustainable mobility opportunities. A recent report by the World Resources Institute indicates that: "Small cities less than 50 square kilometres in area do not require heavy public transportation investments; investments in active modes would be more appropriate. By contrast, medium and larger cities require investments in public transportation and should consider concentrating development along transit corridors" (Shastry and Pai, 2016). Active transportation modes such as walking and biking are also still relevant mobility strategies in larger cities, particularly when it comes to first km/last km connectivity between key destinations and transit stations. The following discussion provides some insights on enabling strategies for sustainable transportation in different city sizes.

The first three 'D's of the 5D framework—density, diversity of use/income, and design—discussed in the previous sections are key land use and city planning considerations that impact compact urban form. The final two 'D's of the 5D framework—distance to transit and destination access—rely on customizing transportation and mobility options that are appropriate for the needs and resources of a given city in order to build and complement investments made in the name of the three previous Ds. While the trip *avoidance* pillar of the ASI framework is a key desired outcome of compact form and complete streets (emphasized when considering the first three 'D's) enabled by better city planning, **the *shift* pillar of the ASI framework—shifting vehicle trips to public transportation modes—is directly linked to how well cities are able to develop customized transportation and mobility solutions, essentially how well they deliver on the final two 'D's of the 5D framework—distance to transit and destination access.**

FIGURE 3.4 Developing Accessible Density by Avoiding Super Blocks *(ESMAP, 2014)*

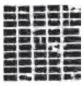
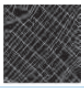
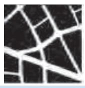
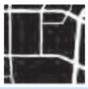
	Turi, Estonia	Barcelona, Spain	Paris, France	Ginza, Tokyo	Pudong in Shangai, China	Towers North in Beiging, China
						
Intersections per km^2	152	103	133	211	17	14
Distance between intersections (m)	80	130	150	43	280	400

FIGURE 3.5 Transport Policy Vision and Strategy for Different City Sizes and Economic Status *(UNESCAP, 2012b)*

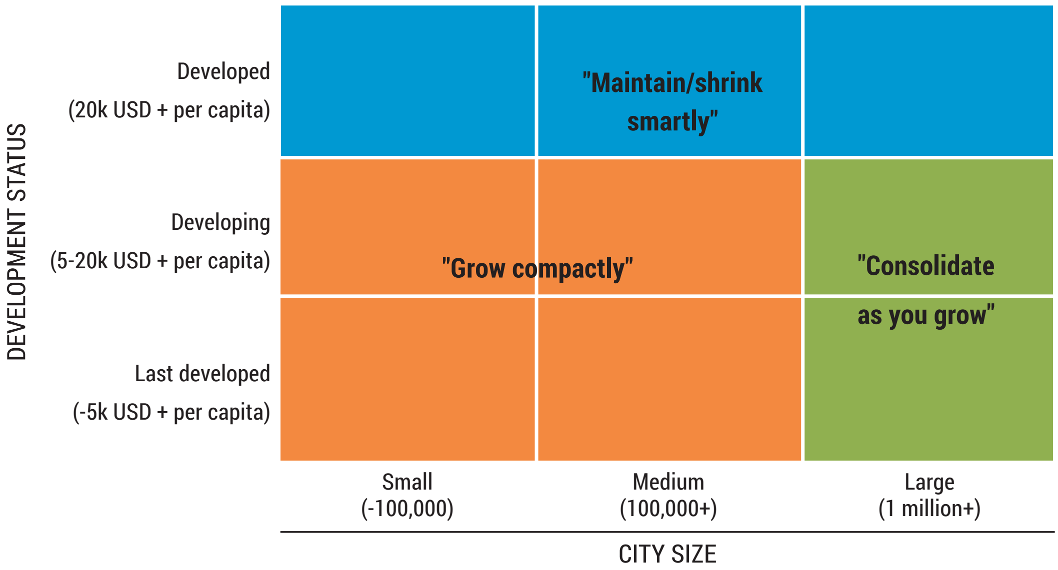
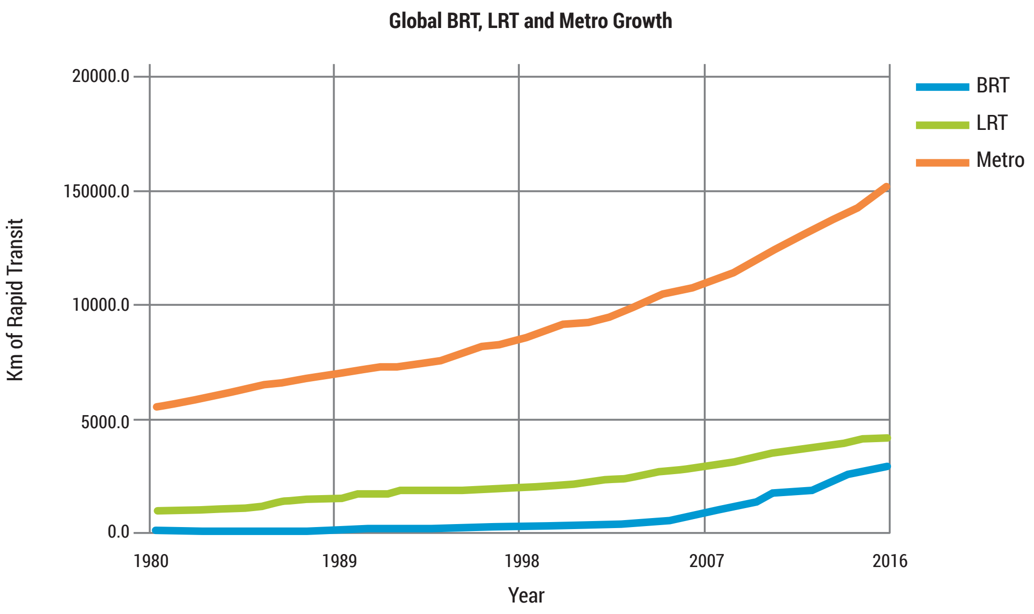


TABLE 3.5 Costs and Capacity of Transportation Infrastructure Investments *(ADB, 2010)*

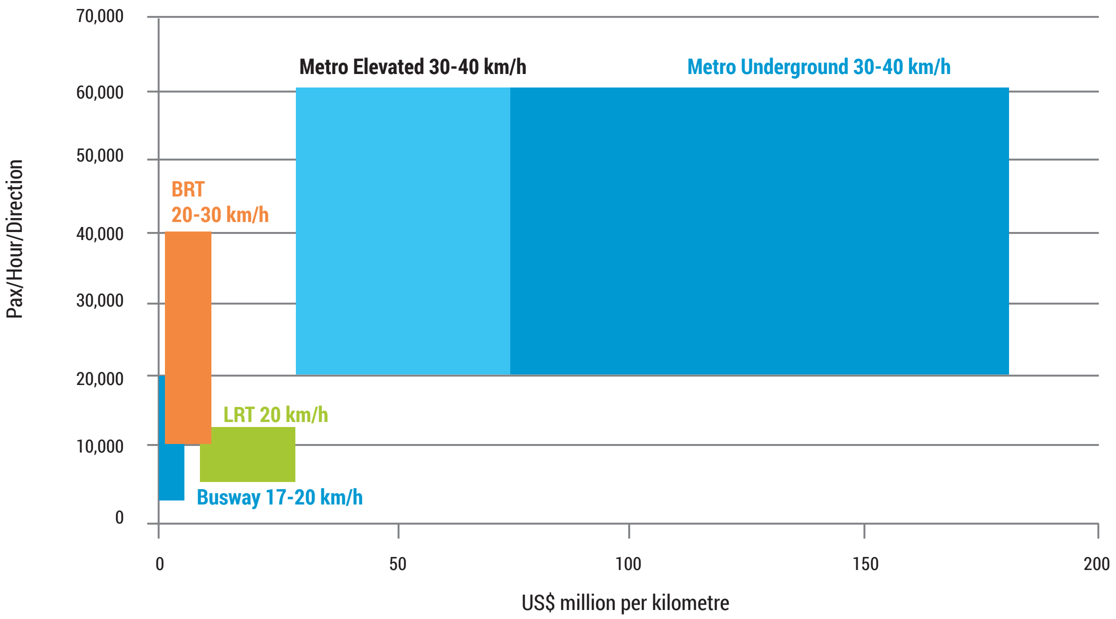
Transportation Infrastructure	Hourly Capacity to Move People per US$1 million in Capital Costs	Capacity (person per hour per direction)	Street Cross Section Used (meters)	Capital Cost (US$ million per km)	Capacity per meter of Street Cross Section (persons per hour per meter of cross section)
Footpath, 2m wide	24,000	2,400	2	0.1	1,200
Bikeway, 3m wide	20,000	3,000	3	0.15	1,000
Expressway, four-lane	5,665	8,500	20	1.5	425
BRT- High Capacity	5,000	35,000	12	10	4,165
BRT- Low Capacity	4,500	6,000	8	3	2,250
Urban Road, two-lane (low income)	4,500	4,500	9	1	500
Urban Road, two-lane (high income)	2,600	2,600	9	1	290
Metro Underground	1,000	60,000	n/a	60	n/a
Elevated Rail	625	25,000	7	40	3,570
Urban Elevated Expressway, four-lane	556	8,500	7	15	1,215
Urban Underground Expressway, four-lane	170	8,500	n/a	50	n/a

FIGURE 3.6 **Worldwide Transit System Growth and Construction** *(ITDP, 2017)*



In the above graphic BRT denotes Bus Rapid Transit; LRT denotes Light Rail Transit.

FIGURE 3.7 **Transit System Initial Cost vs. Capacity and Speed** *(UN Habitat, 2013)*



In the above graphic BRT denotes Bus Rapid Transit; LRT denotes Light Rail Transit.

BOX 3.10 Rapid BRT Infrastructure Development in Jakarta

Jakarta's BRT system began operations in February 2004, **just nine months after the city's leaders were inspired by a visit to the TransMilenio BRT system of Bogotá, Colombia**. The first 12 km line—complete with a dedicated runway and elevated access platforms—cost US$2 million a kilometre and was operational less than a year from the beginning of construction. The system quickly expanded by two additional lines and was serving some 39 million riders a year by 2006 (C40, 2012). By 2014, the system had 12 lines traversing 134 kilometres of dedicated BRT lanes, with another 20 lines being considered or under development. New lines are specifically being designed with the goal of providing service to areas such that the maximum number of personal vehicles are taken off the roadway as users adopt BRT.

A challenge **moving forward is to convince higher-income residents with access to personal** vehicles to opt for mass transit access instead. Authorities are experimenting with routes that have buses pass closer to residences before entering the system of dedicated runways as a way to maximize convenience and drive up ridership among those who own personal vehicles. The efforts to target higher income residents are built on top of long-standing efforts to ensure that BRT offers affordable, enhanced mobility to low and middle-income residents of the city (ITDP, 2014). Overall, the system exemplifies the relatively low-cost and high impact transit solution that BRT represents for cities that are looking to quickly meet growing transit demand.

BOX 3.11 Policy Learnings on Transit Finance in China 1990-Present *(adapted from Peng, Sun & Lu, 2012)*

As Chinese cities grew, **early investments focused more on road development and less on transit**. 'For example, from 1996 to 2000, Beijing's investment in public transportation was only 18 per cent of the total transportation infrastructure investment.' Although substantial investments in roads were made, by 2000 it was clear that challenges of congestion and pollution were unable to be addressed without significantly increasing investment in transit. In 2010 the proportion of expenditure on public transportation increased to 80.84 per cent in Beijing. For the country as a whole, the proportion of expenditure on public transportation in China increased from 10.2 per cent in 2003 to 16.2 per cent in 2009.

While the **increased investments in transit are forward-looking, the investment within the transit** industry were unbalanced, emphasizing rapid and high-capacity public transportation such as inter-city high-speed rail, metro rail, and bus rapid transit, and less focused on essential bus services. In short – every day and last mile travel issues were neglected. Transit oriented development has seen only a few successful cases because of the coordination challenges in transit planning – long distance rail with local transit and then para transit to address the last mile challenge for effective TODs. Furthermore, there are significant equity issues as well as migrants and the poor often have to disproportionately bear the burden of travel costs and time. Increasingly neighbourhood level planning for active streets has been recognized and some cities like Chennai, India are requiring a certain percentage of a city's transportation budget go toward active transport planning.

Bottom line: For large cities in China and elsewhere, both infrastructure finance and coordination challenges must be better focused on transit along major arterials with good connectivity through walkable and bikable streets at the neighbourhood level, not just major transit projects.

3.6.1 Transit Planning for Compact Urban Form in Tier 1 and Tier 2 Cities

The final two 'D's of the 5D framework mentioned in the preceding section (3.4)—distance to transit and destination access—represent two sides of the same issue. Compact and resource efficient urban forms—places where it is not necessary or even desirable to own a vehicle—are often premised on the widespread availability, accessibility, and efficiency of diverse transit and mobility options. *Distance to transit* represents the proximity of transit and mobility solutions to where people work and live or from where they otherwise need to access it. *Destination access* is a question of whether transit options take people where they want and need to go.

Ensuring that a substantial majority of urban residents—if not all urban residents—are within reasonable distance to transit or sustainable mobility options requires that housing policies and transportation policies be coordinated. In some cases, the location of existing housing stock will influence where new transit infrastructure is developed. In other cases, the location of transit infrastructure will influence where new or additional housing is developed. In most cases, the process is iterative as housing stock begets transit demand and transit infrastructure begets housing demand. **Matching transit services to the destinations transit riders need to reach (destination access) requires an even more robust alignment process across policy areas spanning transit, housing, jobs, and economic development.** The upper limit of a standard transit "catchment zone"—the radius of area surrounding a transit station from which it is reasonable to expect people to walk—is often set at distance of 1000 meters, equating to a 12-13 min walk. While 1000 meters is considered an upper limit, 400-800 meters represents an ideal catchment zone. The distance people might reasonably consider walking can be heavily influenced by neighbourhood design, pedestrian connectivity and climate (Pongprasert and Kubota, 2017). **Principles of articulated development often depend on strong transit connections between each node of high density development. Both distance to transit and destination access are factors that can help maintain existing low levels of car ownership across the ASEAN region.**

Buses, bus rapid transit (BRT), light rail (LRT) and metro rail have all emerged as options for providing transit in larger Tier 1 and Tier 2 cities. Figure 3.7 shows the recent penetration of BRT systems as a potential transit offering in many cities. The benefits to BRT include low cost, adaptability as there is less lock in of the rail, and affordability. Yet, establishing dedicated BRT lanes so as to avoid right of way competition with other vehicles has proved to be challenging in India's adoption of BRT (e.g., in Indore). A criticism of BRT has been that it does not support further compact development and land value enhancements along transit corridors as does rail-oriented transit planning (Cervero, 2013). More broadly though, BRT and even traditional bus networks can be optimized to deliver substantial resource efficiency gains without the costs and effort of investing in metro rail mega-projects. Capital costs for BRT systems run between 4 and 20 times less than traditional light rail systems and between 10 and 100 times less than metro rail systems (See Figure 3.7).

With new BRT designs based on non-polluting electric buses, the possibility of low polluting BRT systems may be a very attractive and lower cost option in Tier 2 cities, while a combination of BRT and metro rail may be viable in larger Tier 1 cities as has been seen in Jakarta and Delhi. In smaller cities of less than 500,000 residents, investments in large-scale metro rail systems, LRT or BRT may not be necessary or cost effective. In all cases, the last kilometre challenge remains – and must be addressed through coordination of active transport (cycling and walking) and para-transit options including human powered cycle rickshaws and tuk tuks as well as transportation network companies that provide ride-sharing services, both formal and informal (Cevero, 2013; UN Habitat 2013). Moreover, to the degree possible, transportation planners should be thinking about the comprehensive integration (physical connectivity, multi-modal fare transfers, etc.) of all component parts of an urban area's mobility system, rather than considering them discretely.

3.6.2 Small City Sustainable Active Transportation Enablers

A strategic option for ASEAN urban transportation planning will be to focus the attention of small cities on investing in active transportation modes (see Table 3.6) and traditional public bus networks, while considering rail links to other ASEAN cities, including trans-national connectivity. Inter-city and cross border infrastructure connectivity has already been envisioned in ASEAN infrastructure planning efforts for freight and electric power (ASEAN Secretariat, 2016), and it may be strategic to expand similar consideration for inter-urban transportation infrastructure as a strategy to balance urban growth pressures across a range of city sizes. A critical element of promoting active transportation within smaller cities will be the development of high-enough densities that reflect an urban form that can support 500,000 residents with a land area of 50 km^2. The 50 km^2 benchmark for land area has been identified as an ideal size for a city wishing to encourage heavy reliance on active transportation modes (Shastry and Pai 2016). With average densities of about 8000 to 9000 people per square kilometre already observed in a sample of 34 ASEAN cities (See density table in Chapter 2), this regional context would indicate that such levels of density might be readily achievable and therefore would allow for the accommodation of 500,000 residents within an urban area 50 km^2 in size.

By retaining mixed uses in all parts of the city, investing in early planning efforts to enable centrally located housing for economically weaker sections, investing in safe streets with trees and shade that separate and foster both bicycle and pedestrian mobility, along with the development of efficient public transportation bus systems and shared mobility options like taxis, it is not unreasonable to expect that such cities could slow or halt the inroads of private automobile ownership among middle and upper classes with rising incomes. In industrial cities, providing good quality housing for factory workers on site or near the factories, or providing bus transportation for employees to and from factories, can also reduce the job-housing commute factors that help drive emissions and resource use in cities.

3.7 New Transportation Technologies and Vehicle Futures

New autonomous vehicle (AV), electric vehicle (EV), and shared vehicle (SV) technologies are likely to further advance efforts to reduce or limit private fossil-fuel burning automobile ownership in the ASEAN region. These emerging transportation technologies (see Figure 3.8) are also an important driver of the *improve* pillar of the ASI framework—improving the efficiency of vehicle trips that cannot be outright *avoided* or *shifted* to public transportation. Similarly, the emergence of transportation network companies (TNCs)—commonly known as ridesharing companies—and the emergence of autonomous vehicles (AV) are two independent trends in vehicle and transportation technology that have the potential to reshape urban mobility options in Southeast Asia. While the convergence of EV, AV, and SV technologies derive their greatest sustainability effects when these trends interact with one another (rather than operating independently), AV and TNCs in particular face challenges to widespread deployment in the ASEAN context: namely chaotic traffic patterns and road conditions that are incompatible with current AV technology. EV faces its own challenges from an infrastructure perspective as widespread conversion to EVs requires that public charging stations be widely and readily available. What is more, EV technology alone does not yield resource efficiency benefits unless the underlying electricity generation that fuels EVs is converted to clean and renewable sources.

3.7.1 Electric Vehicles (and Clean Electricity Supply) for Sustainable Mobility

EVs are particularly attractive for urban areas as they generate zero tail pipe emissions and thus have the potential to aid in the substantial improvement of urban air pollution. However, relative to other concerns of urban compact growth and liveability, EV technology deployment does not itself alleviate traffic congestion and its ability to yield GHG reductions is dependent on paired investments in renewable energy that change the way the electricity is generated for the power grid. If the electricity grid that supplies EVs with power is heavily dependent on fossil fuels, the GHG emissions associated with regular fossil fuel-burning combustion engines are simply displaced (to the point of electricity generation) not eliminated. There are also substantial GHG emissions implications that stem from the production of the batteries for EVs. The experience of China indicates that the GHG emissions associated with the production of an electrical vehicle can rise by 30 per cent over the production of a conventional vehicle when steps are not taken to limit the GHG emissions that derive from manufacturing EV batteries (Hao et al., 2017).

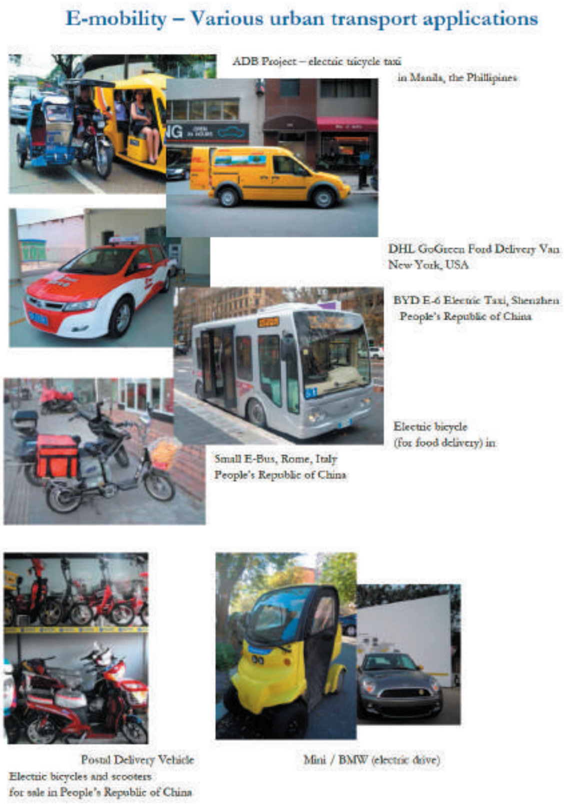
Life cycle analysis of electric cars and scooters in India (with an electric grid that is 60 per cent coal based, more than ASEAN's grid which is projected to be 45 per cent coal in 2050), found that electric cars and scooters are effective in both reducing GHG emissions and air pollution. EVs were also cost-positive for the owners with three layers of subsidies provided by the government (Rokadiya and Bandiwadekar, 2016). EV deployment in large numbers will be very effective in reducing PM2.5 pollution in cities where 3 million deaths annually are attributed to outdoor air pollution, much of it related to transportation. Estimates indicate deployment of e-bikes in Hanoi alone, could potentially reduce two-wheeler CO_2 emissions by up to 21 per cent annually . For reference, the current fleet in Hanoi is 95 per cent comprised of gas and diesel powered two-wheelers.

However, it should be noted that policy goals of encouraging widespread conversion to EV technology still requires an equal emphasis on the underlying electricity grid supply dynamics (i.e. lowering grid reliance on coal)

TABLE 3.6 Best Practices, Interventions and Policies for Supporting Non-Motorized, Active Transportation Modes *(adapted from UNCRD, 2011)*

Best Practices, Interventions, and Policies for Supporting Non-Motorized, Active Transportation Modes in Support of the Bangkok 2020 Declaration - A vision for Asia in promoting sustainable transport towards a Green Economy
• Traffic calming measures including speed bumps, pedestrian refuges, curb extensions, roundabouts etc. • Speed limit enforcement • Stop sign enforcement • Dedicated pedestrian and bicycle lanes • Street signs, traffic signals, and wayfinding for cyclist and pedestrian convenience • Bicycle sharing programmes • Bicycle registration and insurance policies • Secured bicycle parking facilities in public transportation stations and major buildings • Pedestrian friendly, car-free zones (permanent or intermittent—i.e. weekly road closure for cyclist and pedestrian use etc.) • Design and development standards that fix a percentage of all new road development for non-motorized travel

FIGURE 3.8 New Technologies and Vehicles and Fuels Futures *(Photo from Next Generation Solutions for Clean Air and Sustainable Transport in Asia: Electric Mobility, Author: Dr. Frank Wolter, InnoZ, Berlin, Germany Prepared for United Nations Centre for Regional Development (UNCRD) Nagoya, Japan, 2014)*



BOX 3.12 Summary of EV Policy and Market Trends in ASEAN Region *(excerpted and paraphrased from GE Reports ASEAN, 2017)*

Asia accounts for on third of electric vehicle (EV) sales globally, with the bulk of these sales are concentrated in China and India. There is substantial growth potential for EV markets in the ASEAN context. Below is a summary of EV policy and market trends in the ASEAN region.

SINGAPORE
A government-promoted car sharing initiative has set the goal of rolling out 1,000 EVs by 2020, while at the same time installing some 2,000 charging points across the city.

THE PHILIPPINES
Progress towards greater deployment of EVs has been slowed by the cancellation of a government E-trike initiative due to low adoption.

MALAYSIA
The government has set some of the most ambitious goals in the region, aiming to encourage the adoption of over 100,000 EVs by 2020, supported by installing 25,000 public charging stations nationwide.

INDONESIA
Progress on encouraging EV adoption has been relatively slow but on-going research at several universities to develop domestic EVs offers could support future expansion of the market.

VIET NAM
E-bike sales in 2013 totalled 150,000 units (about 14% of total motorcycle sales), but more support is required in developing infrastructure, providing clarity on tax incentives, and legislative requirements, to accelerate e-bike sales.

GENERAL PRO-EV POLICY SUPPORT
Clear fiscal and environmental initiatives are needed to create a transparent, supportive regulatory, sales, and infrastructure landscape. Efficient, cutting-edge electric vehicles are a necessary part of transitioning a nation's vehicle fleet to EV, but without charging points to power them widespread adoption will be curtailed.

in addition to emphasis on the deployment and roll-out of EV vehicles and charging stations for the fullest resource use efficiency gains to be realized.

Recent policy declarations by China and India are creating momentum for EVs in Asia. China has pledged that 7 per cent of its annual 35 million car sales will be EV (7 million cars) by 2020. India has pledged that all its cars will be electric by 2030. There is also a very large market for electric two wheelers in China and India exceeding 300 million over the past 5 years (Navigant Market Research, 2012). EV technology is increasingly being experimented with in the ASEAN context (see Box 3.11). A pilot project was initiated in the Philippines for electric Jeepneys (para-transit) in Manila, but the project ultimately stalled for lack of uptake. The Malaysian government has adopted the goal of supporting the uptake of over 100,000 EVs by 2020, supported by installing 25,000 public charging stations (GE Reports, 2017). The recycling of lead-acid (older technology) and newer lithium ion batteries should also be considered when assessing the environmental impact of widespread vehicle fleet conversion to EV technology. Specifically, is there a plan in place to reuse or appropriately dispose of hundreds of millions of electric batteries as they reach the end of their useful lives in 15-20 years' time?

From a policy and regulatory perspective, a structured system of subsidies, tax credits and fossil fuel taxes can make EV cost-competitive with conventional gasoline vehicles. Similar policy and regulatory frameworks would likely need to be in place to ensure that widespread conversion to EV technology actually reduces (rather than simply displaces) GHG emissions and improves resource use efficiency as a whole.

3.7.2 Shared and Autonomous Vehicles for Sustainable Mobility

Informal ridesharing is a long-standing cultural habit in many ASEAN contexts, particularly the sharing of taxis. Mobile phone based TNC or ridesharing platforms the possibility of bringing the convenience of digital payment and GPS-based ride hailing technology to bear on these existing practices. Ride sharing can offer prove to be a particularly attractive urban mobility solution when goals include limiting the growth in ownership of personal vehicles or providing mobility services in parts of an urban area otherwise not well serviced by public transportation options. However, TNC platforms—developed in advanced industrial economies of Western Europe and the United States—rely on the widespread penetration of data-plan enabled smartphones and access to formal personal finance instruments such as credit cards that can be linked to mobile payment applications (Stocker and Shaheen, 2016). The core business model of such TNCs (transfer of funds through mobile payment options and being summoned by GPS enabled smart phones) has been adapted somewhat for the ASEAN context with many TNC's accepting cash in addition to mobile payment options and with the installation of fixed TNC stands that allow riders to access the service even without a GPS enabled smart phone. Each of these practices, however, result in TNCs in the Southeast Asian context resembling traditional taxi companies and not necessarily an alternative mobility solution that might offer new options for areas of a city underserved by other transportation options. The cost of TNC platforms may also be prohibitively expensive relative to local incomes. According to the current pricing structure of India's "Ola" ridesharing service, which includes motorbike taxis, an average worker would spend 22 per cent of his or her income if they commuted 5 km to and from work each day via the service (Tomer, 2016). **To date, current TNC policy making across urban areas in both developed and developing countries alike has been more or less reactive. More pro-active consideration about the type of mobility solutions TNCs may be able to support will likely be necessary for local governments to reap the full sustainability and accessible mobility benefits that TNCs could potentially offer.**

With respect to self-driving AV technology, there are similar region-specific challenges that may prevent its widespread deployment. While traffic congestion patterns in large ASEAN cities have been identified as having much to gain from route efficiency and congestion reducing AV technology, current road and traffic conditions may limit the viability of current AV technology in the ASEAN context. Specifically, current AV technology has been developed to perform well in relatively conservative and highly regulated traffic conditions. More chaotic traffic patterns and poor road conditions—for example a high prevalence of motorbikes weaving through traffic, the potential incursion of vendor carts and other non-motorized vehicles in a roadway- are challenges for the deployment of AV technology in developing country contexts (ILO, 2016). Analysts suggest that increasing the sophistication of AV technology to the point that it might better cope with chaotic road conditions in developing country contexts would be both prohibitively expensive and time consuming. **For urban areas in ASEAN countries with chaotic traffic patterns, medium to long-term AV-relevant policy goals might revolve around prioritizing traffic management efforts and road network development that will eventually be compatible with AV technology in the future rather than seeking the immediate and widespread roll-out of AV technology on current roadways (Winn, 2017).**

However, in other ASEAN contexts, specifically Singapore, proactive policy measures to encourage the widespread deployment of shared and autonomous vehicles makes for good transportation planning and practice. Widespread technological literacy, access to formal personal banking instruments, and a tightly controlled technocratic regulatory environment make Singapore a conducive environment for experimentation with shared AVs (Winn, 2016). Singapore has invested heavily in shepherding the deployment of AV technology, specifically through the Singapore Autonomous Vehicle Initiative (SAVI). Investments in SAVI are specifically envisioned as helping lay the groundwork for a self-driving future in Singapore that could widely increase ridesharing, with estimates suggesting personal vehicle ownership could be reduced by a full third in such a future (Singapore Ministry of Transportation, 2015). The private ride-sharing platform Grab—operating in Malaysia, Myanmar, Indonesia, the Philippines, Singapore, Thailand, and Viet Nam—is already collaborating on a self-driving car project in Singapore, with the goal of having 100 self-driving taxis on the road by 2018 (Aravindan, 2016). **The eventual joining up of SV and AV technology represents the greatest potential for urban liveability and resource efficiency gains—in contrast to individually owned AVs—as fleets of shared AVs could return benefits including a reduction in personal vehicle ownership rates and reductions in traffic congestion and accidents (as a result of computer optimized travel routes and driving behaviours). The most dramatic sustainability gains would be seen in a system where such vehicles relied on EV technology drawing from a clean electricity grid and are primarily used as a means of first-km/last-km connectivity to and from mass transit nodes.**

3.7.3 Bike Sharing Technology Platforms to Encourage Active Mobility

New dock-less bike share systems are emerging as a technology platform that allows riders to access bikes not tethered to traditional bike share docking stations, usually by using their mobile phone to receive a code to unlock a given bicycle. Dock-less systems stand in contrast to docked bike-share systems which require bicycles to be picked up and returned to specific docking stations (Gray, 2017). Dock-less technology is said to facilitate a more convenient and flexible bike sharing experience, making it attractive to a wider pool of users. As of 2017, dock-less bike system operators–like Mobike and Ofo, the two industry leaders in China—have a customer base of some 100 million users in China (Jing, 2017). Both companies are already operating in Singapore and have plans to expand in Malaysia and Thailand. Currently, expansions of dock-less bike share systems are not necessarily aligning with locations where robust bicycling cultures already exist, for example in Viet Nam or Indonesia. Dock-less systems are seen as attractive both for users and operators precisely because they do not require dedicated docking infrastructure, but they have experienced operating challenges and public backlash in China due to the extreme piling up of excess bikes at congested and popular daily travel destinations, for example transit stations (Yuniar, 2017). **The introduction of dock-less bike share systems in any city should be accompanied by local policies and regulations to ensure that the systems can operate safely and effectively, without causing a nuisance or disrupting daily travel operations for other modes.**

While they are widely used in cities across other parts of Asia, Europe, the United States, and Latin America, traditional docked bike share systems operate on a relatively limited basis in the ASEAN region (Bakker, Guillen and Nanthachatchavankul, 2016; ADB, 2012). Dock-less systems could potentially fare better in ASEAN cities, but robust cycling mode choice in general—regardless of whether it is bike-share enabled—is dependent on more than convenient access to a bicycle. Specifically, a lack of bike lanes, poor traffic controls, and no established culture of motorists sharing roadways are all identified as challenges to bicycling in many of the region's largest and most congested cities (Bakker, Guillen and Nanthachatchavankul, 2016). **While still important in large and medium cities, active transport investments—like bike-share systems—may be particularly well suited for smaller, emerging cities as they have the opportunity to build (or further reinforce) shared cultures and infrastructures around cycling as a core urban mobility strategy from the outset rather than retroactively.**

Regardless of city-size, investments in active transportation should seek to leverage and support multi-modal connectivity, making it easy to incorporate walking, cycling, and transit use in a single trip. Strategic positioning of bike share infrastructure, bike lanes, and bicycle parking facilities at transit stations are all ways to support multi-modal connectivity. Municipally owned or operated bike share systems create opportunities for streamlining digital fare payment across multiple modes, i.e. using the same transit fare payment system for bikes, metro/light rail, and bus services, enabling route transfers between and among them.

3.8 Challenges and Policy Learnings for Strategic Intensification through Land Use and Transportation Planning

We compare the *Weight of Cities* key global assumptions with the ASEAN, India and China case studies and highlight the following key findings.

A first challenge facing urban areas in the ASEAN context is to achieve urban expansion while protecting prime agricultural lands, biodiversity hot spots and ecologically sensitive areas that offer resilience to future disasters. While developing compact cities can reduce urban land expansion, compact development alone will not achieve these objectives – national level urban-corridor planning, eco preservation policies, and urban-rural land pooling strategies are essential to preserve sustainability along the urban-rural continuum. These strategies were not explicitly covered in the global *Weight of Cities* report, and are highlighted here in the contextualization for the ASEAN region.

Low levels of density in major cities around the world, and a global trend of de-densification are a key concern highlighted in Chapter 2 of the global *Weight of Cities* analysis. The study team's of the science and the literature concludes that ASEAN cities are, in general, densifying (i.e. they are physically expanding but at rates slower than population growth), or at the very least are maintaining relatively high levels of density. Of the 34 cities in the ASEAN region with populations of more than 1 million, average density levels already surpass 9,000 persons/km^2. This is in contrast to average urban density of 711 persons/km^2 across the 282 urban areas for which the OECD maintains statistics. Relative to these global norms, achieving high average density per se is not the primary challenge in ASEAN urban areas, rather, the challenge is to manage existing high levels of density so that it is both articulated and accessible, and to manage hinterland expansion in ways that intentionally preserve prime agricultural lands and biodiversity hotspots.

The 5Ds—density, diversity of use and income, design, distance to transit, and destination access—outlined in the global *Weight of Cities* and the complementary ASI framework developed in Asian cities, provide helpful guidelines for maintaining compact urban forms that are premised on articulated and accessible density.

The ASEAN region's diversity of smaller emerging cities alongside, medium, large and mega cities indicates that it will be necessary to customize realistic sustainable mobility and transit strategies for different city typologies. Larger tier 2 and tier 1 cities are likely to find BRT, metro rail, and other mass transit systems cost-effective. Alternatively, smaller and medium-sized cities may find it more cost effective to focus investments on traditional public bus transportation, paratransit, and active transport modes.

In general, both the *Weight of Cities* report and this ASEAN report emphasize the benefits of low levels of personal automobile ownership, compact urban forms, and liveable streets that encourage mixed-use neighbourhoods with options for employment, commerce, and residential use. Key policy learnings from this chapter's discussion and case studies advancing land use and transportation planning for strategic intensification are presented in box 3.13 below.

BOX 3.13 Key Policy Learnings for Strategic Intensification in the ASEAN region

NATIONAL LEVEL ACTION

1. National urbanization and economic development planning can help ease development pressure on primary cities by rebalancing growth and development across a national system of cities that are varied in size.

2. National governments can help avoid uncontrolled expansion by establishing urban development boundaries, setting aside valuable agricultural land and land that provides critical ecosystem services, protecting them from unregulated urban land expansion.

3. National government efforts to statutorily grant increased governing authority and resources to bodies at the urban-regional level can help increase the degree to which growth and expansion can be coordinated from a comprehensive urban-region wide perspective. Currently, urban-regional governance bodies do not exist for all major cities across the ASEAN region, and where they do exist, the degree to which they are formally empowered with adequate governing authority and resources is mixed.

URBAN REGIONAL LEVEL ACTION

4. Planning at the urban-regional levels for guided development can avoid uncontrolled urban expansion onto rural land by creating land pooling, readjustment, and infrastructure development opportunities for controlled urban land expansion through government, private sector, and community partnerships.

5. Urban-regional master planning can be integrated with micro-township planning efforts to ensure that individual expansion areas are planned so that they help advance the goals of urban-regional master planning, including requiring housing set asides for economically weaker sections to ensure proportional space for the urban poor and new migrants in an effort to avoid slum development.

6. *Insitu* slum rehabilitation and non-peripheral siting of new social housing can help ensure the inclusion of economically weaker sections in the central urban fabric, reduce time and cost burdens of commuting, and increase connectivity to critical urban-region assets including employment centres.

CITY-LEVEL ACTION

7. City-level efforts can help develop coordinated land-use and transportation plans for strategic intensification premised on the 5D—density, diversity of use and income, design, distance to transit, and destination access—and the 'Avoid, Shift, Improve' frameworks to create mixed-use neighbourhoods that encourage residents to make short trips by walking or biking and that provide first-mile/last-mile connectivity to high density transit nodes.

8. City-level efforts should plan for diverse transportation strategies based on the size and functionality of cities, recognizing that mobility solutions will look different for cities of different sizes. This means investing in high volume transit systems early and often in Tier 1 and Tier 2 cities, complementing such projects with simultaneous investment in complete streets and active transport at the neighbourhood level for first mile/last mile connectivity, while prioritizing investments in active transport, efficient paratransit, and complete streets in small cities as principal mobility strategies where large investments in mass transit may not cost effective.

9. City-level efforts should remain open to the potential of electric and shared autonomous vehicles to deliver new sustainable mobility solutions particularly in small and medium sized cities, however taking in to account the transboundary life-cycle assessment of such technologies and the underlying electricity grid factors that particularly affect the sustainability of electric vehicles as key determinants of whether GHG emissions and other material resource use impacts will be lessened or simply displaced.

3.9 Potential to advance multiple SDGs

Guided urban land expansion across multiple cities in a nation, protecting regionally and nationally-valuable biodiversity hot spots and agricultural land is a first aspect of sustainable urbanization. Second, compact urban form with considerations of accessible and articulated density can limit urban sprawl, urban slums, traffic congestion, and air pollution. Both strategies together will be instrumental in realizing multiple SDGs, through diverse pathways and linkages (see Figure 3.10). For example, balancing growth and optimizing investment across national systems of cities increases economic opportunity in support of SDGs including no poverty (SDG 1); decent work and economic growth (SDG 8); industry, innovation, and infrastructure (SDG 9); and reduced inequality (SDG 10). Managed urban-regional growth allows for better coordinated infrastructure provision and reduced sprawl in support of SDGs including clean water and sanitation (SDG 6); life below water (SDG 14); and life on land (SDG 15). Non-peripheral social housing and existing slum rehabilitation promotes inclusion and provides basic services while supporting regional compact growth in support of SDGs related to clean water and sanitation (SDG 6); reduced inequality (SDG 10); and life on land (SDG 15). Compact mixed-use and income diverse neighbourhoods promote economic efficiency, inclusion and reduce motorized travel in support of SDGs related to decent work and economic growth (SDG 8); reduced inequality (SDG 10); and climate action (SDG 13). Diverse mobility options efficiently and equitable connect people to livelihoods, create safe streets for walking and biking, and reduce private motorized travel in support of SDGs related to no poverty (SDG 1), decent work and economic growth (SDG 8); reduced inequality (SDG 10); and climate action (SDG 13). Reduced private motorized travel and cleaner powered vehicles reduce air pollution and traffic congestion in support of SDGs related to good health and wellbeing (SDG 3) and climate action (SDG 13). Combined, all of the pathways support SDGs11 (sustainable cities and communities) and 12 (sustainable consumption and production).

FIGURE 3.9 Sustainable Development Goals and land use and transit planning pathways for addressing

Land Use and Transportation Planning Policy Pathways

Use national and cross-ASEAN urbanization planning to balance growth across a range of cities

Engage in urban-regional planning to reduce land expansion and streamline infrastructure provision

Engage in city-level planning to promote compact, mixed-use, accessible, and inclusive urban form

Plan for diverse mobility strategies (transit, walking, biking, motorized travel)

Leverage sustainable travel behavior and new vehicle technologies

Linkages for Impacting SDGs

Balancing growth and optimizing investment across national systems of cities increases economic opportunity

Managed urban-regional growth allows for better coordinated infrastructure provision and reduced sprawl

Reduced sprawl preserves agricultural lands, hinter seas, and biodiversity hotspots

Non-peripheral social housing and existing slum rehabilitation promotes inclusion and provides basic services while supporting regional compact growth

Compact, mixed-used and income-diverse neighborhoods promote economic efficiency, inclusion and reduced motorized travel

Diverse mobility options efficiently and equitably connect people to livelihoods, create safe streets for walking and biking, and reduce private motorized travel.

Reduced private motorized travel and cleaner powered vehicles reduce air pollution and traffic congestion

SDGS

- SDG #1 No Poverty
- SDG #3 Good Health and Wellbeing
- SDG #6 Clean Water and Sanitation
- SDG #8 Decent Work & Economic Growth
- SDG #9 Industry, Innovation & Infrastructure
- SDG #10 Reduced Inequality
- SDG #13 Climate Action
- SDG #14 Life Below Water
- SDG #15 Life on Land

SDG #12 Sustainable Consumption & Production

SDG #11 Sustainable Cities & Communities

CHAPTER 4
Buildings and Energy

BOX 4.1 Highlights of Chapter 4

1. From 2013 to 2040, GDP in the ASEAN is expected to triple, during which time the International Energy Agency (IEA) projects primary energy use will increase by 80 per cent and electricity demand will nearly triple. About 18 per cent of primary energy use goes toward electricity generation, indicating that a vast majority (>80 per cent) of energy use occurs in ASEAN industries, addressed further in Chapter 6.
2. This chapter mainly focuses on the electricity demand and supply to buildings which are responsible for more than 57 per cent of the electricity use in the region.
3. The IEA projects that buildings' electricity use in the ASEAN will triple by 2040 from 35 to 108 million tonne of oil equivalent; a significant portion of this increase will be for cooling, lighting and appliances.
4. Even with significant currently planned renewable energy investments, the ASEAN region will be one of only a few regions globally to see an increase in the share of coal in its electricity supply mix, rising from 32 per cent to 50 per cent by 2040 (OECD/IEA, 2016a).
5. Integrating buildings energy-efficiency with renewable energy generation, particularly in urban areas where future population and economic growth will occur, can substantially reduce the need for large electricity grid investments, improve resilience and reduce coal use, along with associated GHG and air pollution emissions.
6. The Weight of Cities report states that 48 per cent energy savings could be achieved with green building design (e.g. LEED buildings) compared to inefficient, western buildings. Compared to this scenario, vernacular and passive design may result in greater savings than green buildings if behaviour and cultural norms are considered in the design.
7. Vernacular buildings combined with rooftop photovoltaics and solar thermal water heaters may not need additional electric for airconditioning and heating.
8. Often design savings are calculated compared to a case in which occupant behaviour and the original building design are not considered. When estimating savings, it is important to compare to building design common for the region (e.g. passive and vernacular) and to monitor performance.
9. When commercial and residential buildings are grouped together, district cooling offers a more efficient method for providing airconditioning. District cooling can be paired with renewable technologies (e.g. sea water cooling, solar thermal heating, etc.) to result in greater energy reductions.
10. The projected electricity demand increase due to increased domestic hot water and building electric consumption can be offset through the use of rooftop solar thermal heaters, which are commonly used in China and India in 2013, and rooftop solar photovoltaic panels.
11. Improving existing ordinary and vernacular buildings should be considered as a resource saving measure and integrated into national standards.
12. Mandatory and minimum energy performance standards (MEPS) for appliances and lighting should be developed and enforced as they have been proven to be a cost-effective energy efficiency standard. Currently, only 20 per cent of Southeast Asian countries have MEPS (IEA 2014).
13. The cross-ASEAN electric grid and renewable energy planning efforts must also directly incorporate urban buildings and distributed energy systems. Renewable penetration can be enhanced by intentionally including cities in renewable generation through renewable micro-grids, solar water heaters, distributed rooftop photovoltaic (PV) systems and geothermal energy, leveraging rich solar and geothermal resources in the region. Micro-grids that can be disconnected from the larger grid and operate autonomously increase resilience during disasters and other service disruptions.
18. A few ASEAN nations have developed green building standards for new buildings that incorporate passive design features, efficient cooling technologies and renewables. Some of these features are showcased in exemplar modern high-rise office buildings that can reduce building energy use by as much as 30- 60 per cent compared to the design base-case, consistent with the best-case scenarios highlighted in the Weight of the Cities report.
19. However, to achieve the technically feasible energy use reductions across all ASEAN urban areas will require: establishing green building codes in all ASEAN nations; achieving high levels of adoption of green design among builders; paying attention to occupant behaviour which shapes energy use, as well as real-time performance reporting of new energy efficient buildings compared to existing building stock to ensure energy savings anticipated from the design are achieved in practice.
20. Singapore's Green Mark green building rating system, along with its Building Energy Submission System offers a model for design and monitoring of resource-efficient modern high-rise construction that typically uses mechanical cooling and tight envelopes.

BOX 4.1 Highlights of Chapter 4 (continued)

21. Experiences in China and Southeast Asia also demonstrate examples of ordinary buildings (using only fans), and vernacular buildings with passive design features that consume much less energy than modern buildings, and provide occupant comfort suited to regional culture.
22. Green building rating systems and performance assessments must therefore be developed for diverse building types and uses– ranging from high-rise modern buildings to medium- and low-rise multi-storey ordinary and vernacular buildings that together create a compact and resource-efficient building stock in diverse ASEAN cities. Multi-storey buildings reduce material use by about 30 per cent compared to single storey construction; using low polluting materials also reduces pollution.
23. An important recommendation is to invest in research on combining energy efficient low- to mid-rise vernacular building design with resilient building construction codes suited for the ASEAN context.
24. Furthermore, district energy systems and micro-grids that meet cooling and electricity needs of multiple buildings in a neighbourhood or a campus, can also advance resource efficiency. Micro grids integrated with roof top solar photovoltaics and solar hot water heaters can substantially reducing energy use, enhancing disaster resilience of the new cross-ASEAN electricity grid, or be operated autonomously in smaller islands.
25. Mandatory and minimum energy performance standards (MEPS) for appliances and lighting should be developed and enforced as they have been proven to be a cost-effective energy efficiency standard. Currently, only 20 per cent of Southeast Asian countries have MEPS (IEA 2014).

4.1 Rationale and *Weight of Cities* Findings for the Global Case

Buildings are responsible for 20 per cent of the world's energy use and a vast majority of material use globally (EIA, 2016). For example, minerals, construction and wood products account for 26 per cent of the total raw material footprint in the United States and 62 per cent of the material footprint in China (Giljum et al., 2015).

The *Weight of Cities* report identified broad sets of systems level transformation in the buildings sector that are likely to achieve global goals of resource efficient urbanization. The strategies considered whole commercial and residential building efficiency systems, district energy systems and penetration of renewables in the grid consistent with International Energy Agency's (IEA) 6-degree[4] and 2-degree[5] scenarios. The report focused primarily on buildings and energy. A high level of adoption of all these strategies was found to translate to on average a 48 per cent reduction in building electricity and natural gas consumption and a 40 per cent reduction in water consumption.

Green commercial and residential building strategies for energy efficiency included typical measures such as increase thermal insulation, efficient lighting, and white/green roofs. The buildings considered in the *Weight of Cities* report were small sized office buildings defined by the United States Department of Energy commercial reference building models (Deru et al., 2011). Baseline energy performance was estimated for several climate regions using the EnergyPlus software, and various building energy efficiency standards were considered to compute the potential energy savings from that baseline. The report considered the best-case energy savings reported by the United States Green Building Council LEED certification system, estimating a 48 per cent reduction in building electricity use and natural gas consumption and a 40 per cent reduction in water consumption.

For building sharing heat networks, district energy is found to result in substantial improvement of energy efficiency and significant greenhouse gas emission reductions (UN Environment, 2015). The shared district heating and cooling systems were modelled to have efficiencies of around 90 and 65 per cent, respectively (United Nations Environment 2014), and compared with heating and cooling in individual household units. District energy has been tested in European Nations, which are dominated by heating loads, but not in ASEAN countries where cooling needs dominate.

The mix of the electricity generation and their impacts under the baseline and the resource efficient scenarios

4 In the 6-degree scenario primary energy demand and CO2 emissions would grow by about 60% from 2013 to 2050. The global temperature rise above pre-industrial levels is projected to reach almost 5.5°C in the long term and almost 4°C by the end of this century.

5 The 2-degree scenario limits the average global temperature increase to 2°C. The 2-degree scenario reduces CO2 emissions by almost 60% by 2050 (compared with 2013), with carbon emissions being projected to decline after 2050 until carbon neutrality is reached.

was based on the International Energy Agency's (IEA) 6-degree[6] and 2-degree[7] scenarios, the latter including a power grid with renewables (32 per cent), carbon capture and storage (12 per cent), and nuclear (7 per cent) (IEA, 2016). The renewables in the 2-degree scenario include 17 per cent solar PV.

The *Weight of Cities* report was global and aspirational in using the best-case energy efficiency projections for green buildings. This chapter provides the ASEAN context for buildings and energy and presents case studies describing potential solutions to reduce energy use in the building sector in the context of ASEAN nations.

Gross Domestic Product (GDP) in the ASEAN is expected to triple from 2014 to 2040, during which time primary energy use is expected to increase by 80 per cent and electricity demand will nearly triple (See Table 4.1). Only about 18 per cent of primary energy use goes toward electricity generation, indicating a vast majority (>80 per cent) of energy use occurs in ASEAN industries, addressed further in Chapter 6. This chapter focuses on electricity demand and supply to buildings which use a majority (~56 per cent) of the electricity in the region. Buildings electricity use in the ASEAN is expected to triple by 2040 from 35 to 108 million tonne of oil equivalent (IEA/OECD; 2015; Table 4.1); much of this increase will be for cooling, lighting and appliances (OECD/IEA, 2015). Solutions to reduce resource use are presented in this chapter, covering two broad topics: energy efficiency in buildings and renewable energy integration. We focus on methods to improve efficiency of: a) individual buildings (section 4.3); b) groups of buildings through district energy (section 4.3.5), and; c) through renewable energy penetration in the electric grid (section 4.4).

4.2 Overall Energy Sector Trends and Building Energy Demand in ASEAN Countries

To understand the ASEAN context, including economic growth and building demand to 2040, we use baseline data and scenario models developed by the IEA. The key highlights from the IEA scenario model for the ASEAN nations as a group are discussed in this section, as noted below.

4.2.1 Trends in Energy Access and Direct Total Energy Use

The number of people in ASEAN nations without access to electricity has declined from 21 per cent to 16 per cent since 2000, providing crucial steps forward towards the SDGs (SDG 7: affordable and clean energy; OECD/IEA, 2016a). However, 110 million people were still living without electricity in 2016, while another 272 million (44 per cent of the population) relied on solid fuels such as fuelwood and charcoal for cooking (OECD/IEA, 2016a). Improving energy access, along with the upcoming rise of the urban middle class is expected to increase energy use in ASEAN region by 80 per cent while the economy triples from 2010 to 2050 and the population increases by 23 per cent (OECD/IEA, 2015 page 9). This estimation is made by the IEA using the *New Policies Scenario*, which includes policies affecting energy markets adopted as of mid-2015 and assumes relevant policy proposals will be put into effect, even if specific measures needed to put them into effect have not been fully developed (see section Appendix B for more information). Even assuming the New Policies Scenario, electricity demand is expected to triple by 2040 (Table 4.1).

In 2013 electricity generation accounted for only 11 per cent of the total primary energy demand (68 of the 594 million tons of oil equivalent). By 2040 the IEA projects the proportion of the total primary energy use for electric generation will increase from 11 per cent to 18 per cent, during which time electricity demand will triple, creating a significant demand for new electricity infrastructure in the region. Non-electric primary energy use is project to increase as well, but not as rapidly as electric resulting in an 80 per total increase in overall energy use. The tripling of electricity demand is also reflected in the buildings sector that is expected to see its primary energy use for electricity to grow from 35 to 108 metric tonnes of oil equivalent.

IEA's New Policies Scenario describes how the increased energy demand would be met. The IEA projects large increases in coal fired electricity even after implementing significant increases of renewables in its New Policies Scenario that includes policies enacted through mid-2015. Coal production is projected to increase in the ASEAN, with 90 per cent of the steam coal produced in Southeast Asia in 2040 coming from Indonesia. Total ASEAN coal production will rise to 476 million tons of oil equivalent, with 161 million tons of oil equivalent being exported (309 million tons of oil equivalent used, see table 4.1). Given that ASEAN domestic use of coal will increase and second, that international coal

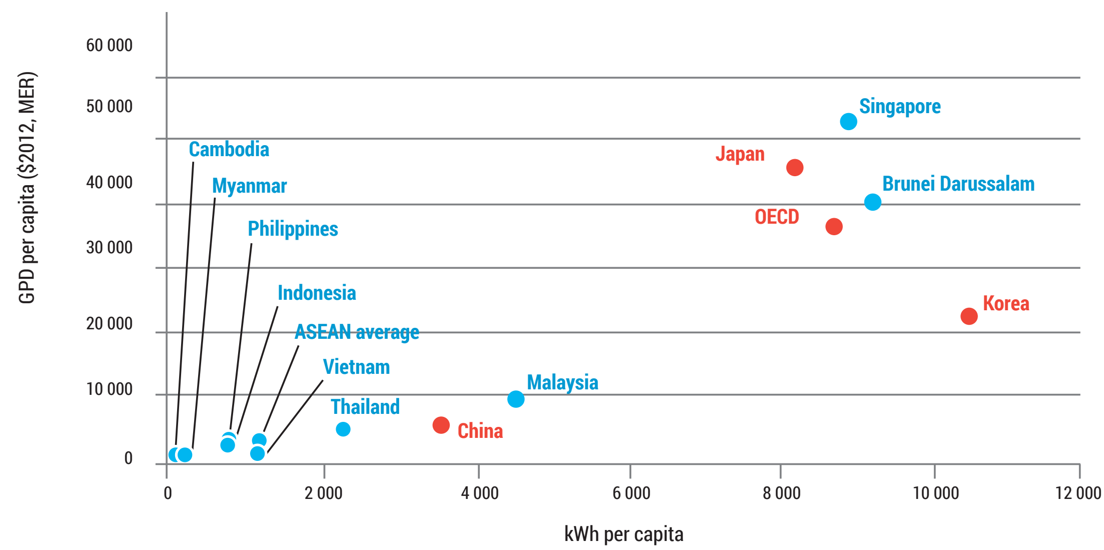
6 In the 6-degree scenario primary energy demand and CO2 emissions would grow by about 60% from 2013 to 2050. The global temperature rise above pre-industrial levels is projected to reach almost 5.5°C in the long term and almost 4°C by the end of this century.

7 The 2-degree scenario limits the average global temperature increase to 2°C. The 2-degree scenario reduces CO2 emissions by almost 60% by 2050 (compared with 2013), with carbon emissions being projected to decline after 2050 until carbon neutrality is reached.

TABLE 4.1 **Total energy use broken down by source and end use for ASEAN Countries in 2013. The 2040 values as calculated using the IEA New Policies Scenario** *(IEA/OECD, 2015 page 128)*

	2013 ASEAN Nation Total	2040 New Policies Scenario, ASEAN Nation Total	Per cent change
Energy Use by Source (million tons of oil equivalent)			
Total Energy Use	594	1070	80%
Coal	91	309	240%
Oil	213	309	45%
Natural Gas	133	220	65%
Nuclear	0	8	--
Hydro	9	22	144%
Bioenergy	122	134	10%
Other renewables	25	67	168%
Primary Electricity Use Separated by End Use (million tons of oil equivalent)			
Buildings	35	108	209%
Transport	0	1	--
Industry	26	60	131%
Other	8	22	175%
Primary Energy Use for Electricity Generation Separated by Source (million tons of oil equivalent)			
Total Electricity	68	190	180%
Coal	22	94	330%
Natural Gas	30	50	66%
Oil	4	2	-47%
Nuclear	0	3	--
Hydro	9	22	132%
Geothermal	2	5	205%
Bioenergy	1	6	650%
Other renewables	0	8	4550%

FIGURE 4.1 **Per-capita total electricity demand (sum of industry, business, housing and other) and income in ASEAN, 2011** *(OECD/IEA WEO Southeast Asia, 2015)*



markets (exports) will slow, the IEA outlook has a high and increasing level of coal use in electricity in ASEAN nations. The ASEAN region will be one of only a few regions globally to see an increase in the share of coal in its electricity supply mix, rising from 32 per cent to 50 per cent of the grid mix by 2040 (OECD/IEA, 2015).

Regarding domestic (ASEAN) primary energy use per capita, approximately 0.96 metric tons of oil equivalent are used per person in Southeast Asia, and is expected to increase to 1.4 by 2040 in the New Policies Scenario, although this is still substantially lower than many developed and other developing nations (OECD/IEA, 2015 page 33). Per-capita electricity demand is expected to increase from roughly 1280 kWh per capita in 2013 to 2910 kWh per capita in 2040. Figure 4.1 shows the per-capita electricity demand for ASEAN nations on average compared to other Asian nations in 2011. Per-capita electricity values in Figure 4.1 include electricity use by the residential buildings, commercial buildings and industry. Nations with lower access to electricity will have lower values over all (e.g. Myanmar) and nations with a higher number of exports (e.g. Japan) may have high per-capita electricity values. These trends indicate leveraging the existing sociocultural norms around energy use will be advantageous as the cities grow.

4.2.2 Residential and Commercial Buildings Energy Use: 2014 and Projections

Total primary energy final use is reported in three categories: transportation, industrial and "other" which includes mainly buildings (ADB, 2015; OECD/IEA, 2015). The relative proportion varies across the ten ASEAN countries. An example of how the final primary energy use is divided among the categories is shown in Box 4.2.

4.2.3 Renewable Energy and Electricity

To provide electricity for so many people in cities requires a massive grid expansion. Right now, coal and gas dominate the electric grid accounting for 32 and 44 per cent of the electric grid, respectively (OECD/IEA, 2015). Oil, hydropower, geothermal and bioenergy account for 6, 14, 2 and 1 per cent of the electricity generation, respectively. Recent innovative cross-ASEAN efforts have focused on creating a trans-national grid to leverage renewables. ASEAN countries have also made a concerted effort to remove subsides favouring all fossil fuels including coal. Mainly hydro, biomass supplemented with wind and solar are being integrated with increasing coal in the future electric grid. Despite a more than tripling of renewables in the electricity grid of the region, the share of renewables in the grid is projected to increase from 18 per cent in 2013 to only 22 per cent by 2040 due to simultaneously increasing reliance on coal. Even with substantial renewable energy policies, coal is projected to be a massive part of the grid (50 per cent) in 2040 (OECD/IEA, 2015), followed by natural gas (26 per cent), hydropower (12 per cent) and other renewables (10 per cent). ASEAN is the only region in the world where coal in the grid is projected to increase. Figure 4.4 shows the energy situation including fossil and renewable assets in the ASEAN countries. Note that Indonesia is presently the largest coal exporter in the world, and Malaysia a key hub for petrochemical industry.

To support large future electricity requirements, one option being considered is a large interconnected grid across the 10 countries, leveraging the hydro power and other country specific renewable assets as available. An interconnect grid could yield up to 481 terawatt-hours together in 2040 as projected by the IEA New Policies Scenario. At the same time, this strategy may raise security concerns and others suggest that each country may develop renewable energy resources close to demand centres (Huber and Roger, 2015; Luukkanen et al., 2015).

Figure 4.4 shows renewable energy assets by nation. Solar and biomass are very good options in all nations. Future technologies like the Smart Grid and Micro Grid may be particularly advantageous as distributing power across small islands can be challenging in the centralized grid. An energy planning scenario models shows that low carbon electricity in ASEAN is feasible with focus on all renewables, and specific foci on biomass and geothermal in Indonesia, and hydro in Brunei, Laos, Myanmar, the Philippines, Thailand and Viet Nam (Huber et al., 2015). For example, Indonesia has approximately 40 per cent (20,000 megawatt electric) of the world geothermal energy resources but only a small portion has been developed for power generation (Abdullah, 2005).

Figure 4.5 shows both energy efficiency and renewable policy targets at the national level. Achieving these targets will require a large emphasis on urban areas. To avoid transmission losses, improve resilience to climate extremes and minimize development cost, urban energy demand should be met with renewables close to the demand locations. Solar photovoltaics along with solar water heaters are just two examples of renewable technologies that can be integrated close to the demand location.

BOX 4.2 End use of energy in industry, residential and commercial buildings in Malaysia

Malaysia has the third-largest economy in Southeast Asia and is also the third largest energy consumer in the region. It has a high per capita energy demand – three times the region's average – and has achieved near-universal access to modern energy services (OECD/IEA, 2015). Roughly 15 per cent of energy use in Malaysia is estimated to be used for transportation, industrial energy use and other. Residential and commercial buildings account for roughly 18 per cent of the total energy use, according to Chong et al. (2015).

The sub categories within the residential and commercial building sector are shown in Figure 4.2 and 4.3. Cooling accounts for 60 per cent of the commercial energy use and lighting accounts for 11 per cent. Likewise, air conditioning, refrigeration and lighting total ~30 per cent for the residential sector.

The IEA forecasts that Malaysia's buildings energy use will increase by 100 per cent by 2040. Electricity demand in the buildings sector is projected to almost triple from 65 TWh in 2013 to more than 170 TWh by 2040, an annual average growth rate of 3.7 per cent per year. Rising living standards and higher incomes drive this high growth rate. In addition, Malaysia's hot and humid climate encourages the use of cooling year-round. Together, cooling equipment and appliances account for around half of electricity demand buildings (residential and commercial together) in 2013 and 57 per cent by 2040. This represents an opportunity for significant energy savings if measures are taken to improve the efficiency (e.g. with passive and vernacular design). However, if efficiency is not prioritized, building energy use could increase as the population grows and average income increases, as has been projected for electricity.

FIGURE 4.2 Commercial energy use in Malaysia in 2011 *(Chong et al., 2015)*

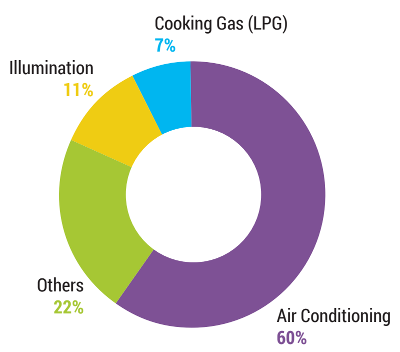


FIGURE 4.3 Residential energy use in Malaysia in 2011 *(Chong et al., 2015)*

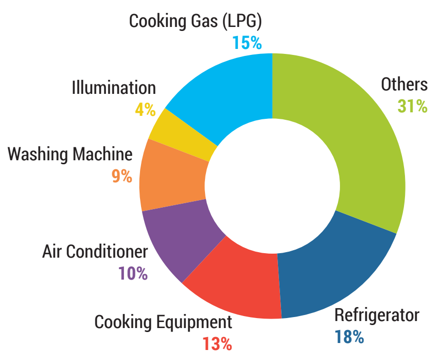


FIGURE 4.4 Energy Overview of Southeast Asia *(OECD/IEA, 2015)*

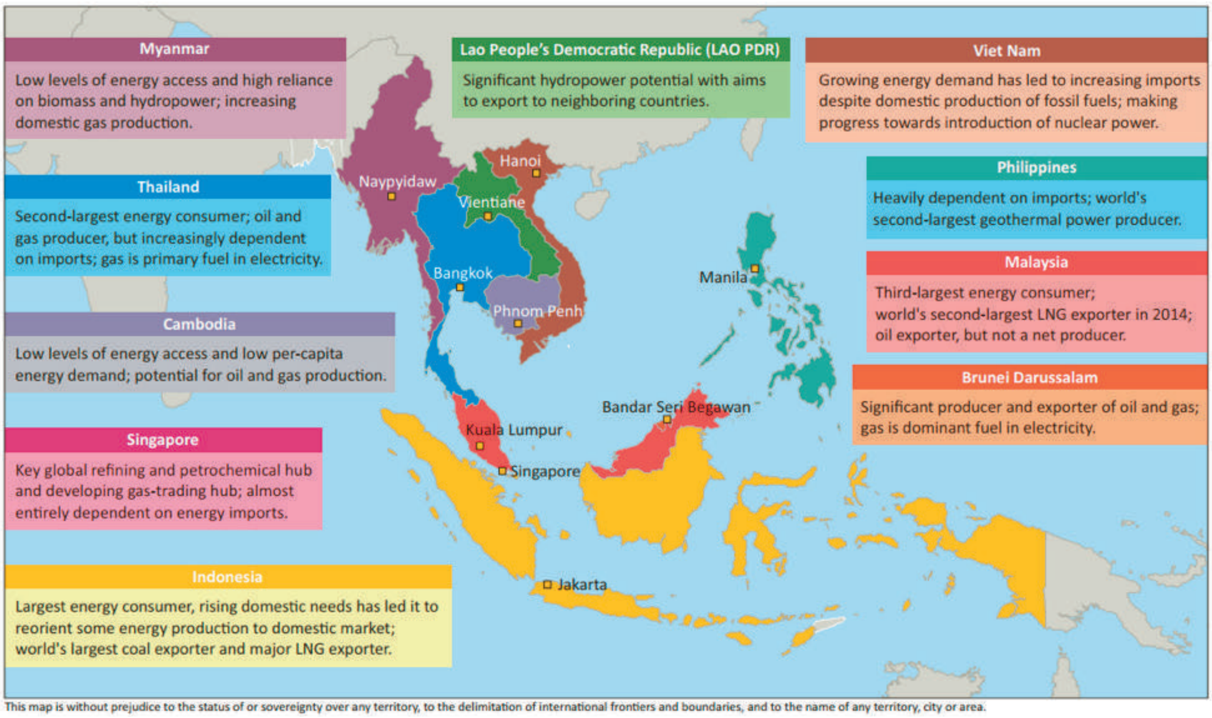


FIGURE 4.5 **Selected energy policies and targets in Southeast Asian Countries included in the New Policies Scenario** *(WEO Southeast Asia, 2015)*

Country	Sector	Policies and Targets
Brunei Darussalam	Efficiency	Reduce energy intensity by 45% from 2005 levels by 2035
	Renewables	Achieve 10% of electricity generation from renewables by 2035
Cambodia	Efficiency	Reduce energy consumption 20% from BAU level by 2035
Indonesia	Efficiency	Reduce energy intensity by 1% per year to 2025
	"New and Renewable Energy"	Increase share of "new and renewable energy" in primary energy supply to reach 23% by 2025 and 31% by 2050
	Climate Change	Reduce GHG emissions 26% from BAU level by 2020, increase to 41% reduction with enhanced international assistance
Lao PDR	Efficiency	Reduce final energy consumption from BAU level by 10%
	Renewables	Achieve 30% share of renewable in primary energy supply by 2025
Malaysia	Efficiency	Promote energy efficiency in the industry, buildings and domestic sectors
	Renewables	Increase capacity of renewables to 2 080 MW by 2020 and 4 000 MW by 2030
	Nuclear	Government is developing plans and undertaking feasibility, site selection and regulatory studies
	Climate Change	Reduce carbon intensity of GDP by 40% by 2020 from 2005 levels
Myanmar	Efficiency	Reduce energy demand by 10% from BAU level
	Renewables	Achieve 15% to 18% share of renewables in total generation capacity by 2020
Philippines	Efficiency	Attain energy savings equivalent to 15% of annual final demand relative to BAU by 2020
	Renewables	Triple the installed capacity of renewables power generation to 15GW by 2030
Singapore	Efficiency	Reduce energy intensity by 35% by 2030 from 2005 levels
	Climate Change	Reduce GHG emissions by 7% to 11% below BAU levels by 2020, which will be increased to 16%, if there is a legally binding global agreement on climate change. Reduce GHG emissions intensity by 36% by 2030 from 2005 levels
Thailand	Efficiency	Reduce energy intensity by 30% compared with 2010 by 2036 through the removal of fossil-fuel subsidies and accelerated energy efficiency improvements
	Renewables	Renewables to reach 20% of power generation by; biofuels to reach 20% of transport fuel use by 2036
	Nuclear	Two commercial reactors have been planned since 2007, although progress has stalled since the Fukushima Daiichi accident
Viet Nam	Efficiency	Reduce energy consumption by 5% to 8% by 2015 and 8-10% by 2020 relative to BAU
	Renewables	Increase the share of renewables in electricity generation to 4.5% by 2020 and 6% by 2030
	Nuclear	Develop 10.7 GW of nuclear power capacity by 2030

Notes: BAU = business-as-usual; ; MW = megawatts; GW = gigawatts

4.3 Strategies for Buildings and Energy in the ASEAN context

Building cooling, lighting and refrigeration are the key areas of building energy efficiency. This can be achieved by way of five strategies:

1. Passive design and efficient technologies integrated into green building rating systems
2. Integrating green building design with performance monitoring
3. Addressing efficiency across modern high rise, ordinary and vernacular buildings Vernacular designs
4. District cooling

Green building rating systems often integrate multiple passive design and energy efficient technology features into a prescriptive checklist-based approach such as that employed by the United States Green Buildings Council's LEED systems and Singapore's Green Mark rating systems, largely developed for modern high-rise buildings. However, studies comparing actual green building performance with their unrated peers in many world cities have shown that while promoting green building design through rating systems can be very effective, their performance must be measured and monitored to ensure resource efficiency gains are realized (Scofield, 2013; Menassa, 2012; BCA, 2015). Furthermore, case studies from China and design standards developed in India highlight the importance of retaining existing ordinary and vernacular buildings that already consume much less energy, accommodating local cultural norms and behaviours. All these aspects must be considered together to develop a highly resource efficiency building stock in diverse ASEAN cities, ranging from small to large. The case studies and strategies presented in this section highlight the nuances of building design, rating, monitoring and structural code-compliance in the context of diverse multi-storey buildings seen in Asia, contextualized to local behaviours and norms.

No one strategy is best for all situations. Each city, neighbourhood and building is different and as such, a variety of strategies should be considered depending on the region, climate, natural disaster risk, cultural norms and available materials.

4.3.1 Passive Design Strategies and Multi-Storey Green Buildings

Passive design strategies must be incorporated in green building standards and rating systems, aiming to reduce energy demand by leveraging natural site features and natural phenomena (like shading, day-lighting or natural ventilation), followed by the use of for energy efficient technologies for heating, lighting and ventilation and air conditioning systems; and efficient appliances. The primary objective in a passive design strategy in hot and humid climates is to minimize solar thermal heat gains and promote ventilation, so that the cooling requirements in a building can be reduced, thereby, reducing the cooling capacity required of the air conditioning equipment (ERIAA, 2017). Box 4.3 lists some key principles of passive design.

Passive buildings in hot and humid climates employ shading, open corridors and courtyards to promote passive cooling (TERI, n.d.). However, few examples of fully passive multi-storey commercial buildings exist for the hot and humid climates as in the ASEAN region. As is often common in multi-storey green commercial buildings, a combination of mechanical and passive cooling strategies are used.

The Diamond building (Figure 4.6) is an example of a green-rated commercial building in the ASEAN that incorporates several passive design features, and is designed to consume only one third the energy of a comparable high-rise building in Malaysia, while delivering the same benefits (Leung and Mar, 2013). This example indicates that high levels of energy efficiency can be achieved in a fully operating large office building in the ASEAN compared to its peers.

The Diamond building incorporates the following passive features: landscaping around the first level promotes cross ventilation through the basement, as shown in figure 4.6b; a central light atrium that promotes passive ventilation and harvests visible sunlight and distributes daylight to each floor through a central open space; glass exterior has a glazing that reflects infrared radiation (e.g. heat) but allows visible light to penetrate, minimizing heating from the sun and the need for conventional lighting; diamond shaped structure which maximizes rooftop surface area for solar panels that fulfill 10 per cent of the building's energy needs. While glazed glass can be useful for optimizing daylighting and controlling heat gain/loss, using large quantities of glass covering a full building may not be the best way to reduce heat gain, and further, increases resource use in manufacturing of the glass.

Passive building designs, which take advantage of shading and building orientation, thermal insulation strategies, as well as use of energy efficient technologies, have been shown to collectively help increase the number of comfortable hours experienced by residents of hot climates, leading to significant reductions in cooling loads. An example of a partially passive low-rise office building design in Bangalore, India is shown in Box 4.4. In other case studies in Delhi and Mumbai, India passive design strategies have been used in multi-storey housing, increased the number of hours in the comfort range by approximately 60 per cent (IIEC 2011), particularly relevant in low income and social housing to minimize energy bills.

As discussed in Box 4.3, reducing the thermal transmittance of the building envelope can improve the efficiency of a building. Maximizing the insulation and minimizing the leakage can reduce the cooling and heating load, and reduce the overall energy consumption. Locating lifts (elevators), staircases, air handling units and other service cores on the perimeter of the building will also provide added insulation.

The landscape needs to be considered when evaluating whether to incorporate passive design. Passive cooling is ideal for cities with wide roads where air circulation is not inhibited. If the roads are narrow surrounding the building the road ways are often congested, the air flow may not be conducive for passive cooling.

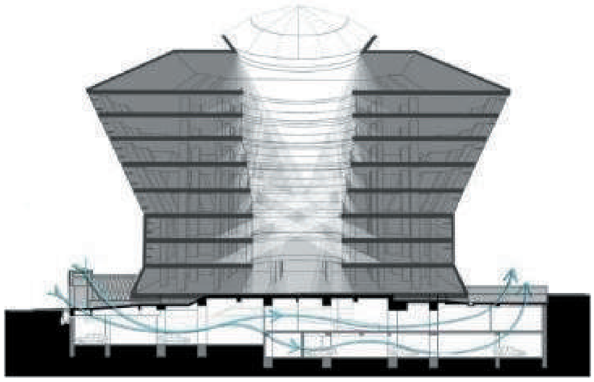
Natural disasters such as flooding, earthquakes and typhoons should be accounted for in the design of passive buildings. During typhoon Yolanda wind gusts reached speeds of 385 kilometres per hour and max ten-minute sustained speeds of 285 kilometres per hour (HKO, 2017), resulting in over 6,300 deaths in the Philippines alone (NDRRMC, 2015). Passive homes need to be able to withstand high winds. If flooding is common the living quarters should be elevated to the second level or higher. Windows that allow for passive cooling, but are also safe and difficult to break into should be incorporated. For example, windows with louvres allow for natural air flow, shade the sun reducing heat gains, can be closed during storms and are secure.

After exploiting natural daylight, light-emitting diode (LED) and compact fluorescent lamp (CFL) lighting can save building energy use by as much as 78 per cent compared to traditional incandescent lighting and providing similar levels of lighting (United States DOE, n.d.). Across six Southeast Asian countries, including, Thailand, Singapore, Malaysia, Indonesia, Viet Nam and the Philippines, market penetration of LED lighting has increased substantially from 2012 to 2015, representing just over 30 per cent of the lighting market indicating progress and much more room to grow (TrendForce, 2015). All these examples and trends suggest that green buildings with efficient technologies can be approximately 40 per cent efficient.

FIGURE 4.6 Example of passive design- the Energy Commission "Diamond" Building in Putrajaya, Malaysia
(Leung and Mar, 2013)

A

B



BOX 4.3 **Passive building design elements** *(ERIA, 2017)*

1. Building orientation that has the longer building axis facing north–south so that the narrow ends of the building face east–west.
2. Building facades that provide shading to windows.
3. External shading devices.
4. Windows with low thermal transmittance and glazing that minimizes solar heat gains in order to minimize energy use while maximizing daylight effectiveness.
5. Reduce window to wall ratio.
6. Building and insulating materials that provide low thermal transmittance of the walls and roofs. Suitable building materials including better insulating materials (roofs, walls and windows) are recommended to be used in roofs and walls.
7. Location of service cores, such as lifts, staircases, air handling units (AHUs), and toilets, at the sides of a building especially facing east and west will help minimize solar heat gain through the building envelope.
8. Strategic landscaping that provides shading from the sun, shielding from heat reflection, and use of paving materials with a high solar reflective index in the surrounding spaces will help create a cooler microclimate environment around the building.
9. Daylighting design that captures the natural daylighting to reduce the need for artificial lighting.
10. Natural ventilation that makes use of the natural forces of wind and buoyancy to deliver sufficient fresh air and air change to ventilate enclosed spaces without the needs of relying on air conditioning. There are two basic methods for providing natural ventilation: cross ventilation (wind-driven) and stack ventilation (buoyancy-driven).
11. Measures to prevent air leakage as uncontrolled mixing of outside air with airconditioned spaces require more energy to remove moisture and heat gain contributed by air leakage. Vestibules should be installed on primary entrance doors to reduce the infiltration of outside air for commercial buildings or buildings with large floor areas.

BOX 4.4 **Passive cooling at The Energy and Resources Institute (TERI) building in Bangalore** *(TERI)*

The Energy and Resources Institute (TERI) in Bangalore is designed to maximize passive cooling. The longer side of the building is parallel to the exterior air flow. The building is oriented so that hot air coming from the south rises over the building, creating a low-pressure zone north of the building. Windows are located on the lower levels of the north side of the building and bring in lower pressure and cooler air. The roof of the south side of the building has vents to allow the hot air that rises in the building to exit. This creates a natural air flow from the lower north side of the building to the upper south side. To reduce the heating on the south side due to the direct sunlight there are two layers of walls to provide added insulation and trees to block part of the sunlight. The building also has a mechanical airconditioning unit to support the building when needed.

FIGURE 4.7 **TERI building in Bangalore passive ventilation** (*HPCB*)

BOX 4.5 **Singapore Green Mark building performance rating system**

An example of a national green building programme to promote building efficiency is Singapore's 'Green Mark' programme. The Green Mark programme was launched in January 2005 as an initiative to drive Singapore's construction industry towards more environmentally-friendly buildings. Much like the United States LEED certification programme, any residential or commercial building can apply to become Green Mark certified and all buildings with a square footage of 2,000 square metres or more are required to participate. The Green Mark programme takes a check-list approach to rating buildings. The building is rated based on the qualifications met. By July 2016, over 2,800 buildings had been 'Green Mark' certified.

To receive the certification, buildings are assessed for energy efficiency, water efficiency, environmental protection, indoor environmental quality and other green features. The requirements for Green Mark certification differ for existing and new construction buildings, and based on the building category (e.g. residential, non-residential, landed houses, schools, healthcare facilities, etc.). After meeting the various requirements to become Green Mark certified, it is expected that gold and platinum buildings will use 25- 30 per cent less energy than other, non-Green Mark buildings. However, with Singapore's building performance monitoring programme the actual savings was discovered to be much lower, highlighting the importance of pairing green building ratings with performance monitoring and assessments.

4.3.2 Green Building Rating along with Performance Tracking is Essential

Passive design and the use of energy efficient technologies should be incorporated into building standards and encouraged through green building rating programmes. Many ASEAN nations have instituted voluntary and some mandatory green building rating systems, however, not all ASEAN nations have instituted such rating systems. Examples of two rating systems, one in Singapore and one in The Philippines, are shown in Boxes 4.5 and 4.6. Green building standards are mandated to varying levels in ASEAN nations, as noted in Appendix C.

While green rating schemes that employ a checklist approach like the Green Mark, BERDE and United States LEED programmes can be effective in promoting the integration of energy efficient technologies and passive design features, recent studies have shown that the actual performance of green rated buildings can be highly variable. Studies show that green building rating systems that rely solely on the checklist approach underperform compared to modelled expectations (Box 4.7; Scofield, 2013; Menassa, 2012), and may not always result in reduced resource use (per area) compared to non-rated peer buildings. For example, benchmarking studies of more than 900 buildings in New York City (including 83 LEED certified buildings), found that only the highest Gold rated buildings consumed 20 per cent less energy compared to peer non-rated buildings; LEED silver and lower rated buildings actually were shown to consume the same or even more than their un-rated peers. These examples illustrate the importance of performance monitoring and benchmarking energy use in real-world buildings.

Understanding how buildings use energy through performance monitoring and reporting is critical to ensure that anticipated energy use reductions are achieved in practice, and to uncover technological malfunctions or occupant behaviours (See Box 4.8) that impact energy use. Data enables informed decision making and good quality data is essential for policy makers to prioritize energy saving strategies and track implementation. Building owners, facilities managers and tenants gain information necessary to improve the efficiency of their building. Tracking building performance allows stakeholders to determine whether energy efficiency measures dependent on behavioural changes are carried out. An example of a building performance monitoring programme in Singapore is shown in Box 4.9.

4.3.3 Energy Intensity of Modern Buildings, Ordinary Buildings and Vernacular Buildings

Well-designed and operated green buildings show great technical potential to increase efficiency. However, city-wide energy use reductions may be lower than expected based solely on comparing modern green building with their modern peers, where modern is used to denote steel-concrete high rises with tight-envelopes that are centrally cooled/heated, which is the norm in advanced economies. In reality, cities, particularly cities in Asia, offer a diversity of architectures and functioning of buildings, such as ordinary buildings that may not use any air conditioning or only be partially spot-cooled, to fully passive vernacular designs that consume much less energy than the “modern green building” because of occupant behaviour, fully passive design and cultural practices that support a warmer room temperature. Thus, it is important to consider energy efficiency in modern steel-concrete high-rise buildings and the value offered by ordinary buildings and vernacular building designs that require minimal cooling.

In some cases in Asia, modern green-rated buildings may be more efficient when compared to their peer design comparison-case, but may have greater energy intensity compared to ordinary or vernacular counterparts. For example, Zhang et al. (2010) found older commercial buildings with split AC units that cool select spaces for fewer hours a day, used less energy per square foot compared with newer, green commercial buildings in China that are centrally-cooled efficiently, but cooled all the time. Green rating systems should therefore account for the purpose of the building, occupant behaviour, cooling requirements (e.g. is a set point temperature of 30 degrees Celsius acceptable), and alternative designs that could meet the primary needs of the building. For example, the Indian Green Building Council Green Rating for Integrated Habitat Assessment (GRIHA) rating programme accounts for various building cooling strategies and functional uses. With the GRIHA programme, a suite of Green Building standards are developed to promote increased energy efficiency in different building types, including modern buildings with tight envelopes and shared central cooling; ordinary buildings with variable cooling loads; and vernacular buildings in which passive cooling alone is acceptable.

It is important to consider the cooling requirements of a building, the required indoor temperature during the day and night, and occupant behaviour when selecting a cooling system. Green rating systems should be adaptive and promote a variety of design approaches, comfort requirements and cooling methods depending on the functional requirements of the building and occupant behaviours. This also raises a healthy debate

BOX 4.6 The Philippine BERDE green building rating system

The Philippine Green Building Council (PHILGBC) green building rating scheme Building for Ecologically Responsive Design and Excellence (BERDE) is a voluntary green building rating scheme started in 2009 (Altin, 2017). The Net Lima building in Bonifacio Global City was the first building to receive BERDE certification in 2014. The commercial building received a four-star rating (The Manila Times, 2016).

Buildings receive a rating of one to five stars, with a higher rating indicating the building is more sustainable. Buildings are evaluated on the environmental performance of the building from pre- to post-construction phase; land use; protection of ecological features; energy demand and use of energy efficient technologies; water consumption and wastewater production; use of alternative transportation; indoor comfort; use of recycled materials; waste production during the construction and operation phase; and use of innovative technologies (PHILGBC, 2013). As part of the energy rating system, additional points are given if the building has passive cooling features. The buildings are also evaluated in terms of the preservation of historical heritage. As part of the BERDE certification buildings are also assessed for climate vulnerability, including flood risk management.

BOX 4.7 Green design accompanied by performance tracking is essential

The Government of Singapore launched the Building Energy Submission System (BESS) in 2013, with the goal to monitor the energy use of the existing commercial building stock and assess the performance of Green Mark buildings (Iyer et al., 2016).

High Levels of Reporting

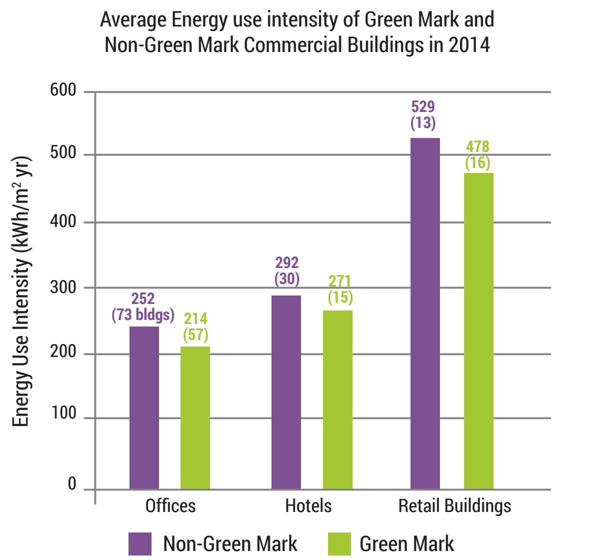
The monitoring system BESS requires reporting of building ownership and activity, characteristics, service information (e.g. number of escalators), and energy consumption by building owners. The benchmarking data is made available to the building owners so that building energy performance and energy consumption dependent on user behaviour can be pro-actively monitored and improved. Though the building energy consumption details are made available only to building owners, the Building and Construction Authority (BCA) releases an annual report highlighting energy consumption patterns among commercial buildings, as well as a comparison of green-rated building performance to the rest of the building stock. BESS is conducted annually, and surveyed 1,108 buildings in 2014.

Building Performance Monitoring: Understanding Energy Savings Relative to Existing Buildings

With the BESS, Singapore is able to compare the overall efficiency of Green Mark buildings and non-Green Mark buildings. In 2014, 1,018 Green Mark and non-Green Mark buildings entered energy data for their facilities representing a 96 per cent compliance rate. Figure 4.8 shows a comparison of a subset of non-Green Mark (blue) and Green Mark buildings (green) with similar functions (130 offices, 45 hotels, 29 retail buildings), size, annual occupancy, airconditioning, contain rooms with similar functions and tenant mixes (retail) as well as proximity to public transportation. Green Mark buildings have on average a lower energy use per gross floor area (EUI) than non-Green Mark buildings. Green Mark offices consumed 15 per cent less energy than similar non-Green Mark offices in 2014 (BCA, 2015). Hotels consumed 7 per cent less and retail buildings Green Mark buildings consumed 10 per cent less. **While these reductions are positive, it is less than the 25-30 per cent reduction expected with Green Mark certification and 48 per cent reduction associated with LEED as was modelled in the *Weight of Cities*.** These real-world findings indicate the importance of both behaviour in green buildings and the importance of monitoring and benchmarking actual building performance systematically. The Singapore BCA is now providing incentives for actual energy use reductions, incorporating behaviours rather than only the adoption of green buildings. For more information on buildings energy in Singapore, see the BCA Building Energy Benchmarking Report 2015.

FIGURE 4.8 Singapore's Green Mark building performance compared to non-Green Mark performance. Numbers above bars indicate the energy use intensity and number of buildings included in the average in parentheses *(data from BCA, 2015)*

To ensure fair comparison between the Green Mark buildings and non-Green Mark buildings in terms of EUI performance buildings were normalized based on size, annual occupancy type of airconditioning system, whether they contain function halls/meeting rooms (hotels only), tenant mix (retail only) and proximity to public transport facilities (retail only).



as to whether buildings with efficient centralized air-conditioning in Asia are more or less energy intensive than ordinary and vernacular buildings in the region (Box 4.9) that are spot-cooled for fewer hours of a day, or not mechanically cooled, respectively. A further consideration is the materials used in multiple split air conditioning units used to spot cool different rooms in the house versus a single large chiller that may be used in centrally cooled buildings and district cooling systems. More field studies of large groups of diverse building types in Asia, along with life cycle assessments comparing direct energy savings with embodied energy of materials, will help answer this question that is critical to answer as Asia urbanizes and its residents enter the urban middle-class consumer group. In general, where possible, passive cooling should be promoted. When passive cooling alone will not meet the functional needs, minimizing the cooling load by limiting the time and the number of rooms cooled either using sensors technologies in smart buildings, or by considering spot-cooling in ordinary buildings, may both result in a lower energy intensity.

4.3.4 Vernacular building designs

The design of vernacular buildings incorporates local conditions such as climate, available materials, architecture design and lifestyle to design buildings that may have virtually no mechanical cooling. Walk up low-rise multi-storey buildings (2-3 storeys) may be constructed using vernacular approaches versus large steel and concrete buildings. Vernacular design often incorporates region specific building materials and often consume much less energy than modern green buildings. Vernacular design typically use materials that enhance passive cooling, versus steel and concrete buildings which inhibit ventilation.

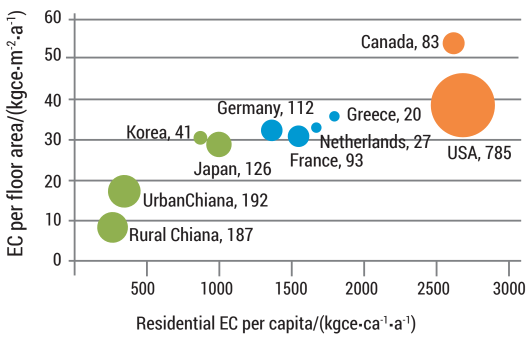
Many ASEAN countries have policies to preserve historical and vernacular buildings. For example, the master plan for Phnom Penn, Cambodia includes the preservation of historical monuments. The Philippines has a Cultural Heritage Law which protects and preserves historical and cultural sites. Myanmar has a "Protection and Preservation of Cultural Heritage Regions Law". Incorporating vernacular design into building standards can help reinforce existing heritage preservation laws and may provide an alternative source of funding for green buildings if funding has been allocated to preserving historical and vernacular sites.

Vernacular designs offer several climate specific passive features (Zhai and Previtali, 2010; Omar and Syed-Fadzil, 2011). Design features, common in vernacular architecture that reduce indoor temperatures in hot and humid climates include high ceilings, low walls on the first floor, low windows and passive vents in the ceiling. Vernacular buildings typically have thermally efficient walls made of materials commonly found in the region. Windows are fitted with openings for ventilation and typically made of timber. This allows stack ventilation to occur more efficiently. Stack ventilation occurs when low-density, warm air rises and exits through openings either in the ceiling or higher in the walls. Cool air enters the room through low-positioned openings and occupies the low-pressure space created by the exited warm air. When additional cooling is needed, distributed solar can be incorporated into the design (see the next section for discussion of distributed solar and geothermal cooling options).

BOX 4.8 Lifestyle and culture reduce energy use in households in China *(Zhang et al., 2010)*

In China, when heating is omitted from the total, the unit area household energy use is one third of the United States unit area household energy use (Figure 4.9). The lower energy intensity of Chinese households has been attributed to lifestyle differences. Examples include: 1) the preference for natural lighting in China, resulting in less energy being used per person; 2) turning lights off when not in use is common; 3) passive aircondition methods are more common and when mechanical air conditioners are used the units are used in moderation; 4) residents wear less and lighter weight clothing when the outdoor temperatures rise; 5) residents use less energy to dry clothes, since the preferred method to dry clothes is on clotheslines; and 6) taking more showers than use bathtubs. Using bathtubs require more than three times as much energy as showers and are less common in China than in developed countries. In addition, Chinese usually take showers when the sun is out and can heat auxiliary heaters. In the United States, over-cooling commercial buildings is also an issue. Over-cooling commercial building was estimated to cost US$10 billion and was responsible for 57,125 kilotons carbon dioxide equivalent in 2012 (Derrible and Reeder, 2015).

FIGURE 4.9 2005 primary energy use in residential buildings. Number after the name of the country is the total energy use of the corresponding country (Mtce)
(Zhang et al., 2010)



BOX 4.9 Accounting for existing buildings and behaviours in building rating systems

The Indian Green Building Council Green Rating for Integrated Habitat Assessment (GRIHA) is a national rating system in India that incorporates differences in energy system components in existing buildings versus new buildings. The standard recognizes that systems in existing buildings (e.g. split air conditioning, fans) can be operated differently than systems (e.g. continuous air conditioning units) in new buildings.

A key difference between Singapore's Green Mark and India's GRIHA programme are the requirements to become certified. The Green Mark programme assesses individual components of the building. For example, in Non-Residential Existing Buildings the unitary airconditioners efficiency must be greater than 2.4 coefficient of performance. Mechanical fan system must use less than 0.47 W per meter cubed per hour if it is a constant air volume fan and less than 0.74 W per meter cubed per hour for variable air volume fan. Alternatively, the GRIHA programme uses an adaptive thermal comfort model meaning different requirements are listed for naturally ventilated buildings, mixed-mode air conditioned buildings and full air conditioned buildings.

The Singapore BCA may consider changing the rating system to take into consideration the existing building systems. For example, existing buildings without continuous air conditioning units could have different requirements to become Green Mark certified.

BOX 4.10 A Debate on Centralized Cooling in Modern Buildings versus Spot Cooling in Ordinary Buildings

Zhang et al. (2010) found older commercial buildings with split air conditioning units used less energy than newer, green commercial buildings. Figure 4.10 compares the energy intensity of ordinary commercial buildings in Beijing with fans only, ordinary commercial buildings with split air conditioning units and large scale commercial buildings with centralized air conditioning systems in newer green buildings that focus on a tight envelope.

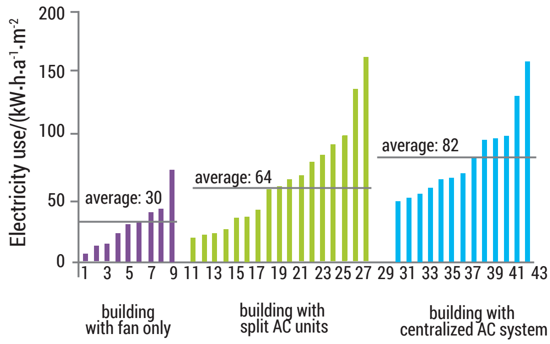
Centralized AC systems are considered more energy-efficient compared to split air conditioning units that serve individual households or rooms, when comparing cooling achieved over the same time period and area. However, this may not always translate to reduce energy use intensity in buildings during real-world operations, since split airconditioners can be operated part-time or only in occupied rooms, as is commonly practiced in China.

At the same time, split air conditioners may create much added use of materials in multiple smaller air conditioning units, including ozone depleting chemical refrigerants. Life-cycle assessments are needed to compare the load profile incorporating occupant behaviours, interior temperature requirements, refrigerants and overall resource requirements of the different cooling strategies and practices in different building types.

In general, where possible, passive cooling should be promoted. When passive cooling alone will not meet the functional needs, minimizing the cooling load by limiting the time and the number of rooms cooled either using sensors technologies in smart centrally-cooled buildings, or by considering spot-cooling in ordinary buildings, may both result in a lower energy intensity in real-world building operations.

FIGURE 4.10 Annual unit area electricity use of buildings in Beijing in 2006 *(Zhang et al., 2010)*

Annual unit area electricity use of buildings in Beijing in 2006 (Unit: kWh) showing that ordinary commercial buildings with split air conditioning units consume less energy on average relative to large scale commercial buildings with central centralized air conditioning, which is expected and designed to be more efficient.



In recent years, Malaysia has seen an increase in energy consumption by buildings from all sectors. A significant portion of the energy consumed annually is spent to cool residential and commercial buildings (Omar and Syed-Fadzil, 2011). However, there is possibility that the country's overall energy usage may be reduced if cooling loads are minimized via passive design which is common in the regions vernacular architecture. While low cost vernacular solutions for cities in hot and humid climates can be challenging to find, good examples do exist. Box 4.11 provides an example of a vernacular design, the Penang shophouse, in the state of Penang in Malaysia.

When incorporating vernacular design into building standards it is important to consider structural performance needs in high rise buildings as well as region specific risks including typhoons, earthquakes, flooding and extreme heating. ASEAN cities located on coastal areas and their infrastructure are exposed to higher risks of disasters and negative effects of climate change, such as flooding, typhoons and mudslides. In 2014, 56 per cent of the cities with 300,000 inhabitants or more were at risk to at least one of six types of natural disasters (United Nations, 2016). For cities located in coastal regions, building ordinances or codes should require the building to be designed to withstand typhoon speed gusts. For buildings located in flood prone areas, it is recommended to raise the ground floor or leave the ground floor open to cope with flooding.

Designing for disaster risk resilience is not the focus of this report, however resource efficiency can be combined with disasters resilience design. Further, some vernacular architectures can offer resilience to certain risk factors, e.g., vernacular bamboo construction housing, and also offer environmental sustainability. Research is needed to combine vernacular architectures which offer high levels of resource efficiency and occupant comfort with established guidelines for disaster resilience. Examples of building design features that enhance resilience to extreme events are shown in Box 4.12.

The need for regional research and capacity building: Given than significant future urbanization will occur in smaller and larger ASEAN cities, regionally relevant research centres that investigate the integration of vernacular and high rise building design, combining elements of disaster risk resilience and environmental sustainability can advance both goals. In addition to building design, institutionalizing resource efficient and disaster resilient design guidelines into building codes is of high importance, along with capacity building to implement, monitor and enforce the codes (GFDR, 2016). A UNESCAP (2012) study found that few nations have institutionalized multiple elements of

BOX 4.11 Penang heritage shophouse: Vernacular design case study

One common Penang building with vernacular architectural features is 'shophouse'. Shophouses can be used in the residential and/or commercial sector. Many of Penang's shophouses were built in the nineteenth and twentieth century and have key design elements of that time such as arches and stylized columns. Most of the original shophouses incorporate passive cooling and solar shading design features such as large open spaces, shuttered doors and sheltered pedestrian walkways. Other features such as jack-roofs and air wells can also be found in some of the buildings. Due to these design features the indoor environment tends to be much cooler than the outside.

One study found the interior of a shophouse in Penang, the UNESCO World Heritage Site, remained at a temperature the occupants found comfortable during the day despite the lack of mechanical ventilation and outdoor temperatures fluctuating between 25 °C to 32 °C (Omar and Syed-Fadzil, 2011). In Penang, 28.7 °C is considered comfortable (Omar and Syed-Fadzil, 2011) as compared to 22 °C in the United States (NREL, 2014). As is typical in Penang heritage shophouses, this World Heritage Site has relatively high thermal mass as its thick walls are constructed of clay bricks. A few of the features of this building which may contribute to its thermal performance include Chinese styled air vents near the ceiling, the doors and windows are constructed of timber and are fitted with shutters that allow passive ventilation to occur (Figure 4.12), the wall is constructed low on the first floor (to allow maximum ventilation via tall shuttered windows) and fitted with air vents (Omar and Syed-Fadzil, 2011).

The main contributing factor that may have affected the reduced peak temperature within the Penang heritage shophouse is its high ceiling on the lower level. This allows stack ventilation to occur more efficiently.

FIGURE 4.11 Heritage shophouse in Penang, Malaysia
(Omar and Syed-Fadzil, 2011)

BOX 4.12 Disaster resilient strategies for buildings
(UN-ESCAP, n.d.)

The following strategies can improve the resiliency of buildings and minimize impacts of extreme weather events.

- Build where there are natural barriers or add natural barriers from the wind. For example, build into the side of a hill or near vegetation.
- Avoid positioning buildings in rows since it can create wind tunnels.
- Build square versus rectangular or L-shaped buildings.
- If the building is rectangular, have the short side face the wind.
- Avoid having long dimensions or high walls.
- Reinforce the main structural frame by installing bracing and cross-bracing on walls and roof frame.
- Ensure critical joint connections are safely anchored.
- Roofs should have a slope between 25 and 45 degrees to prevent 'fly-off'
- Avoid low pitch roofs.
- Avoid long eaves or roofs with extended overhangs.
- Raise the first floor using stilts in areas prone to flooding. However, for multi-storey concrete construction, the use of 'soft storeys', i.e. the open ground floor will require strategies for additional structural strength (Arya and Gupta, 2014).
- Ensure there are exits on more than one side of the building in case one exit is unable to be opened due pressure on the outside.

FIGURE 4.12 Example of a building on stilts
(wfeo.org, n.d.).

FIGURE 4.13 Countries with environmental sustainability integrated into building codes (green) and not integrated into building codes (red) *(ESCAP, 2012)*

Environmental Sustainability	USA	Singapore	Australia	UK	Thailand	India	Bangladesh	Philippines	Sri Lanka
Material Conservation & Efficiency	●	●	● (red)	● (red)	● (red)	●	● (red)	● (red)	● (red)
Energy Conservation & Efficiency	●	●	●	●	●	●	updating (red)	voluntary (red)	updating (red)
Water Conservation	●	●	●	●		●	updating (red)	● (red)	● (red)
Land and Soil Conservation	●	●	● (red)	● (red)	● (red)	●	● (red)	● (red)	● (red)
Solid Waste Reduction	●	●	● (red)	● (red)	● (red)	●	● (red)	● (red)	● (red)
Air Pollution Control	●	●	● (red)	● (red)	● (red)	●	● (red)	● (red)	● (red)

FIGURE 4.14 Countries with disaster resilience integrated into building codes (green) and not integrated into building codes (red). N/A means could not be verified or not applicable *(ESCAP, 2012)*

Environmental Sustainability	USA	Singapore	Australia	UK	Thailand	India	Bangladesh	Philippines	Sri Lanka
Wind Load	●	●	●	●	●	●	●	●	voluntary (red)
Snow Load	●	N/A	●	● (red)	N/A		N/A	N/A	N/A
Seismic Load	●	N/A	●	N/A	●	●	●	●	N/A
Rain & Flood	●	N/A	●	● (red)	● (red)	● (red)	updating	● (red)	● (red)
Wildfire and Bushfire Resistance	●	●	●	N/A	● (red)	● (red)	● (red)	● (red)	N/A
Landslide Resistance	● (red)	●	●	● (red)	● (red)	● (red)	● (red)	● (red)	● (red)

BOX 4.13 District cooling in Singapore

The city of Marina Bay in Singapore, for example, which has a climate that is very warm and humid requiring a relatively high number of cooling degree days which is almost double that experienced by several major Indian cities (Shanmugapriya and Migdalska 2016, WeatherUnderground 2016), implemented a pilot district cooling system in 2006. The system provides air conditioning services to residential and business consumers using an integrated network of underground pipes which has grown since 2006 to become the world's largest district cooling system, with a piping network of 5 kilometres. The Marina Bay district cooling system is reported to result in energy savings of more than 40 per cent (Othman 2016), resulting in less greenhouse gas emissions and improved air quality for the surrounding region. Singapore Energy is also slated to open a new district cooling plant in Raffles City Chongqing, China in 2018, expecting energy savings of up to 50 per cent compared to conventional building chiller technologies, which is an equivalent savings of approximately US$30 million over 20 years (AsianPower 2015).

BOX 4.14 District cooling with sea water in Stockholm

The Fortum Värme district cooling network in Stockholm uses sea water to produce 0.45 TWh annually and a cooling load of 220 MW (Levihn, 2017). Sea water is drawn into the system from Baltic Sea and used to cool water in pipes which is then returned to the district cooling network in the city. When 24-hour storage is needed, the cooled sea water is stored in a 50,000 cubic metre rock storage chamber beneath the city. In the winter, the water for district heating is heated with waste incineration, biomass, combined heat and power (CHP) and centralized heat pumps utilizing recycled heat from sewage treatment facilities (Levihn, 2017). Sea water cooling can be leveraged in coastal ASEAN cities.

BOX 4.15 Thailand's renewable energy policy

Thailand's renewable energy policy is unique to other Southeast Asian countries as it includes both a renewable energy target for electricity generation and for transportation fuels, calling for 20 per cent of transport fuel and power generation energy mixes to be supplied by renewables by 2036 (OECD/IEA, 2015). These 2036 targets are expected to reduce Thailand's current carbon emission intensity per unit of electricity generated by 20 per cent by shifting to greater shares of renewable energy and higher efficiency technologies (LSE 2015). To meet such goals, Thailand's national government have set forth a series of milestones through the Power Development Plan 2015-2036 (LSE 2015) and Alternative Energy Development Plan which would more than triple the amount of renewable energy capacity in the electric grid system by 2036. Solar photovoltaics have a planned generation of 6,000 MW, the largest portion of the planned generation capacity, followed by use of biomass at 5,570 MW and onshore wind at 3,000 MW. These goals are supported through various mechanisms, such as feed-in tariff schemes to accelerate investment in renewable energy generation.

environmental sustainability and elements of disaster resilience in their building codes. See Tables. Thus, there is a critical need both for regional research and capacity building to develop models for different types of resource efficient and disaster-resilient buildings, suited to different city sizes (e.g., row houses, low-rise and high rise buildings).

4.3.5 District cooling

For higher density neighbourhoods, district cooling can be used to cool multiple buildings and is assumed to be more efficient than individual homes using their own presumably less efficient airconditioners (see Box 4.7 for behavioural impacts on air conditioning energy use). A district cooling system refers to a system that generates cooling energy at a central plant and distributes chilled water through a network of supply and return piping interconnected with multiple buildings within region via an energy transfer station. It is ideal for a region with mixed development of residential homes, offices, commercial buildings, hospitals, schools, and other institutional buildings (ERIO, 2017). Due to rising temperatures experienced by ASEAN nations, and the climbing household incomes, electricity use for airconditioning is increasing (OECD/IEA, 2015). Several ASEAN countries including Singapore and Malaysia, have begun to implement district cooling systems to satisfy the population's growing thermal comfort demands. Benefits of district cooling include: (1) combining cooling loads for multiple buildings allows the overall system to be more efficient; (2) sea water, geothermal and waste-heat can provide virtually fossil-energy free cooling resulting in large savings; (3) electrically driven heat pumps can be used and run using renewable energy (e.g. solar).

Various technologies and fuels can be incorporated into district energy systems, including: waste-to-energy, high-efficiency boilers, waste heat recovery, combined heat and power, heat pumps, solar thermal and absorption chillers. Sea water can be used as well as freshwater, reducing electricity required to cool the water by up to 15 per cent per degree the sea water cools the alternative source for district water. Typically, sea water district cooling systems reduce electric consumption for AC by 90 per cent (MOE, 2017). Sea water district cooling has been used in the Canada, Netherlands, Sweden and the United States Additional projects are planned for the Bahamas and Reunion Island (MOE, 2017). One example is Copenhagen's district cooling system which draws water from an intake pipe reducing carbon emissions by 67 per cent and electricity consumption by 80 per cent compared to conventional cooling (Gerdes, 2012).

4.4 Material Efficiency from High-rise and Alternate Construction Materials

Multi-storey construction is an important aspect of achieving the higher densities implicit in the 5D compact city framework. The *Weight of Cities* report found multi-storey construction compared to single storey could reduce material use by 36 per cent. Case studies show multi-storey buildings require only ~2,000 kilograms of materials per household compared to single-storey units that require 3,140 kilograms of material (UN Environment, 2017). Material and resource efficient designs suited for multi-storey buildings in India's hotter climate have been field tested and show basic energy services can be provided with a comfortable living environment, consuming less than 25 kWh/person/month (World Bank, 2011), applied to provide low-cost and more comfort-oriented social housing within cities (See also Chapter 5). Similar strategies are expected to yield similar savings in ASEAN nations given the hot climate in the ASEAN region.

The production of construction materials has significant environmental impacts. For example, concrete consists of cement, coarse aggregate and fine aggregate. Cement production contributes to more than 10 per cent of greenhouse gas emissions and also contributes to particulate emissions that are a leading cause of air pollution. Likewise, the construction boom in China and India have also created a massive demand for sand, which is being extracted from rivers, affecting water flows and regional resilience to drought and floods. Therefore, looking to the future the use of alternate, resource efficient materials in developing ASEAN cities can yield multiple benefits. The World Bank has identified several alternative construction materials to concrete and kiln-fired bricks such as fly ash bricks and reinforced concrete filler slab, which can potentially decrease the fossil fuel required and associated air pollution and energy required by 20 per cent (World Bank, 2011). Blended concrete that uses industrial waste provides a resource efficient alternative through industrial symbiosis, discussed further in Chapter 6. Locally-produced, low-polluting construction materials that can use waste materials have been field tested and shown to generate lower PM2.5 emissions. Examples of low-polluting materials include (World Bank, 2011):

- Fly ash bricks
- Hollow concrete blocks (masonry)
- Compressed stabilized earth blocks (masonry)
- Precast reinforced concrete planks (flooring)

In many ASEAN countries bamboo is grown and can be used as a substitute building material especially since bamboo can be grown rapidly and in a sustainable manner.

4.5 Urban Strategies for Renewable Energy

While a complete transition off of coal and oil is not likely to happen, renewable resources are available in the region, and can be exploited very well as noted in the *Renewable Energy and Electricity* section. One option being considered for exploiting renewables is a large interconnected grid across the ASEAN region that leverages country specific renewable assets as available. Each country offers different renewable energy assets: Hydro in Viet Nam and Laos; geothermal in Malaysia and biomass is a large asset in Cambodia and Laos and across the region. Thailand, Lao, Cambodia, Brunei, Indonesia, Malaysia, Myanmar, Philippines and Viet Nam have already taken steps toward transitioning the fuel mix toward having greater shares of renewable energy through setting national policies and targets. Myanmar, for example, aims to have hydropower represent 18 per cent of the total electricity generation capacity by 2020; Philippines plans to triple their installed capacity of renewable power generation to 15 GW by 2030; Indonesia seeks to ramp up renewable energy supply to reach 23 per cent by 2025 and 31 per cent by 2050. Many of these targets are in-line with the *Weight of Cities* analysis and the International Energy Agency's 2-degree scenario estimate of 32 per cent renewable energy globally.

However, an interconnected grid raises security and resilience concerns (Huber and Roger, 2015; Luukkanen et al., 2015). In addition, even with aggressive renewable energy targets the IEA still predicts coal will be a dominant part of grid supply by 2050. Micro-grids paired with an increased integration of renewables into the urban fabric can provide a solution to these issues. Micro-grids that can be disconnected from the larger grid and operate autonomously can increase resilience during disasters and other service disruptions. Renewable penetration can be enhanced by intentionally including cities in renewable generation through renewable micro-grids, solar water heaters, distributed rooftop photovoltaic (PV) systems and geothermal energy, leveraging rich solar and geothermal resources in the region. Urban areas will play a large role in implementing renewable energy, particularly solar energy. In this chapter we discuss three key pathways to increasing renewable integration in cities:

- Solar thermal collectors
- Rooftop solar photovoltaics (PV)
- Micro-grids

FIGURE 4.15 **Fly ash brick**
(Rodriguez, 2017)

FIGURE 4.16 **Rooftop solar water heaters/solar thermal collectors**
(YouGen United Kingdom)

FIGURE 4.17 **Rooftop solar photovoltaic**
(US Department of Energy)

BOX 4.16 **Micro-grid with solar photovoltaics in Sabang, Palawan, Philippines**

The Philippines has a goal to triple the amount of renewable energy generated by 2030 (OECD/IEA, 2015). Micro-grids paired with renewable energy sources can be used to meet much of this goal and provide added resilience to climate extremes.

In 2014, the Philippine government approved the construction of a 2.4-megawatt hybrid power plant and 15 kilometre micro-grid in Sabang, Palawan, Philippines (WEnergy, n.d.). Of the 2.4 megawatts, 1.3 will be generated by 5,000 solar PV panels. The grid will provide electricity to 650 buildings, including homes, business and hotels in Puerto Princesa City's Sabang district. The entire system will cost 325 million Philippine pesos or approximately US$6.5 million (Eco-Business, 2014). The micro-grid will also be equipped with a 1.7 megawatt-hour battery pack and diesel generators to provide electricity at night and during cloudy days (WEnergy, n.d.).

Rooftop solar water heaters: A renewable technology that can be incorporated into building design with district energy systems is solar thermal energy. There is an abundance of solar energy in varying degrees in a hot and humid climate. Harnessing solar thermal energy to meet the cooling requirements in buildings in the ASEAN region will be an ideal situation. Solar thermal energy is harnessed through solar collectors for the production of hot water, which provides the driving heat source for the generation of chilled water through absorption chillers for airconditioning purposes.

Substantial amount of fuel can be saved by using solar waters heaters for domestic purposes like bathing, washing of clothes and utensils and in industries like textiles and dairy (Santra, 2015). The natural circulation type solar water heaters with flat plate collector have been found suitable for hotels, hostels, guest-houses etc. (Nahar et al., 2003). Solar thermal panels are usually installed on a roof and are used in conjunction with a boiler, collector or immersion heater. In 2004 approximately 40 million households worldwide used solar water heaters (Gowda et al., 2014). Most of these were used on Chinese households. In 2004, 10 per cent of Chinese households had solar water heaters. Solar thermal technologies (e.g. collectors) heat water or air, and other possible working fluids, for non-electricity uses of energy. Solar water heaters can displace conventional electrical water heaters in homes and in commercial establishments. Hot air-based thermal collectors can displace fossil fuel use in cooking, agricultural drying and more generally in industrial heat processing (Santra, 2015). The Indian Ministry of Renewable Energy Sources has a goal of installing 20 million square meters of solar thermal collectors by 2022 (Santra, 2015).

Rooftop PV: Distributed rooftop photovoltaic (PV) systems can be used to offset electricity demand in residential and commercial buildings. Due to their location in the tropics ASEAN solar insolation levels range from 1460 to 1892 kWh/m^2 per year on average (Ismail, et al., 2014).

An example of a PV system combined with passive design is the Diamond building shown in Figure 4.6. The diamond shaped structure maximizes the rooftop surface area for solar panels that resulting in a 10 per cent of the buildings electricity being provided by solar. An example of how solar PV can be used to meet national renewable energy targets is shown in Box 4.16.

Micro-grids: Micro-grids make the use of renewable energy to power multiple buildings more possible. A micro-grid is a local energy grid with control capability, that can be disconnect from the national grid and operate autonomously. A micro grid generally operates while connected to the grid, but importantly, it can break off and operate on its own using local energy generation (DOE, 2014). A micro-grid can be powered by renewable resources like solar PV and hydro. The capacity to operate in hybrid and in "island" mode offers great resilience during disasters and disruptions. Micro-grids are a great option for nations composted of islands, like the Philippines, since micro-grids can run autonomously. Micro-grids provide resilience to extreme weather events since they can break off from the national grid and are powered by multiple sources. The grid is less dependent on the national grid being functional. Box 4.17 shows an example of how a micro-grid can be used to power part of an Island in the Philippines.

4.6 Policy Learning and Insights for ASEAN Cities

Contextualizing *Weight of Cities* assumptions: We compare the *Weight of Cities* global assumptions with the ASEAN, India and China case studies and highlight the following key findings:

- Based on United States buildings data, the *Weight of Cities* report extrapolates that certified green buildings can technically save up to 48 per cent due to systems level improvements as the best case. The ASEAN best cases show similar levels of reductions. For example, Singapore's Green Mark Platinum standard is designed to reduce 30 per cent energy use compared to its reference case and the award winning "Diamond" building in Malaysia reduced its energy use by 60 per cent compared to reference case.
- However, our findings show the reference cases are based upon western building energy use and do not represent the way people in Asia are operating their ordinary buildings. For example, ordinary office buildings in Beijing with split-air conditioning consume less energy than 'green' buildings with centralized air conditioning units (Zhang et al., 2010). Existing ordinary buildings, even without an air conditioner, use on average 28 per cent less energy. Therefore, policies that only focus on green building certification of new buildings may not result in any energy use reductions.
- Promoting the retrofit of existing buildings with efficiency appliances, lighting and cooling can result in greater efficiency than new 'green' buildings (see section 4.3.4 for more information).
- In fact, promoting and improving existing ordinary and vernacular buildings to greater comfort levels might offer much greater resource efficiency. Thus, a dual strategy focusing on green building standards for new steel-concrete construction, as well as regionally developed standards for ordinary and vernacular buildings will be important to achieve resource efficiency.
- Combining resource efficient design with disaster risk resilient building design is an important need in the ASEAN region, given its vulnerability to typhoons and earthquakes.
- Building performance monitoring is as important as design. Singapore's experience monitoring the energy use of green buildings compared to non-green buildings have revealed the importance of providing incentives to promote sustainable energy use behaviours.
- Widespread adoption of green building designs is also necessary to achieve resource efficiency at-scale. The *Weight of Cities* report is an aspirational global document that assumes 100 per cent adoption of green buildings (UN Environment, 2017 page 139). However, Singapore's experience has shown that mandating buildings can be challenging. Therefore, ASEAN countries will have to consider policies and incentives to achieve a high level of participation once it is clearly identified that green buildings will translate to energy use reduction. Studies in US cities have shown that a mix of incentives and regulations can enhance the adoption of energy efficiency standards (Ramaswami et al., 2012); for example, some United States cities such as Boston are mandating green building standards for all large new constructions; cities such as Berkeley and San Francisco require that all older homes be upgraded to basic energy efficiency standards at the time-of-sale. While a high level of adoption is possible, policies and incentives are necessary to achieve it.

The case studies highlighted point to the strong role that governments can play in implementing policies such as changing building codes, incorporating vernacular construction and incentivizing building energy efficiency upgrades and promoting sustainable behaviours. Reducing resource requirements in the buildings and energy sector will require a blend of these types of policies. Encouraging the adoption of only one technology, design or practice will not lead to resource optimization. However, a comprehensive strategy that promotes the adoption of passive features, vernacular design, renewable energy generation and modern efficiency appliances as well as incentivizes environmental stewardship and continual improvement will lead to the maximum resource use reductions. A few key policy recommendations based on the case studies discussed above are shown in Box 4.17.

Policy Levers and Multiple Sustainable Development Goals benefits: The strategies noted in the buildings and energy sector in this chapter provide multiple SDG benefits that can further help promote their recognition and adoption by local governments and businesses. Figure 4.18 summarizes the policy levers, and their SDG linkages. For example, resource efficiency advances economic efficiency promoting SDGs including decent work and economic growth (SDG 8) as well as industry, innovation and infrastructure (SDG 9). Promoting energy efficiency in the buildings sector reduces energy use and associated greenhouse gas emissions as well as air pollution promoting SDGs including good health and wellbeing (SDG 3) and climate action (SDG 13). Material efficiency reduces demand for material extraction reducing associated environmental impacts in support of SDGs including life on land (SDG 15), clean water and sanitation (SDG 6), and climate action (SDG 13). Preserving existing conservation behaviours and norms promotes sustainable consumption and reduces demand for material extraction further supporting SDGs including preserving life on land (SDG 15) and clean water and sanitation (SDG 6). Micro-grids and district energy systems enhance efficiency and improve disaster resilience in support of good health and wellbeing (SDG 3). Grids with renewable energy reduce pollution and GHG emissions, improve disaster risk resilience and mitigate pollution further promoting good health and wellbeing (SDG 3).

BOX 4.17 Building efficiency and energy policy recommendations

- Integrate vernacular buildings and local behaviours into standards for energy efficiency early on.
- Consider where to invest in concrete and steel buildings versus ordinary and vernacular buildings.
- Set national targets for energy efficiency, carbon emissions reduction and renewable energy increases. See Figure 4.5 for an example of national targets set in ASEAN Countries.
- Develop and enforce standards for the green building design, including the incorporation of more environmentally friendly construction materials. Many nations do not currently require mandatory energy performance standards (MEPS) for appliances, equipment and lighting, with only 20 per cent of Southeast Asian countries having MEPS (IEA 2014). The market penetration of energy efficiency labelled appliances is also low compared to OECD member countries (IEA 2014), and many nations' building codes have low to no standards for energy efficiency (IEA 2015).
- Integrate environmental sustainability and disaster risk resilience designs into building codes, for different types of buildings – vernacular, ordinary and high-rise steel-concrete buildings.
- Adopt building energy reporting, leveraging the experiences of Singapore and India.
- Assess new technologies like micro-grids to improve penetration of renewables. Recognize there is a diversity of renewables available for different cities.
- Institute policies for widespread adoption of green buildings and energy efficient appliances, including incentives and mandates. For buildings, new construction and time-of-sale offer windows of opportunity to promote resource efficiency.

FIGURE 4.18 Building and energy pathways for addressing Sustainable Development Goals

Buildings and Energy Policy Pathways

- Integrate a mix of mid-rise and high-rise buildings using advanced and vernacular efficient design strategies
- Develop resource efficient green building codes for new and existing buildings, incorporating local cultural norms and behaviors
- Combine disaster resilience with energy and material efficient design in building codes
- Provide incentives to promote the penetration of energy efficient buildings and appliances, as well as real-time monitoring
- Integrate urban renewable energy, micro-grids and district energy into national electricity grid planning

Linkages for Impacting SDGs

- Resource efficiency advances economic efficiency
- Energy efficiency reduces energy use and associated GHG emissions and air pollution
- Material efficiency reduces demand for material extraction reducing associated environmental impacts on land, water and air
- Preserving existing conservation behaviors and norms promotes sustainable consumption and reduces demand for material extraction
- Micro-grids and district energy systems enhance efficiency and improve disaster resilience
- Grids with renewable energy reduce pollution and GHG emissions
- Disaster risk resilience and pollution mitigation enhances human well-being

SDGS

- SDG #3 Good Health and Wellbeing
- SDG #6 Clean Water and Sanitation
- SDG #7 Affordable and Clean Energy
- SDG #8 Decent Work & Economic Growth
- SDG #9 Industry, Innovation & Infrastructure
- SDG#13 Climate Action
- SDG #15 Life on Land

SDG #12 Sustainable Consumption & Production

SDG #11 Sustainable Cities & Communities


TRÁI CÂY NHẬP KHẨU
THỰC PHẨM - ĐỒ UỐNG
HÀN QUỐC - NHẬT BẢN
NHẬP KHẨU MỸ, ÚC, CANADA, NEW ZEALAND
CỘNG ĐỒNG
Xuất
Xứ
Ràng

CHAPTER 5
Resource Implications of Inclusive Urban Development

BOX 5.1 Highlights of Chapter 5

1. The intersections of resource efficiency, disaster risk resilience and inclusive development are explored. Strategies are discussed for more inclusive development, in the context of avoiding and mitigating the development of urban slums and informal settlements.
2. As a first principle, urban-regional master planning should explicitly avoid actions that push economically weaker sections and new migrants to the periphery of an urban area. Rather, they should integrate urban migrants and the poor into the fabric of the city through development efforts to create socially mixed neighbourhoods.
3. Micro-planning/town-planning guidelines for neighbourhood level development have been successful—both in areas of new development and expansion as well as for areas of redevelopment within a city—in setting aside land to accommodate economically weaker sections in larger development efforts. Urban macro and micro plans should also ensure that the poor are not originally settled or resettled in areas that are prone to disasters.
4. The compact city 5D framework, along with high land prices and high general demand for land within cities requires the development of multi-story housing, including for slum rehabilitation within the city core. While there have been challenges associated with early experiments with high-rise social housing for slum rehabilitation in developing countries, recent efforts in India show that is possible to overcome these challenges, developing inclusive and resource efficient housing within the city core, with ready access to employment, often via non-motorized modes.
5. There is an opportunity to couple site design and building resource efficiency design with disaster resilience in the face of typhoons, flooding, and earthquakes, emphasizing efforts to 'build back better' where informal settlements have been destroyed by a natural disaster.
6. Research and capacity building is needed to better integrate design for resource efficiency with design for disaster risk resilience and institutionalize them in building codes.
7. Slum rehabilitation is not only about providing improved housing, it is also about livelihoods, educational and social opportunities for the poor, and overall urban upgrading and enhancing the liveability of the city for all residents.
8. A long term sustained effort is needed to create zero-slum cities, developing targeted and customized strategies for diverse slum settlements, as exemplified in the Philippines' efforts post Super Typhoon Yolanda.
9. The material requirements to upgrade slums are a small fraction of the material-energy requirements of the whole community (including all households, businesses and industries). Thus, small improvements in resource efficiency can ensure that housing is provided for all without substantially increasing material-energy use. This represents an example of decoupling material use from high levels of improvement in human wellbeing.

5.1 Infrastructure, Informal Settlements/Slums and Inclusive Development

United Nations Habitat defines slums as human settlements characterized by a lack of one or more of the following: land tenure, durable housing, sufficient floor space per person, or basic services such as water supply and sanitation. The terminology of informal settlements refers to buildings built without land tenure, or that are not built to conventional engineering building codes prevalent in the area (OECD). As such, there can be significant overlap between homes in slum settlements versus informal settlements in any given city. Slums in many countries are further delineated into notified slums (that have legal status and are recognized by the government) versus non-notified slums. Countries may have further definitions of slums and distinctions based on building types including buildings that are durable, semi-durable and temporary. A recent review article notes that "slums and informal settlements denote largely self-built urban communities, which are rarely recognized officially and

TABLE 5.1 Slum Characteristics and Select Associated Health Risks *(adapted from Corburn and Sverdlik 2017)*

Example Slum Characteristics	Definition and Indicators (examples)	Community Health Risks
Overcrowding	>2 persons/room or <5 m^2 per person	Spread of TB, influenza, meningitis, skin infections and rheumatic heart disease
Low-quality Housing Structure	Inferior building materials dirt floors and substandard construction	Vulnerability to floods, extreme heat/cold, burns and falling injuries
Hazardous Housing Sites	Geological and site hazards (e.g., industrial waste sites, garbage dumps, railways, wetlands, steep slopes, etc.)	Acute poisoning; unintentional injuries, landslides, flooding, toxic contamination, environmental pollutants, leptospirosis, cholera, malaria, dengue, hepatitis, drowning
Inadequate Water Access	<50% of households have affordable, 24/7 access to piped water/public standpipe	Malaria, dengue and diarrheal diseases, cholera, typhoid, hepatitis; increased HIV/AIDS vulnerability
Inadequate Sanitation Access	<50% of households with sewer, septic tank, pour-flush or ventilated improved latrine	Fecal-oral diseases, hookworms, roundworm; missed school-days during girls' menstruation; malnutrition and children's stunting; safety/ sexual violence for women from unsafe toilets
Limited Services and Infrastructure	Inadequate healthcare, drainage, roads, energy, transport, schools, and/or refuse collection	Traffic injuries; lack emergency provision; fires; flooding/drowning; waste burning and air pollution; respiratory diseases and cancer
Tenure Insecurity	Lack of formal title deeds to land and/or structure	Fear; increased hypertension; diabetes; low birth weight newborns
Poverty and Informal Livelihoods	Low incomes, few assets, and access to credit; lack of social protection	Increased occupational hazards; maternal health complications; vaccine-preventable diseases; perinatal diseases; drug-resistant infections
Violence and Insecurity	Elevated crime, including domestic and gender-based violence	Homicides; hypertension; obesity; sexual violence; vulnerability to STIs, esp. for young people forced into sex work
Political Disempowerment	Low or no governmental responsiveness to needs and services	Lack of health services; poor education; preventable hospitalizations; typhus, leptospirosis, cholera, chronic respiratory diseases, growth retardation

typically are denied life-supporting services and infrastructure" (Corburn and Sverdlik, 2017). Corburb and Sverdlik trace the trace the historical development of slum upgradation, ranging from early efforts of aid agencies in the 1970-80s that focused on governments providing housing and infrastructure/basic needs but often resulted in the poor being relocated to urban peripheries; agencies shifted focus in the 1980-90s to the concept of governments offering financing to non-governmental organizations to provide housing; more recently (from the 2000s onward), a shift has occurred placing greater emphasis on *in situ* upgradation aiming to integrate the urban poor into the fabric of the city without significantly relocating them away from access to livelihoods within the city. Recent efforts of United Nations Habitat focus on participatory multi-objective integrated slum upgrading, focusing not only on housing and basic infrastructure, but also on social aspects of health and wellbeing including education, livelihoods, access to credit, and overall renewal of urban areas (United Nations Habitat 2016c).

As such, multi-objective slum upgrading is expected to yield multiple and diverse benefits to wellbeing (shown in Table 5.1, adapted from Corburn and Sverdlik 2017). These efforts also often improve gender inequality in slums. Current infrastructure deprivations such as dirty biomass cooking fuels and lack of access to drinking water or sanitation disproportionately affect women, more than men. Increasingly, more nations are taking a multi-objective approach to slum upgradation and developing national plans to work toward zero slum cities.

In this chapter, we focus on the natural resource use (energy, water, and materials) implications of developing more inclusive cities, focusing on improving housing and infrastructure for the urban poor living in slums and informal settlements, referred to by United Nations Habitat as addressing socio-spatial exclusion (see Box 2.5). We assess the material basis for upgrading slums and connect these material requirements to multiple SDGs, including the SDGs related to access to basic services, poverty alleviation, reducing inequality and improving human wellbeing. Thus, this chapter addresses the intersection between resource uses in multiple infrastructure provisions, with the goal of inclusive development.

BOX 5.2 Defining Socio-Spatial Exclusion

United Nations Habitat (2015b) defines socio-spatial exclusion as: 'the processes that contribute to the geographic marginalization of particular individuals and groups because of where they live and who they are. It is characterized by their inability to access or effectively use a whole range of facilities and resources which improve well-being and position people to take advantage of available opportunities. Particular groups and individuals often suffer a disproportionate "disadvantage" because of their identity, which is physically represented in urban contexts by the presence of informal settlements."

5.2 The ASEAN Context of Slum Settlements

Across the ASEAN countries in 2015, about 73 million urban residents were living in slums. The median national share of urban populations living in slums in ASEAN countries in 33 per cent, although there is large variation between national contexts. Some countries like Singapore and Brunei have no slums (0 percentage of urban residents living in slums as reported by the World Bank's World Development Indicator Series). The percentage of urban populations living in slum settlements in ASEAN nations with reported slum populations ranges from a low of 22 per cent in Indonesia to a high of 55 per cent in Cambodia. Chapter 2 provides the percentages of urban residents lacking durable housing, clean drinking water, sanitation, electricity and cooking fuels (table 2.6). Much work is needed to provide better housing (alleviate slum conditions) and improve sanitation in urban areas of many of the ASEAN nations, while Laos and Myanmar, must also address provisioning of electricity and clean cooking fuels.

The situation of informal settlement families is often exacerbated in ASEAN informal settlements are often located along a coast or other urban waterways. Informal settlement residents are exposed to heightened disaster risk generally--from typhoons to earthquakes-- due to poor housing conditions.

Fast urban population growth rates exhibited in many cities across the ASEAN region (see section 2.1) increase the likelihood that some urban areas may find their infrastructure investment capacity outpaced by population growth and thus overwhelmed by demand for basic services and infrastructure. Such infrastructure deficits are a leading cause of slum formation and the insufficient provision of basic services. New emerging infrastructure and basic service deficits of emerging infrastructure and basic service deficits threaten to compound already existing deficits in cities across the region.

5.3 Extending the findings of the *Weight of Cities* Report

Several important strategies emerge from the *Weight of Cities* report to move toward both resource efficient inclusive development of the urban poor living in informal settlements and slums. These include:

- Integrated urban-regional master planning and city-level township planning for slum avoidance and mitigation
- *In situ* or very nearby slum rehabilitation of existing slum settlements within cities in multi-storey housing
- Coupling resource efficient and disaster resilient construction for all new social housing, emphasizing the idea of "building back better"

These strategies may be integrated into long term plans for developing zero slum cities (e.g., see case study of Philippines after Hurricane Yolanda), which is one of the goals of the New Urban agenda (UN Habitat 2017).

a. Integrated urban-regional master planning and city-level township planning

Macro and micro planning instruments must work together to avoid pushing economically weaker sections and migrants to the city periphery. To achieve compact city development goals, this requires combining a master plan based on 5D principles with micro-pans where land is set aside for rural-urban migrants and the urban poor so that they are fully integrated in the urban fabric. At the intra-city and neighbourhood planning level, micro-planning/town-planning guidelines should set aside land and space within larger development plans for economically weaker sections and new migrants so that new development areas constitute socially and economically mixed neighbourhoods. Macro and micro plans should ensure that the poor are not originally settled or resettled in areas that face substantial disaster risk. They should also

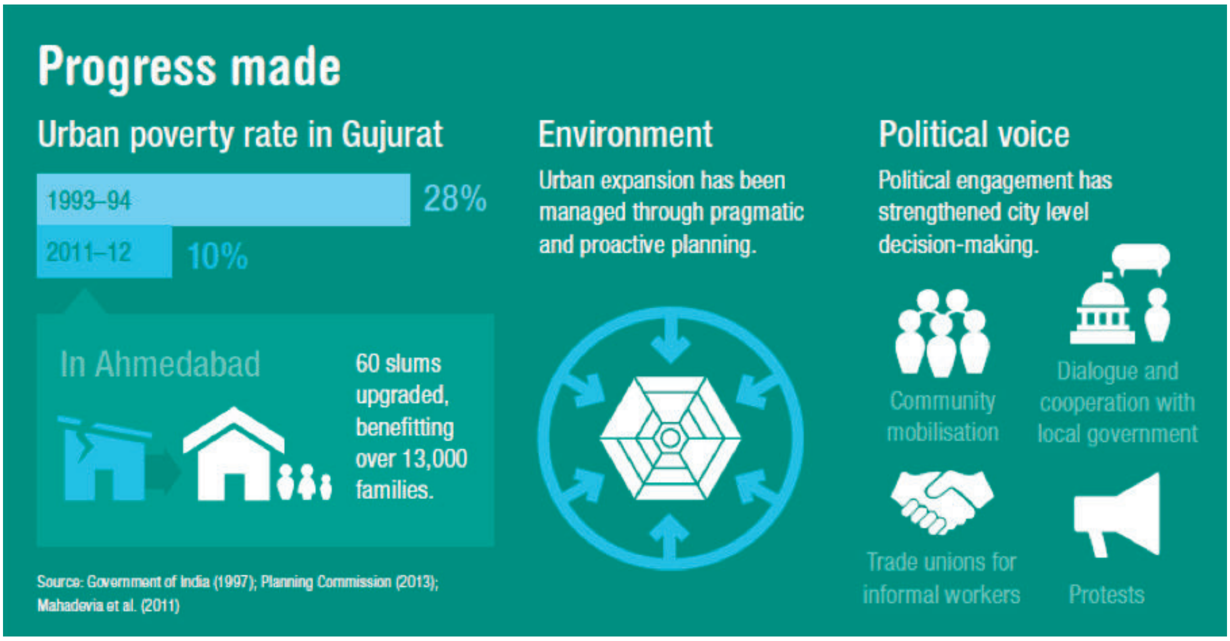
BOX 5.3 Township Planning for Slum Avoidance in Ahmedabad, India

Ahmedabad is noted as one of the few growing Indian cities that has successfully managed its urban expansion along with microplanning (town planning) to provide land for weaker sections (for slum prevention) and rehabilitation of existing slums can be carried out in a coordinated manner. Indeed, among several fast-growing cities in India, Ahmedabad features as one that has seen a reduction in the slum population from about 12 per cent to less than 5 per cent from the period 2001- 2011, during a period when the city's population grew significantly. Several authors have indicated that the success of slum prevention and rehabilitation are due to a confluence of several enabling factors, chiefly:

- Coordination of the regional development master plan with the town planning schemes to achieve both compact development and a reduction in the percentage of people living in slums;
- Models of participatory slum upgrading and rehabilitation through partnerships between the communities, municipal government and non-governmental organizations;
- Successful demonstration of *in situ* relocation of slum dwellers into multi-storey buildings near or within the city, achieved through public-private partnerships where developers obtain consent of >75 per cent of the slum residents, and provide the capital construction in lieu of floor area for development whether on site or in other (wealthy) parts of the city. Mahadevia et al., (2014) indicate that the involvement of NGOs as a bridge between slum communities is beneficial;
- The local government regularly sets aside 20 per cent of its annual budget to provide services to the poor.

FIGURE 5.1 In situ slum rehabilitation in multi storey construction offering slum dwellers new housing units built by developers in lieu of development rights on adjacent land or in other neighbourhoods *(Mahadevia et al.,2014; photo credit © Jerry Zhao)*

FIGURE 5.2 **Urban Poverty Progress Made Infographic from the State of Gujarat, in which Ahmedabad is located** *(Mahadevia et al., 2014)*



support the social and economic integration of neighbourhoods as much as possible, ensuring that economically weaker sections are not unduly isolated from the services, opportunities, and facilities of the central city. These strategies are described in Chapter 3, and are expected to create resource efficiencies in terms of land use (more compact growth), as well as by reducing the time and travel burden on the urban poor, promoting the use of walking, bicycling and transit to access jobs. A key tool for supporting managed growth introduced in Chapter 3 is the idea of land pooling for general guided development which also requires that specific land and space be set aside for economically weaker sections, in line with the recommendations noted above that promote both compact growth *and* slum avoidance. Township planning schemes that couple land pooling with land set-asides have been successful in some parts of India (primarily in urban areas of Gujarat and Maharashtra states) (World Bank, 2008). However, land pooling and accompanying requirements to include set asides for economically weaker sections can encounter public opposition when the projects encounter significant delays, go over budget, are seen as lacking transparency, or do not meet land owner expectations (Sanyal and Deuskar, 2011). The underutilization of land set aside for economically weaker sections within land pooling town planning schemes is also a challenge when local governments do not have the funds, or fail to make them available, for constructing social housing on set aside land within the larger town planning scheme (Joshi and Sanga, 2009).

b. Participatory *in situ* slum rehabilitation of existing slum settlements within cities, including in multi-storey housing

In order to achieve the articulated densities embodied in the 5D Compact City framework, housing for economically weaker sections and the rehabilitation of slum dwellers must consider high-rise housing or dense low- to mid-rise row housing as strategies for relieving the cost pressure of developing housing on centrally located land. While high rise slum rehabilitation housing experienced early challenges, more recent efforts of multi-storey slum rehabilitation have proven successful in several cities in India and in Indonesia (See Boxes 5.4 and 5.5).

In situ slum rehabilitation in multi-storey buildings provides an opportunity to reduce the land and material requirements of slum rehabilitation and social housing construction, all the while providing good housing and basic services (water, sewerage, and electricity) for underserved populations within the city core, enhancing well-being and providing access to livelihoods without an added burden of long commutes (IRP 2018). Specifically, the *Weight of the Cities* report found multi-storey buildings required less materials per household (2,015 kilograms) compared to single-storey units (3,140 kilograms) (Nagpure et al., 2018). Multi-storey social housing compared to single storey could reduce material use by 36 per cent, while also reducing motorized travel demand and improving access to employment (IRP, 2018). Furthermore, using alternative building materials can limit the resources required for slum rehabilitation. Concrete and cement are highly

BOX 5.4 *In situ* slum rehabilitation in India: High Rise rehabilitation in Mumbai, India

In situ slum rehabilitation in Indian cities has recently been affected through partnerships with developers who provide the capital for construction, and must obtain the permission of more than 75 per cent of the original slum residents to move to the multi-storey housing. In Mumbai's Slum Rehabilitation Scheme slum dwellers are relocated to social housing on site which are usually around 23 stories with 25 square metre units (Hindman et al., 2015). The new units are funded and built by the builders – increasingly, it is recommended that community members play a role in the design. In lieu, the developers receive rights to build profitable developments on land freed up on the site, or elsewhere in the city. Mahadevia et al (2014) indicate that these schemes, while attractive in relocating slum residents on site in new structurally sound housing, work only in locations where developers see a profitable advantage. They also may fare better when non-governmental agencies help build trust and communication and broker the relationship between developers and the impacted slum communities. In Mumbai, the buildings (shown) typically have a central atrium or courtyard, fire doors, fire sprinklers, elevators and a fence around the building for privacy and security. The first floor is allocated for storefronts and given to residents that had stores in the slums. Each unit contains two bedrooms, a kitchen supplied with municipal drinking water and a separate shower and wash room. Buildings are usually constructed with prefabricated concrete, reducing construction cost by 30 per cent and construction time by 40 per cent compared to non-prefabricated concrete.

FIGURE 5.3 Multi-storey slum housing rehabilitation in Mumbai, India

resource intensive, resulting in significant greenhouse gas and particulate emissions leading to air pollution. The use of alternative construction materials, such as blended concrete, fly ash bricks and reinforced concrete filler slab, can potentially decrease fossil fuel use and associated air pollution by 20 per cent (World Bank, 2011).

A holistic approach is important, one that does not just consider the resources necessary to build the housing but also that considers how people live, the common spaces for retaining social networks of the original slums and spaces for small businesses relocated from the slums as well. An example of a multi-storey social housing project in Mumbai, India that promotes a local economy by reserving space for businesses and minimizes resource requirements for construction by using a concrete alternative is shown in Box 5.4.

In situ upgrading in multi-storey construction, especially in centrally located areas of a city, can unlock inclusive development financing options as desirable land suitable for private development can be opened up through such efforts. When the residents of a low-rise slum settlement are resettled into multi-storey buildings that are able to accommodate residents on a relatively small footpint of the total land that was previously occupied by the slum settlement, the sale of the remaining land for market rate commercial or residential development can finance the entire resettlement and upgrading effort (see section 3.3.2). In India, examples of this approach have taken shape in which the onus is put on developers to work with local civil society organizations to reach a threshold of community consent before development can proceed, ensuring a certain degree of community buy-in and enhancing the political viability of the project (Zhang 2013). While offering an innovative financing pathway, authorities overseeing multi-storey *in situ* upgrading in Mumbai faced early criticism for allowing developers too much discretion and not imposing formal development standards, resulting in poor construction quality. Establishing a state-level Slum Rehabilitation Authority to serve as a regulator was considered an important part of efforts to oversee the continuing improvement of the programme (Srinivasan and Viswanathan, 2014).

c. Build back better after disasters

Slum rehabilitation efforts, especially those that occur after slum housing is destroyed during a natural disaster, present an important opportunity to 'build back better' relying on building codes and standards that change the quality, safety, resilience, and resource efficiency of the new housing stock constructed. Several studies have noted the importance of studying the resilience of informal structures in cites, as well as assessing their passive design features (GFDR, 2011). The integration of community based design principles for local ASEAN construction into resilient and resource efficient building codes and standards can increase compliance with and adoption of those standards by leveraging traditional ways of community construction rather than imposing imported design and material requirements that may be readily ignored by communities and housing developers. With the exception of Singapore and Thailand to some extent, few ASEAN nations have effectively developed building codes—for social housing or market-rate housing—that combine both disaster and energy efficiency standards to simultaneously reduce resource use and increase resilience. Recent efforts in the Philippines provide a long-term plan to create slum free cities, and are emphasizing engineered disaster resilient designs for a variety of different construction types. In applications in Quezon City, ideas of green buildings are being integrated. In other countries, decentralized wastewater treatment is also being proposed to improve resource efficiency and provide infrastructure services.

An example is the Boezem Morokrembangan, Surabaya project located on a water reservoir. The Ministry of Public Works, the Government of East Java and the Surabaya City Government worked together to improve the living conditions of the residents, improve the infrastructure and restore the reservoir. The three units worked together building a bridge over the reservoir, streets, a new drainage system, communal latrines, an improved sanitation system, green space and space for businesses and markets. The programme is funded by the Indonesian Government, Province Government and City Government. Non-government institutions help fund community empowerment programmes.

BOX 5.5 Slum-rehabilitation in multi-storey construction in Indonesia

Between 2000 and 2010 the percentage of Indonesia's population living in urban regions increased from 42 per cent to almost 50 per cent (Government of Indonesia, 2012). With the urban population growth, Indonesia has seen an increase in slum population. Indonesia defines slums as inhabitable settlements due to building irregularity, high level of building density, poor building quality and low standard of facilities and infrastructures. Slums in Indonesia lack access to safe water, sanitation and other basic infrastructure services. Housing is usually overcrowded, insecure and structurally unsafe. In 2004 slums covered 540 square kilometres. By 2009 the slum area increased to 590 square kilometres (Government of Indonesia, 2012). To avoid the development of slums, Indonesia has developed a National Housing Development Policy. As part of the National Housing Development Policy, Indonesia has developed a National Long-Term Development plan for 2005 through 2025 to increase access to decent, safe and affordable housing, infrastructure and utilities. The goal of the programme is to support the achievement of the United Nation Millennium Development goals by developing housing that is 'sustainable, adequate, decent, affordable and supported by adequate and quality facilities and infrastructures'. As part of the programme, 685,000 low-cost housing units, 180 owned low-cost apartments and 650 rented low-cost apartments will be built. Between 2008 and 2012, 373 slum areas (approximately 73 square kilometres) had been upgraded. During this time 253 multi-storey buildings had been built for over 1.1 million residents (Government of Indonesia, 2012).

In 2010 the Ministry of People's Housing begin an 'Area-Based Slum Upgrading Project' that upgrades slums through an integrated multi-sector approach and requires communities to prepare community action plans. As part of the slum upgrade programme the government develops neighbourhood roads, drainage, waste-treatment and drinking water system. The housing that is developed is typically multi-storey (e.g. Figure 5.4).

FIGURE 5.4 Bambe slum upgrade building in Indonesia
(Government of Indonesia, 2012)

FIGURE 5.5 **Disaster resilient row houses and Low-rise multi-storey slum rehabilitation construction as proposed for those displaced by Typhoon Haiyan in the Philippines** *(Regala, 2014)*

FIGURE 5.6 **Steps for Effective Development of Building Codes** *(World Bank GFDRR, 2015)*

2.1 Establish an open participatory, consensus-based process for code development.	**2.2** Adopt a local building code referencing an established model code while incorporating necessary adaptations to local context.	**2.3** Develop a comprehensive building code that covers the full range of relevant construction types and practices.	**2.4** Establish building materials testing and certification laboratories that are accessible to major construction zones.	**2.5** Provide for wide dissemination of code documents and training for builders and owners based on code documentation.	**2.6** Create and maintain public awareness of basic safe construction principles for the community, building owners, and informal sector builders.

5.4 Long-term Plans and Policy Guidance for Zero-Slum Urbanization

The learnings of Typhoon Haiyan (also referred to as Super Typhoon Yolanda) in the Philippines resulted in the development of a national slum rehabilitation programme where priority for slum rehabilitation is given to those in disaster vulnerable zones for building upgrades with additional demarcation of vulnerable zones where settlements should be avoided. The Philippines example illustrates the multi-level coordination of action and policy across different jurisdictions that is required to begin realizing a development vision in which zero-slum urbanization might be an achievable reality (see Table 5.2). While individual cities can take actions, nation level zero-slum urbanization policies offer important guidance and standards that can help advance slum mitigation and avoidance.

While the national slum rehabilitation programme in the Philippines was only initiated recently after Typhoon Haiyan in 2013, and was done so largely in response to a national natural disaster, Indonesia initiated a 20-year long-term housing development plan in 2005 to help reduce the proliferation of slum development that was accelerating in the country along with increased urbanization. As a part of the programme, between 2008 and 2012, 373 slum areas (approximately 73 square kilometres) had been upgraded. During this time 253 multi-storey buildings had been built for over 1.1 million residents (Government of Indonesia, 2012).

These national level, long term plans have helped to mobilize expert knowledge and resources to create new cultures around slum rehabilitation and social housing development. Cities often cannot meet the challenge of slum avoidance and mitigation by themselves and thus long-term plans from other levels of government to provide policy guidance, clear standards, and resource mobilization become increasingly important. Such support is likely to be especially important for fast-growing small and medium cities which may otherwise lack the necessary capacity to appropriately address existing or emerging infrastructure and basic service provision deficits.

BOX 5.6 Combining Resource Efficiency and Disaster Resilient Social housing development in Philippines

Quezon City, Philippines, is part of Metro Manila and has an area of approximately 166 square kilometres and in 2010 had a population of 2.96 million (Ragragio, n.d.; Quezoncity.gov, n.d.). More than a third of Quezon City's population lived in slums in the early 2000s (Nakamura, 2009). Of Metro Manila's 701,753 informal settlements 69,490 are located in Quezon City (Nakamura, 2009) and many are located on earthquake fault lines. To improve the living conditions of low-income families, Quezon City has a social housing programme that involves slum rehabilitation through relocation and *insitu* slum rehabilitation.

Quezon City social housing facilities are usually two to five stories. Five stories is the maxium height since any higher would require an elevator which would increase the property value and result in the residents not being able to afford to live in the property. The housing is set up with traditional electricity but must meet green building ordinance requirements. To meet the requirements, most buildings have passive cooling features to minimize resource use. The number of properties depends on the size of the property. The units range in size, between 20 and 40 square metres with around five family members. To maximize space, the single storey, row houses are built with loft space that adds approximately 10 square metres. However, row houses are not being built as often since land is limited (Cuña, personal interview, 26 July 2017) and disaster resilient mid-rise construction is used instead.

After moving in, the residents are required to elect an estate manager who is responsible for keeping the property clean, paying amortization and maintaining common areas. Beneficiaries are given 25 years to pay off the loan on the property. The cost is up to 5,000 pesos (US$50) a month and covers the amortization plus interest. The capital to develop the social housing comes from the interest collected on the loans and a tax collected from high income families. The socialized housing funding is put in a separate account that can only be used for socialized housing. Residents are provided financial training on how to afford the monthly payments. (Cuña, personal interview, 26 July 2017).

Social housing development efforts in the Philippines, and elsewhere in the ASEAN, still struggle to adequately integrate low-income social housing into mixed-income neighbourhood development plans. Ensuring economically and socially mixed neighbourhoods, in contrast to neighbourhoods of concentrated social housing, is a key strategy for ensuring that low income and poor urban residents have access to the services and infrastructure that more affluent areas of the city are likely to receive.

5.5 Resource Implications of Inclusive Development: Large Benefits from Small Investments

Few studies have assessed the material requirements of inclusive development in cities, comparing the material needs of slum rehabilitation in single storey and multi storey construction with the business as usual case. Nagpure et al (2018) conducted field work to assess the material requirements of slum upgradation projects and compared them with the material used in existing slums in India. Results are shown here and indicate that 30 per cent reductions in material sue in code compliant multifamily construction compared to single family low rise buildings (see Figure 5.7). They also found that the material requirement for providing sewerage is a small fraction (1 to 5 per cent) of the material required for new housing.

Using such field data, along with data on ten Indian cities that showed the proportion of homes lacking access to or consuming below minimum benchmarks for service provisioning, the study computed the resource requirements for providing electricity, clean cooking fouls and durable housing to all deprived households in each of the cities, and compared them with current community wide demand of similar amenities. The paper found that across the ten cities, to provide basic electricity (25 kWh/person-month) to underserved households, will require an addition of only 1-10 per cent in current community wide electricity use. This is because higher income homes consume much more electricity that poorer households, and further, there is significant electricity consumed by businesses and industries. Thus, the resource requirements to provide basic electricity services to underserved residents are a small fraction of the current community wide electricity demand.

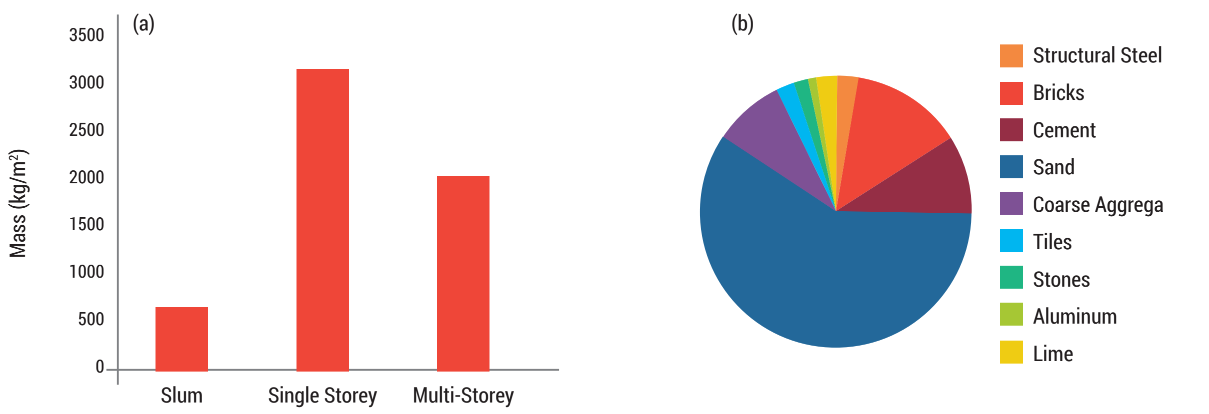
Similar results are found for providing liquid petroleum gas (LPG) and durable housing to the underserved. These results indicate that inclusive urban development can be achieved with relatively small increases in the overall material and energy demanded today in cities. This implies that modest adoption of sustainable consumption practices among the wealthy and by businesses can readily create a more equitable situation by offsetting the material requirements of meeting the basic needs of the underserved without substantially changing current material-energy flows in cities. This is an unexpected finding, arising from the high levels

TABLE 5.2 Guiding Principles from the Philippine's National Informal Settlements Upgrading Strategy *(NISUS, 2014)*

Guiding Principles: Shepherding Actions Toward the Vision	
GUIDING PRINCIPLE n° 1	**Scale-Up the Current Interventions** Current programmes for ISFs must benefit more.
GUIDING PRINCIPLE n° 2	**Maximize Retention and Minimize Relocation of ISFs** Relocate only those in danger areas and on land needed for public infrastructure.
GUIDING PRINCIPLE n° 3	**Build on Lessons Learned** Successful interventions must be institutionalized and replicated; learn from past mistakes.
GUIDING PRINCIPLE n° 4	**Focus on People** The informal settlers must drive the process and decision making– demand-driven approach.
GUIDING PRINCIPLE n° 5	**Adopt Strategic City-wide Planning** Planning must be undertaken with a long-term strategic perspective that sets the spatial pattern for future growth and enables cities to plan primary infrastructure in advance of land development.
GUIDING PRINCIPLE n° 6	**Plan for Climate Change** Incorporate climate change adaptation in urban renewal and ISF housing programmes.
GUIDING PRINCIPLE n° 7	**Shift More toward the Market** House construction and rental housing must be provided predominantly through the private sector and civil society; and housing finance must be market-related.
GUIDING PRINCIPLE n° 8	**Target Subsidies Toward the Needy** Provide capital subsidies instead of interest rate subsidies, and target them towards the needy.
GUIDING PRINCIPLE n° 9	**Adopt an Incremental Approach to Providing Housing** Recognize that ISFs have low incomes and most of them can only build houses incrementally.
GUIDING PRINCIPLE n° 10	**Use Alternative Rights-based Instrument** Lease variants and other rights based instruments to secure tenure must be applied.
GUIDING PRINCIPLE n° 11	**Integrate Upgrading with Urban Renewal** Policies for ISFs must be seen as part of a more embracive city-wide urban renewal and inter-city connectivity.
GUIDING PRINCIPLE n° 12	**Implement ISF Programmes at the Local Level under a Participatory, Decentralized** Framework. LGUs must lead programmes with support from people's organizations, NGOs, civil society and the private sector using participatory approaches.
GUIDING PRINCIPLE n° 13	**Tailor Housing Finance to the ISF's Income and Expenditure Patterns** Adopt principles of microfinance and community finance which are proving to be more appropriate for ISFs.
GUIDING PRINCIPLE n° 14	**Implement and Act through Partnerships** Urban renewal and ISF housing must be implemented through partnerships of the local governments with the people's organizations, civil society, private sector and the national government.

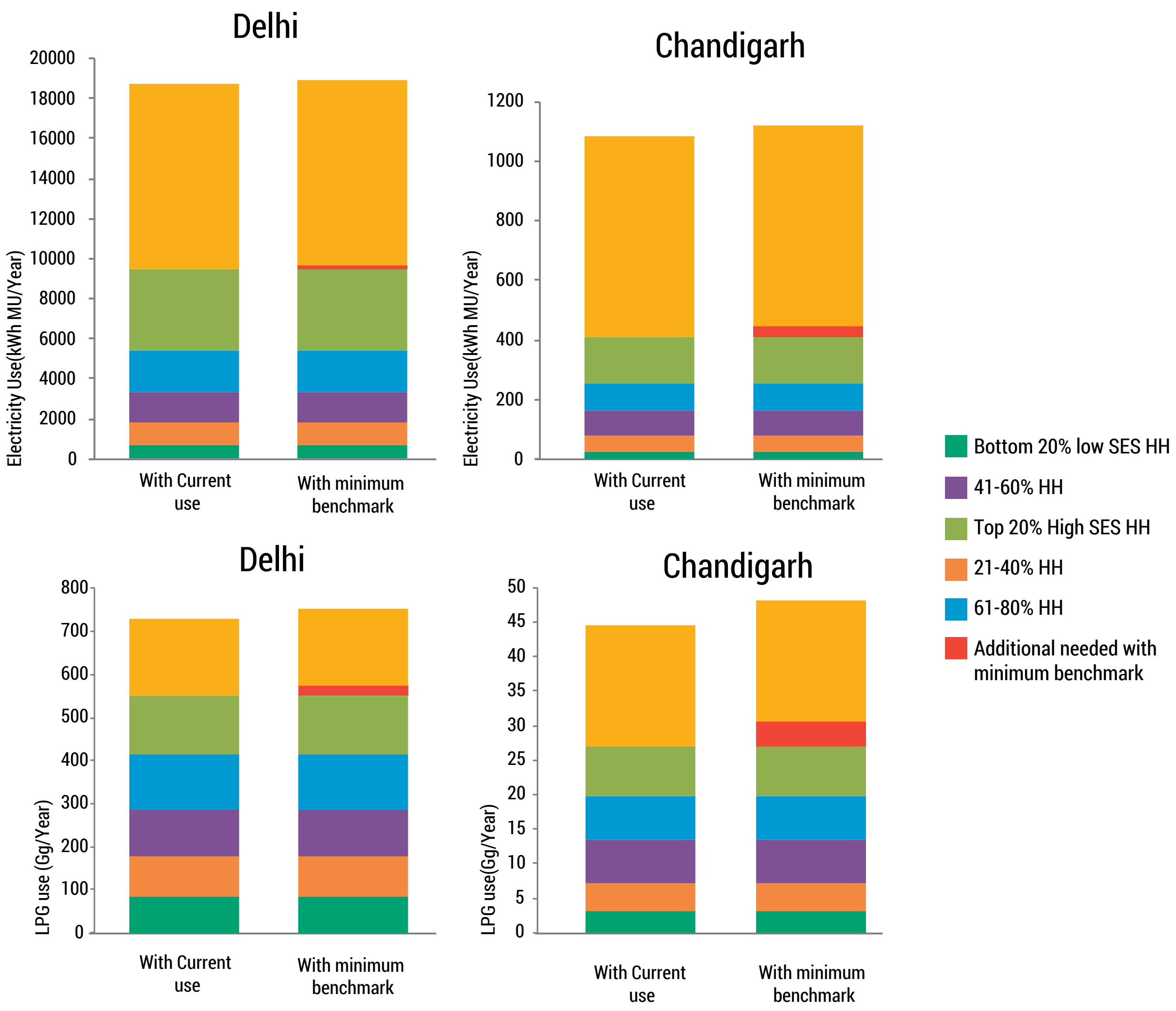
**ISF stands for informal settler family*

FIGURE 5.7 **Using material by mass per square meter based on housing construction type** *(Nagpure et al., 2018)*



Housing material by mass, normalized per square meter for (a) slum, single family and multifamily homes, and (b) share of different material for single and multifamily buildings

FIGURE 5.8 **Electricity Use and Liquid Petroleum Gas Community-Wide Flows and Resource Requirements to Meet Minimum Service Benchmarks for Underserved Populations** *(Nagpure et al., 2018)*



of inequality in consumption patterns, and shows that resource requirements for inclusive development will be modest, suggesting policy priorities for inclusion are likely not constrained by physical availability of resources.

Policy Levers and Multiple SDG benefits: Incorporating the human health benefits shown in Table 5.1, we find that resource efficient and inclusive infrastructure strategies can support multiple SDG co-benefits, as shown in Figure 5.9. For example, social housing and slum rehabilitation in multi-storey buildings reduces resource requirements of inclusive development in support of SDGs related to reduced inequality (SDG 10) and climate action (SDG 13). Increased basic sanitation and waste management infrastructure enhances standards of living and reduces pollution in support of SDGs related to good health and wellbeing (SDG 3); clean water and sanitation (SGD 6); reduced inequality (SDG 10); life below water (SDG 14); and life on land (SDG 15). Increased access to basic electricity and cleaner-burning cooking fuels increases standards of living and improves indoor air quality in support of SDGs related to good health and wellbeing (SDG 3); affordable and clean energy (SDG 7); and reduced inequality (SDG 10). Non-peripheral siting for social housing and slum rehabilitation integrates the poor into the urban fabric and reduces commuting burdens and sprawl in support of SDGs related to reduced inequality (SDG 10) and life on land (SDG 15). Building codes for efficiency and resilience decrease loss of life and property in disasters while reducing urban resource through-put in support of SDGs related to good health and wellbeing (SDG 3) and climate action (SDG13). Combined, all of the pathways and linkages support sustainable cities and communities (SDG 11) and sustainable consumption and production (SDG 12).

FIGURE 5.9 Sustainable Development Goals and Resource Use Implications of Inclusive Development

Inclusive Development Policy Pathways	Linkages for Impacting SDGs	SDGS	
Establish national zero slum urbanization policies for high level guidance and finance mobilization Pursue integrative social housing development and in-situ or nearby slum rehab in resource efficient multi-storey construction Support 'build-back-better' slum rehabilitation after natural disasters to upgrade housing stock	Non-peripheral siting for social housing and slum rehabilitation integrates the poor into the urban fabric, reduces sprawl and increases access to livelihoods Social housing and slum rehabilitation in multi-story buildings promotes compact urban form and inclusive development, while reducing resource requirements and associated environmental impact Improved basic sanitation and waste management infrastructure enhances standards of living and reduces pollution Increased access to basic electricity and cleaner-burning cooking fuels increases standards of living and improves indoor air quality Building-back-better in efficient and resilient housing decreases loss of life and property in disasters while reducing urban resource through-put	• SDG #3 Good Health and Wellbeing • SDG #6 Clean Water and Sanitation • SDG #7 Affordable and Clean Energy • SDG #10 Reduced Inequality • SDG #13 Climate Action • SDG #14 Life below Water • SDG #15 Life on Land	**SDG #12 Sustainable Consumption & Production** **SDG #11 Sustainable Cities & Communities**


CẤM ĐỂ XE

CHAPTER 6
Resource Efficiency through Cross-Sectoral Urban Industrial Symbiosis Strategies

BOX 6.1 Highlights of Chapter 6

1. Industrial symbiosis, which involves the exchange of 'waste' resources through a cross-sector network of businesses where at least three different entities exchange at least two different resources, is an effective method for reducing material use in industry.
2. Informal industrial networks or eco-industrial parks can be facilitated through incentives (e.g. grants, subsidies, tax incentives, market access, quotas, etc.) and minimum environmental performance standards to encourage waste material/energy outputs from one facility to be beneficially reused by another facility (e.g. use the slag output from steel plants in cement production).
3. Significant co-benefits can be achieved through implementation of cross-sectoral industrial symbiosis strategies utilizing waste materials and heat in district energy systems to provide thermal energy and electricity to residential, commercial and industrial consumers, including savings in energy use and economic costs, and reductions in greenhouse gas emissions and air pollution.
4. Reutilizing municipal solid wastes and agricultural wastes through urban-rural industrial symbiotic exchange (e.g. gasification of rice husks and production of chemicals) can reduce air pollution, displace fossil fuel resources and greenhouse gas emissions and result in the development of market opportunities providing jobs and livelihoods for the informal sectors of the economy.
5. Industries ripe for symbiotic exchange of waste materials include the pulp and paper industry, cement production industries, energy utilities and chemical industries. Utilization of waste materials in the construction industry can minimize the resource requirements for the development of new urban infrastructure.
6. Urban land-use policies should support mixed use and compact urban development allowing for energy and material exchanges to occur.
7. Governments should support district energy systems for reutilization of waste heat and support eco-industrial park development. Policies that create barriers or economically disincentives industries from reutilizing waste materials and heat should be avoided.
8. Government support for centralized organizational bodies can be an effective way to increase information exchange and help identify/connect industrial partners for waste material and energy exchanges.

6.1 Rationale and *Weight of Cities* Findings for Global Case

Significant resource savings can be achieved through the reutilization of waste material by-products, energy, and water resources, thus helping to avoid the associated impacts of virgin resource extraction and waste disposal. Industrial symbiosis can be an especially effective way toward resource efficiency, involving the exchange of 'waste' resources through a cross-sector network of businesses, where at least 3 different entities exchange at least two different resources (Chertow 2007, Van Berkel et al. 2009). The material or energy waste outputs of one industry, for example, serve as the raw materials or energy resources for another industry, whose waste by-products in turn serve as the input to yet another industry. Several industries have been identified as particularly strong areas for symbiotic resource exchanges to occur, including the pulp and paper industry, cement production industry, energy utilities, and chemical industries. The pulp and paper industry, for example, produces substantial lignin waste by-products. These by-products, instead of being discarded can be used as a cement dispersant and/or burned to produce heat and power. These cross-sector exchanges reduce demand for other raw materials, thus increasing the resource efficiency of these industries.

Cities are areas of high concentrations of human activities, where residential, commercial and industrial activities are co-located. Such co-location offers systems-level opportunities for resource efficiency through cross-sectoral urban-industrial exchange of energy, materials, water and by-products, often referred to by the term 'urban-industrial symbiosis' (Van Berkel et al. 2009, Ramaswami et al., 2017). Urban industrial symbiosis is often understood as a practice highly relevant to the larger field of industrial ecology in cities and urban areas (Kennedy, 2016). Urban-industrial symbiosis includes examples such as the beneficial reutilization of industrial 'waste' materials and water in other co-located industries, as well as the reutilization of industrial waste heat to provide heating and cooling to homes and businesses. The *Weight of Cities* report presented a case study of urban-industrial symbiosis, demonstrating through a scenario analysis of two cities in China (Kaifeng and Beijing) that up to 36 per cent reduction in city-wide

BOX 6.2 Industrial Symbiosis

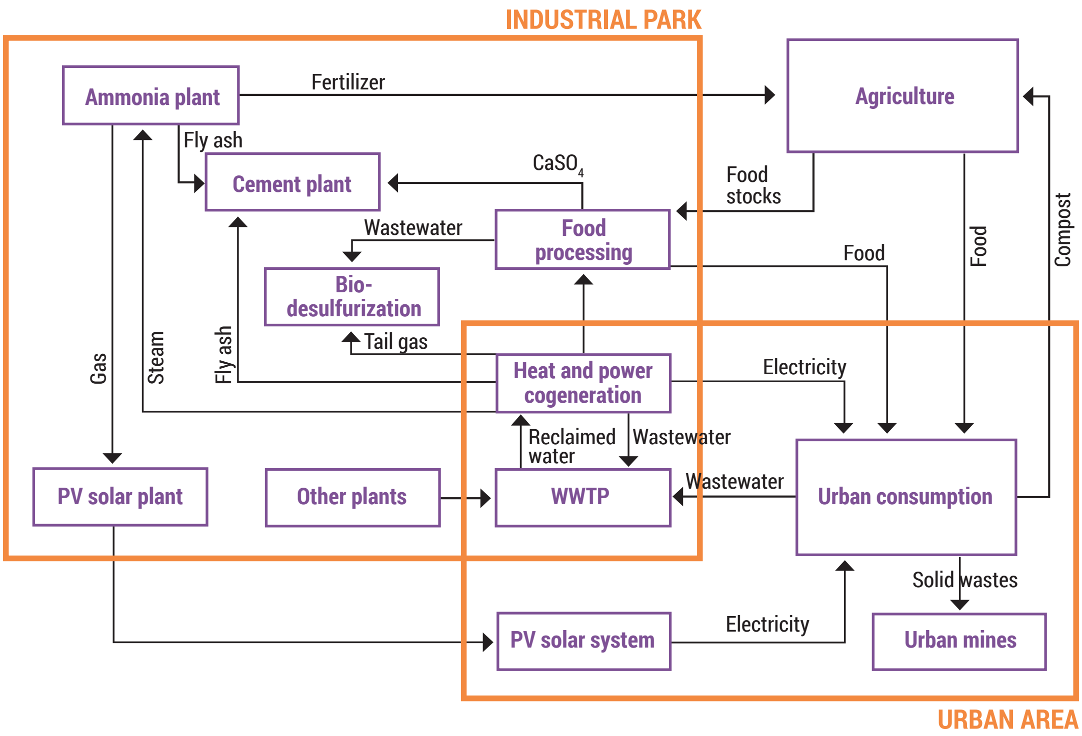
- Circular exchange of material by-products, waste heat and/or waste water resources between industrial production entities.
- 3-2 Rule: At least three industrial entities must be involved in exchanging at least two waste material by-products, water and/or heat to be considered as industrial symbiosis.
- The beneficial exchange of materials across different industries co-located in cities or in eco-industrial parks (example: reutilization of slag from steel plants or fly ash from power plants in cement production blended with Portland Cement).
- Beneficial reuse of high temperature waste heat from an industry to produce steam in another industry (e.g., for food processing or drying) or for hotels.
- Using low temperature waste heat from industries in district energy systems to heat or cool buildings. Often called advanced 4th generation district energy systems, are a new technology that enables low-grade waste heat, which does not have reuse opportunity in industry, to be instead reutilized in homes and commercial buildings, thus avoiding the use of dirty fuels such as diesel in small stoves and boilers.
- Using wastes, such as municipal solid waste, as feedstocks for energy production.

energy use and GHG emissions are possible through such cross-sectoral urban-industrial strategies. Higher urban density and compact urban form help enable such cross-sectoral synergies, along with circular economy policies implemented in China that promote eco-industrial parks and district energy using waste heat.

Urban-industrial symbiosis strategies can offer system-level reduction in energy and material use through beneficial exchange of material and heat across multiple co-located industries, homes, businesses and the energy, water, waste and construction infrastructure serving cities. Figure 6.1 is an example schematic of urban-industrial symbiosis in action. Cities can leverage such co-location, which uniquely occurs only in cities, though compact urban planning that allows for proximity and physical exchange. Information about the availability of the resources as well as the development of networks for material and energy exchange is also shown to be useful. Urban industrial symbiosis can offer many co-benefits including economic savings, resource (material and energy) savings, and health benefits from avoiding the burning of fossil use by reusing waste heat (Van Berkel et al. 2009).

This chapter draws upon ASEAN as well as Indian and Chinese case studies in cross-sectoral material and energy exchange strategies impactful in developing sustainable and healthy cities in the context of ASEAN nations.

FIGURE 6.1 Example schematic of urban industrial symbiosis material-energy exchanges between industries
(Dr. Lei Shi in Ramaswami et al., 2014)



6.2 ASEAN Context

New urbanization and infrastructure development results in a large demand for materials, as building infrastructure and cities require steel, cement, bricks, wood and other construction materials. Indeed, more cement has been used in China in 3 years than all the cement used in the United States in the entire 20th century (Tabarrok and Rajagopalan, 2015). In fact, about 62 per cent of all material requirements in China are related to the construction and wood products sectors (Giljum et al., 2015). Similarly, significant construction materials, electricity, oil and gas are expected to be required in the ASEAN nations, and projections indicate that many ASEAN nations will likely produce a vast majority of that coal, oil, cement, steel, pulp and paper. For example, the World Energy Outlook find that in Southeast Asia, cement and chemicals are the largest industrial energy consumers in 2013, but energy demand from the iron/steel sub-sector grows an average 5.6 per cent per year, and by 2040 is the largest energy consumer, followed by chemicals, with oil as the predominant feedstock (IEA 2015). Cement, iron and steel factories, and coal production is expected in Indonesia, while Malaysia will significantly grow its petrochemical industries given its eminence in this industry. The pulp/paper sub-sector is also expected to see large increases - particularly in Thailand, Malaysia, Viet Nam and Indonesia. **All these industries are high users of fossil fuel, and hence also produce a lot of waste heat and materials that are particularly suited for symbiosis**.

The World Energy Outlook projections assume under business-as-usual scenarios that industrial energy intensity will decline to 62 per cent per unit of GDP (compared to 2013) due to improved auditing and management of individual sectors. However, cross-sectoral urban-industrial symbiosis is not considered, and may offer significant additional benefits, as will be explored through case studies. These industries also emit substantial quantities of waste to land, air and water, making them particularly important opportunities for industrial symbiosis, especially when located within cities/urban areas where co-location can provide even greater potential for resource efficiency savings.

Urban industrial symbiosis can be particularly beneficial for young cities that are simultaneously undergoing both urbanization and industrialization, and thus is expected to be highly relevant to the ASEAN nations. ASEAN nations are expected to see an increasing emergence of highly populated cities, with up to 500,000 people and cities in the 0.5 to 2 million population range. In these emerging cities, early planning can enable co-location of industries within eco-industrial parks, as well as facilitate the laying of piping infrastructure (if found cost-effective) to transfer waste heat from industries to homes and businesses in cities. Such low-grade waste heat can effectively be transmitted with relatively low losses at distances of 20-30 kilometre from the industries to serve homes and businesses in district energy systems (UN Environment, 2015). District energy systems are cost-effective in multi-storey construction – thus a compact urban form is important to support urban industrial symbiosis. The use of low-grade heat from industries to heat buildings has been demonstrated to be cost-effective in numerous EU cities, and recent estimates have also found this to be a viable option for cooling buildings in China (Tong et al., 2017), with economic payback ranging from 1 to 4 years. **Given that significant new urbanization-industrialization is expected in the ASEAN region (see Ch. 1 and 2), and that the region already has a history of developing denser cities (see Ch. 2 and 3), the patterns of urbanization in ASEAN nations are highly conducive to urban-industrial symbiosis.**

6.3 Case Studies of Urban-Industrial Symbiosis from ASEAN, India and China

Urban-industrial symbiosis occurs relatively informally in many countries (Chertow 2007) and can be further facilitated by policies, such as those that promote circular economy and eco-industrial parks. China and India represent excellent examples of informal and formally planned/facilitated development of industrial symbiosis, representing two ends of the industrial symbiosis development spectrum, as depicted in figure 6.2. Urban-industrial symbiosis is thus applicable to the diversity of ASEAN nations, using informal and formal approaches. In this section, we first present:

- Industrial symbiosis in ASEAN nations.
- Industrial symbiosis in India through informal networks.
- Planned Eco-industrial parks in China.
- Reducing air pollution through urban-rural symbiotic exchange.

- Role of urban-industrial symbiosis on sustainability across 19 Chinese cities.
- Sustainable development co-benefits of industrial symbiosis in national context.

FIGURE 6.2 ASEAN nations can take different paths toward developing industrial symbiosis, where India and China represent two ends of the development spectrum *(ASEAN map from Mooney 2016)*

BOX 6.3 ASEAN example of developing industrial symbiosis strategies

In Viet Nam, out of 321 industrial processing areas, 16 per cent had not built waste treatment facilities, resulting in significant pollution to land and water, affecting water quality, eco-toxicity and human health. Recognizing these negative externalities, the Vietnamese government mandated in 2014 that all newly established industrial parks be built as eco-industrial parks, having criteria for promoting use of recycling of wastes and using renewable energy, reducing greenhouse gas emissions and treating wastes (VBN 2016). Several existing industrial parks across Viet Nam, including in Ninh Binh, Da Nang, and Can Tho have since been retrofitted for increased implementation of industrial symbiosis, cleaner production and renewable energy strategies, resulting in significant energy and greenhouse gas emission savings from a reduction of electricity consumption by 72.5 per cent, 63 per cent and 84 per cent, respectively (VNCPC, 2016).

6.3.1 Industrial Symbiosis in ASEAN countries

The application of industrial symbiosis in ASEAN nations and other nations has been fairly new, where the possibilities are just beginning to be explored. As such, formal examples of industrial symbiosis in ASEAN countries is somewhat limited. Southeast Asia is home to many industrial parks, most of which remain significant sources of environmental pollution, having high rates of resource use, and waste discharge and disposal. As such, the diffusion of industrial symbiosis strategies across ASEAN industrial parks is a particularly important strategy for reducing pressures on the environment and society while increasing economic growth and livelihoods.

Other piecemeal examples of industrial symbiosis exist, where technologies, such as combined heat and power, can help reduce substantial amounts of energy and greenhouse gas emissions through strategic use of waste heat to satisfy both thermal and electricity needs. Such technologies can be extended further through utilization of waste materials, and expanding the function to include heat, power, hot water, and cooling generation. These and other technologies, such as centralized water treatment and reclamation technologies, can be implemented across a wide variety of industries, having cross-sectoral benefits. The following sections draw on examples taken from India and China, demonstrating both formal and informal application of industrial symbiosis strategies and illustrating the range of likely application in ASEAN countries.

6.3.2 Industrial Symbiosis in India through Informal Networks

While there is significant interest in promoting industrial symbiosis in India through planned development of eco-industrial parks, much of these formal efforts are still in planning phases. Nonetheless, several informal industrial symbiosis examples have been uncovered. The Nanjangud Industrial Area (NIA) located near Mysore India, for example, is home to over 60 industrial processing facilities, spanning a diversity of industries, including paper manufacturing, sugar refining, natural oils processing, food processing, textile manufacturing, chemical manufacturing and alcohol distilling, to name a few (Bain et al 2014). The symbiotic use of materials and energy across these industries has informally emerged due in part to the relatively resource scarce context, where there are shared norms to maximize resources and minimize waste (and correspondingly minimize economic costs and maximize revenues), leading to unique ways in which by-products and wastes are used across industries.

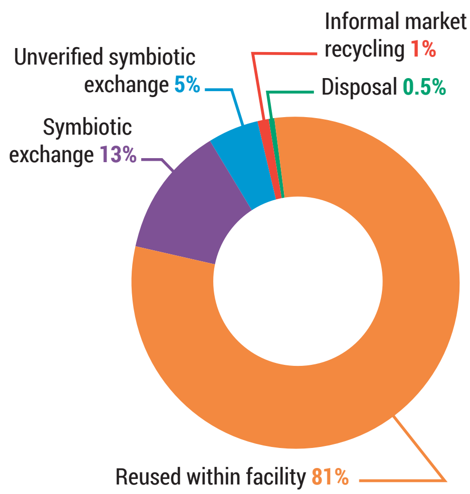
Across the NIA industrial facilities, a total of 28 symbiotic interactions have been identified (11 across NIA facilities, 17 transboundary by-product exchanges between NIA facilities and facilities outside the NIA boundary), resulting in large scale reductions in waste and quantities of virgin natural resources used per value added from the eco-industrial park (Bain et al. 2014). Most of these interactions involve the reutilization of waste materials, while some involve the sharing of electricity. For example, the paper manufacturer avoids the costs of sludge waste disposal by instead selling sludge by-products to a fertilizer manufacturer which uses the sludge as a fertilizer component, to be beneficially used to produce food for the region. A portion of the in-house generated electricity (generated from purchase of waste biomass resources such as paddy and coffee husks, coconut shells, etc.) is also sold to the grid, which can reduce consumption of fossil fuel resources. Food processing facilities in NIA have formed relationships with local biofuel and brick manufacturers, which respectively processes food residues into biofuels (a portion of which is circularly used by the food processor) and uses boiler fly ash in the production of brick materials. The NIA distillery is a particularly strong node of industrial symbiosis, both acting as a consumer and producer of inter-industrial material and energy flows. The distillery uses molasses by-products from the local sugar refinery to produce alcohol and exports carbon dioxide to a local compression facility, isopropyl alcohol by-products to the local dairy processing facilities, and excess electricity produced through combustion of methane generated through anaerobic digestion of waste rice paddy husks, to a local bottling facility (Bain et al. 2014). Altogether, across 42 facilities annually generating 897,210 metric tons of waste, at least 95 per cent of materials are reutilized or recycled from the NIA facilities through informal industrial symbiosis practices (see Figure 6.3).

This case study underlines the concept that large networks of symbiotic industries are likely to exist in many industrial regions, informally evolving as industrial exchanges are identified and contracts/relationships are facilitated. These symbiotic relationships have evolved in the Nanjangud Industrial Area in the absence of regulatory pressures, instead emerging because of the social norms and networks established for reuse and recycling. Scholars are broadly in agreement that informally evolving industrial symbiosis may be more sustainable over time (Chertow 2007, Bain et al. 2014, Tian et al. 2014), as the exchanges are driven by economic viability and reuse/reutilization strategies are internalized by the corporate culture. These findings have particularly positive implications for countries like Laos and other Southeast Asian countries that, like India, have a high level of social networks, which help facilitate knowledge diffusion and enable symbiotic industrial exchange of materials, energy and water. Governments can help facilitate these relationships and should also be cognizant of policies that could unintentionally work to suppress such exchanges, as seen in the United States where, for example, pricing benefits for combined heat and power generation were stymied through increasing the criteria for qualification, thus failing to incentivize industries to implement (Chertow 2007).

BOX 6.4 Nanjangud Industrial Area (NIA) example of industrial symbiosis exchanges *(Bain et al. 2014)*

- Paper manufacturer: sludge by-products sold as fertilizer component to produce food, electricity generated from waste biomass materials for in-house and external grid use.
- Food processor: food residue wastes processed into biofuels and boiler fly ash used in brick material production.
- Sugar refinery: molasses by-products sold for producing alcohol beverages.
- Alcohol distillery: CO_2 emissions are captured and diverted to a local CO_2 compression facility, isopropyl alcohol by-products are sold to local dairy processing facility, and combustion of methane gases from anaerobic digestion of waste food residues generate electricity for internal use and sold for external use in a co-located bottling facility.

FIGURE 6.3 Fate of Material Wastes generated by Nanjangud Industrial Area facilities *(Bain et al., 2014)*



6.3.3 Eco-Industrial Parks in China: National Policy Framework

In China, over 1,500 industrial parks at national and provincial levels are in existence, contributing to both the substantial growth in national GDP as well as rising environmental and human health pressures, affecting air

BOX 6.5 Co-benefits of Eco-Industrial Parks in China *(2005-2011)*

Across 12 Chinese eco-industrial parks, several resource and environmental impact reducing co-benefits have been realized, including (on average):

- 28% improvement in land productivity;
- 22% reduction in energy consumption intensity (Btu/value added);
- 25% decrease in freshwater consumption intensity (m^3/value added);
- 28% reduction in wastewater emission intensity (COD/value added);
- 32% decrease in solid waste production intensity (tons/value added);
- 69% reduction in SO_2 emission intensity (tons/value added).

BOX 6.6 Policies promoting industrial symbiosis in Tianjin Economic Development Area *(TEDA)*

The Tianjin Economic-Technological Development Area (TEDA) is an excellent example of successful industrial symbiosis policies at play. Mandatory environmental disclosures and minimum performance standards increased participation and awareness of wastes and pollution emissions. Pricing mechanisms helped to economically incentivize symbiotic interactions, reuse of wastes and by-products. For example, subsidies were used to stimulate facilities to retrofit their own technologies in order to use reclaimed water in industrial operations, which was responsible for successfully increasing reclaimed water sales by 84 per cent in just one year, thus helping to alleviate pressures on scarce freshwater resources. Subsidies used for incentivizing implementation of desulphurization technologies similarly helped increase desulphurization efficiency by more than 98 per cent. Other financial incentives, in the form of subsidies, discounted loans, and/or grants are also effectively earmarked to support industrial engagement and implementation of other energy/water/material saving technologies, waste reutilization, environmental management certifications (e.g. ISO 14001, eco-labelling) and environmental disclosure. These incentives help increase company participation and help to embed industrial symbiosis norms and values in the corporate culture. The centralized Eco Center organization was also particularly instrumental in the identification and collaboration for possible industrial exchanges, resulting in over 400 company collaborations and 40 industrial symbiosis projects. The combination of these policies resulted in significant co-benefits and substantially improved performance over the minimum performance standards set for eco-industrial parks in China. Regarding water indicators, such policies resulted in reductions in freshwater consumption, wastewater discharge, and COD emissions that were 52 per cent, 69 per cent and 69 per cent, respectively, lower than the standards. Altogether, freshwater consumption and wastewater discharge were reduced by 29 per cent and 40 per cent, solid waste generation decreased by 35 per cent, SO_2 emissions reduced by 49 per cent, and energy use per industrial added value decreased by 11 per cent (Yu et al. 2014).

quality, climate change, water quality, and so on (Tian et al 2014). In response to the increasing environmental and human health pressures caused by relatively unregulated industrial processing, the Chinese government in 2001 mandated the establishment of a national eco-industrial park demonstration programme, which, by 2017, resulted in 48 accredited eco-industrial parks, with another 45 listed as trials. The widespread success of Chinese eco-industrial parks in reducing environmental impacts while increasing economic value are thought to be a result of the combination of both top-down regulatory policies requiring compliance within minimum performance standards, as well as facilitation strategies which help expand knowledge about and incentives for symbiotic material and energy inter-industrial exchanges (Yu et al. 2014). A study by Tian et al. (2014) reviewed the environmental and economic performance of 12 national eco-industrial park demonstrations between 2005 and 2011, and found that, while most have absolute increases in resource use and impacts due to the high degree of industrial growth, the eco-industrial parks also resulted in substantial reductions in resource and environmental emissions intensity, indicating progress towards a relative decoupling of economic growth, resource use and associated impacts. Over the time period, these eco-industrial parks contributed to a 56 per cent increase in added value, with a 22 per cent, 25 per cent, 28 per cent and 32 per cent decrease in the intensity of energy and freshwater consumption, wastewater, and solid waste emissions, respectively, per value added.

Regarding water quality and air emissions, the eco-industrial parks experienced both absolute and relative decoupling, due in part to the new regulatory requirements (applied across all of China) as well as the additional incentives provided to implement new technologies, resulting in an absolute reduction of chemical oxygen demand (COD - an indicator for water quality) and sulphur dioxide emissions (SO_2 - an indicator for air quality) of 25 per cent and 51 per cent, and a decrease in emissions intensity by 52 per cent and 69 per cent, respectively.

Even though these new regulatory requirements were applicable to all Chinese industries, the eco-industrial parks substantially out-performed conventional Chinese industrial producers, which had more modest absolute reductions in COD and SO_2 emissions, at 12 per cent and 14 per cent, respectively. The range with which the 12 investigated eco-industrial parks achieved resource savings and emissions reductions varies substantially, largely due to the differences in policies, programmes and incentives established in the different regions to promote material and energy reutilization and exchange.

- Yu et al. (2014), identifies several strategies that can help facilitate industrial symbiosis and improved environmental and economic performance, especially if used in combination, including:

- Establishment of an administrative committee and/or leading group under the auspices of an administrative committee, accredited by municipalities to oversee the development and management of eco-industrial parks that allow for regulatory, economic, and voluntary policies to be implemented.
- Regulation and direct enforcement of minimum performance standards and mandatory material/energy information disclosures using a variety of enforcement mechanisms (e.g. fees, quotas, deprivation of preferential policies and stock market listing penalties).
- Shared use of city infrastructures with pillar industries, such as centralized wastewater, solid waste and hazardous waste treatment and reclamation facilities, and district energy facilities utilizing combined heat and power technologies. These pillar industries can be hubs for increased network connections to initiate industrial symbiosis exchanges, but require large upfront investments and/or subsidies. Despite the substantial upfront investments, such facilities can result in several co-benefits, including cross-sectoral cost and resource savings, and reductions in environmental pressures, such as lower greenhouse gas emissions and air pollution.
- Voluntary incentive programmes using pricing mechanisms to help incentivize reuse of resources and materials (e.g. tax incentives, rebates, subsidies, grants, and quotas). Such pricing mechanisms make the purchase of reusable materials, such as reclaimed water, economically more attractive than virgin resource counterparts.
- Concerted knowledge diffusion and coordination via a centralized organization that can help facilitate matchmaking workshops and trainings to help identify material/energy flows ripe for collaborative exchange.

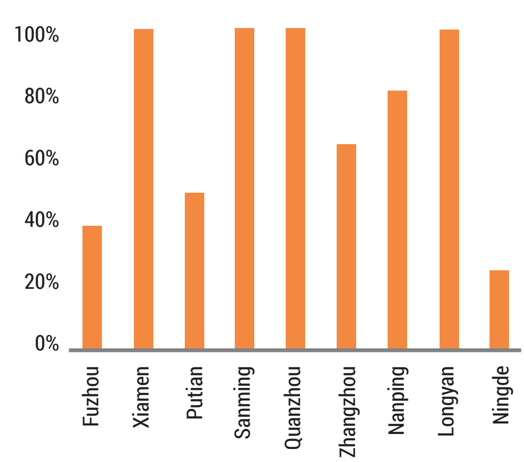
The Yu et al (2014) study highlights how the planned eco-industrial park (EIP) model can still be useful in the early stages of development to both identify potential material-energy-water connections and for setting minimum performance standards to direct efforts toward, which can lead to substantial gains in environmental performance over a relatively short period of time. The study also highlights the importance of combining these top-down planning models with strategies that can further encourage and facilitate voluntary relationships and initiatives to continue to reduce inefficiencies and optimize flows. Not doing so runs the risk that such collaborative norms and values that enable long-term symbiotic relationships to take shape are not actively embraced and consequently resource efficiency efforts may falter, as has been seen particularly in the case of United States eco-industrial parks of the 1990s. In recent years, China has recognized the importance of such efforts, putting greater emphasis into facilitation of symbiotic exchanges in existing EIPs.

6.3.4 Urban-Industrial Symbiosis across 19 Chinese Cities

A study by Tong et al. (2017) characterizes the potential resource and greenhouse gas savings, and health co-benefits of applying urban-industrial symbiosis strategies across 19 Chinese cities compared to single sector efficiency improvements (e.g. improvements in buildings, industries and power plants) as outlined in China's five-year plan. Various indicators were assessed, including reductions in PM2.5 emissions and greenhouse gas emissions, and savings in materials and energy. The primary industrial symbiosis strategy evaluated included the utilization of different grades of industrial waste heat (e.g. high, medium and low-grade heat) in different reuse applications such as in electricity generation and in district energy systems using steam and hot water. Cities located in Fujian province, for example, were able to achieve significant electricity savings ranging from 20 per cent to 100 per cent through utilization of waste heat in district energy systems as illustrated in Figure 6.4 for each of the indicated cities. The energy savings resulting from utilization of waste heat in district energy systems can thus reduce the demand for fossil fuel resources significantly, and have other co-benefits that involve reductions in greenhouse gas emissions and reduced air pollutant emissions, thus providing viable pathways toward achieving the United Nations Sustainable Development Goals across ASEAN nations.

Overall waste production can be reduced through urban-industrial symbiosis as well. Programmes like Sorsogon's shown in Box 6.7 can be used to convert waste to reusable materials such as plastics and pillows.

FIGURE 6.4 Percentage of energy savings from reutilizing industrial waste heat in District Energy Systems in total energy use for cooling in commercial and residential sectors



BOX 6.7 Waste-reuse in Sorsogon, Philippines

Sorsogon produces 0.23 kilograms of waste per capita per day which is less than half the country average of 0.5 kilograms per capita per day (AECOM/ADB, 2016; World Bank, 2012). Sorsogon has several ordinances restricting where waste can be disposed, requiring waste be separated at the household and limiting the use of non-biodegradable materials like plastic bags. Plastic bags can be used for the packaging of dry goods and as secondary packaging, however, they cannot be used as grocery bags. Plastic bag disposal has been shown to have substantial deleterious effects on the environment, particularly on aquatic life, where plastics can harm biota through entanglement, ingestion and contribute to harmful hypoxic conditions (Derraik 2002).

In Sorsogon, instead of disposing of plastic bags to landfills, plastic bags are reused for industrial purposes to limit the impact on the environment. If not brought to a temporary storage first, household waste is brought by pedicab or pushcart to Materials Recovery Facilities (MRFs). At the MRF, tin cans, papers, bottles and other materials deemed useful are separated from the waste and sold to junkshops. Plastic bags that are not restricted are sorted in the MRF, washed, hang-dried, shredded into small pieces, and packed to be used either as filling materials for making hollow blocks or as stuffing materials for pillows or dolls (AECOM/ADB, 2016).

In addition, the remaining non-biodegradable solid wastes are turned into charcoal. All combined, these ordinances and processes result in a lower waste production per capita per day than seen in other ASEAN nations.

FIGURE 6.5 Waste-sorting in Sorsogon, Philippines *(http://bicoltoday.com)*

6.4 Reducing Air Pollution through Urban-Rural Industrial Symbiotic Exchange

In many developing countries, including those in the ASEAN region, open burning of municipal solid wastes and agricultural wastes are commonplace. As a result, such practices have emerged as a key source of particulate matter pollution with particle sizes of less than 2.5 micrometers (PM2.5), having significant implications for human health as PM2.5 exposures have been associated with increased rates of cardiovascular diseases, respiratory disease, diabetes and asthma (Lin et al 2002, Burnett et al. 2014, He et al. 2017). Novel business arrangements that create livelihoods for informal reuse and recycling of municipal solid wastes and agricultural wastes can provide significant co-benefits through reduction of PM2.5 emissions, displacement of fossil fuel resources and greenhouse gas emissions, and the development of market opportunities that can provide jobs and livelihoods for the informal sectors of the economy.

Several countries in Southeast Asia have begun to utilize food wastes as important feedstocks for producing value-added products (Ong et al. 2017). In Thailand, for example, food wastes associated with sugar cane production are used by other industries to produce a multitude of value-added products, including briquette fuel from leaf residues, bread, concrete, ethanol, lactic acid and biohydrogen from bagasse by-products, concrete from filter cake wastes. In Singapore, waste from palm oil production are used to produce value-added base chemicals, such as lactic acid and cellulose, to be subsequently used for producing other intermediary chemicals and products. In Malaysia, pineapple wastes and extracts are used to produce lactobacillus growth mediums, vanillic acid and vanillin, and violet pigments. In addition to these products, energy is also often produced from utilization of waste materials (Ong et al. 2017).

Although utilization of waste for producing energy is less preferable than avoiding waste in the first place or reusing/recycling waste into value-added products, it is an important strategy for reducing use of fossil fuel resources and associated impacts. See the below inset as one possible waste-to-energy pathway utilizing biomass gasification technologies. Altogether, the utilization of waste streams to produce value-added products and energy can provide an important means for the informal economy to gain market access through the facilitation of industrial waste material exchanges that are otherwise unproductively disposed to various environmental sinks, causing both increasing pressures on the extraction of new resources and pressures on environmental and human health.

BOX 6.8 Waste-to-energy through Gasification with Rice Husks

Cambodia and Laos have low electrification rates, an unreliable electricity supply and are 100 per cent dependent on imported fuels (Luukkanen, 2015). In 2009, only 24 per cent of the Cambodian population had access to electricity (Luukkanen, 2015). Biomass gasification technologies provide a solution to the electricity problems of both countries. Biomass gasification can be an effective solution to decrease diesel consumption and dependency on imported fossil fuels for power generation. The excessive use of diesel in rice mills and sugarcane factories in Cambodia and Laos can be partly replaced by biomass-based wastes. Rice husks and bagasse can be used to generate electricity for their own needs. Rice is the biggest potential source in Cambodia and Laos since it is the main agricultural crop and staple food and approximately 80 per cent of the cultivated area in both Cambodia and Laos has been devoted to rice cultivation (Luukkanen, 2015). High amounts of rice production contribute to high availability of rice residues such as paddy husk and rice straw. One of the inspiring examples of rice husk gasification is the Batt Daeng Electrification Company in Kampoung Speu, Cambodia. Cambodia could, on an annual basis, offset all of the current electricity production, about 1380 GWh, by using all the rice husk supply for electricity generation if it employed similar technology to that being used by Batt Daeng (Silva et al., 2013).

FIGURE 6.6 Rice husk gasification in Cambodia
(ARE n.d.)

In addition, there are also some other smaller scale biomass gasification projects in Cambodia which utilize resources such as coconut husk, cassava stem, mulberry stem and Cassia tree. It is clear that gasification strategies can be an effective way for redirecting wastes for more productive energy generation needs.

6.5 Sustainable Development Co-Benefits of Urban-Industrial Symbiosis in National Context

Urban-Industrial symbiosis strategies, such as the reutilization of waste heat in urban district energy systems, and reuse of waste materials have been shown to have significant co-benefits, where savings in economic costs, energy, GHG and particulate matter emissions can be achieved. These co-benefits, realized through urban-industrial symbiosis strategies, can thus provide viable pathways toward achieving the United Nations Sustainable Development Goals (SDGs).

A study by Ramaswami et al. (2017) examines the potential magnitude of co-benefits that can be achieved in a national context through a scenario analysis modeling energy use in different sectors (residential, commercial and industrial) and comparing single sector efficiency improvements made, for example in buildings, industries and power plants, to cross-sectoral urban-industrial symbiosis strategies applied across 640 Chinese cities in Mainland China. These strategies have high relevance to ASEAN nations, where significant industrialization and urbanization are expected to co-occur. The study examines multiple urban-industrial symbiosis strategies, such as construction of denser high-rise multi-storey buildings that require less land resources, district energy systems that reuse waste heat of different grades for electricity generation, heating and cooling, and material substitution exchanges where wastes are beneficially reused in applications like the construction sector (e.g. steel slag and boiler fly ash replacing a portion of cement requirements for concrete production). These cross-sectoral urban-industrial symbiosis strategies show substantially greater co-benefits than single-sector strategies alone, as illustrated in Figure 6.6 demonstrating the scale with which these co-benefits can be achieved. Results show that approximately 47,000 annual premature deaths associated with PM2.5 air pollution exposure could be avoided (using the globally integrated health risk assessment provided by Burnett et al (2014) and considering meteorological effects on pollutant concentrations for exposure).

From a greenhouse gas standpoint, urban-industrial symbiosis strategies provide an additional reduction of about 15-35 per cent in greenhouse gas emission compared to single-sector strategies alone, with payback periods for technological investments of only 1-4 years (Ramaswami et al. 2017, Tong et al 2017). Greenhouse gas and health risks reductions can vary significantly within each individual city, as shown in Figure 6.7, ranging from <1-41 per cent and <1-64 per cent, respectively across individual cities, thus reflecting the differences in populations and economics, industrial, commercial and residential structural characteristics, and differences in meteorological conditions and dispersion for air pollution modelling.

Collectively, such urban-industrial symbiosis strategies are shown to be an important tool in driving the transition towards sustainable development, directly affecting several of the Sustainable Development Goals.

FIGURE 6.7 Co-Benefits of district heating and cooling strategies and linkages to the UN Sustainable Development Goals

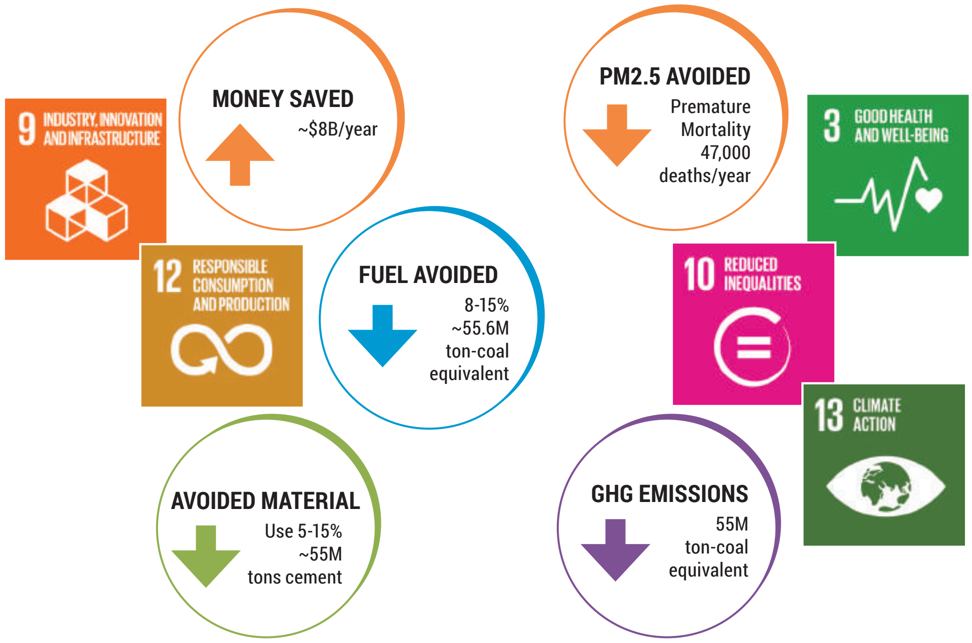
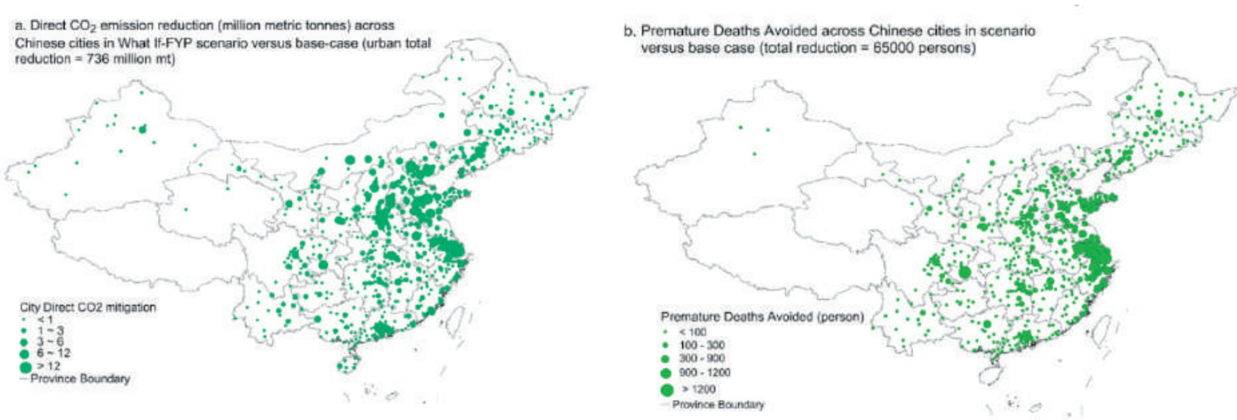


FIGURE 6.8 GHG and air pollution co-benefits of reutilization of industrial waste heat in urban district energy systems and reuse of waste materials across 640 Chinese Cities in Mainland China. The map shown below is used to illustrate cities in mainland China, not as the standard territorial map of China



6.6 Policy Learning and Insights for ASEAN Cities

Contextualizing *Weight of Cities* assumptions: The two case studies (Kaifeng and Beijing) in the *Weight of Cities* report show that approximately 36 per cent of energy use and greenhouse gas emissions could be saved through implementation of cross-sectoral industrial symbiosis strategies that utilize waste heat for district energy systems to provide thermal energy and electricity to residential, commercial and industrial consumers. The indicated co-benefits, including costs savings and reductions in environmental and human health impacts are also substantial. Given the context of ASEAN nations, where significant industrial development has and will continue to occur, these results are likely to be very much in line with what ASEAN nations could achieve through similar industrial symbiosis strategies.

ASEAN nations with governance structures that allow for top-down policy making and enforcement can more readily follow the formal planning approaches, where industrial symbiosis is actively facilitated and incentivized. Other ASEAN nations, where strong social networks exist but may have weaker governance structures may have industrial symbiosis exchanges occurring more spontaneously, informally encouraged through intrinsic economic benefits and cultural norms. A combination of formal and informal industrial symbiosis strategies, will thus be relevant for the ASEAN region. The case studies illustrated in this chapter highlight key learnings applicable to ASEAN nations whereby industrial symbiosis can be facilitated through:

- Policies requiring conformance with minimum environmental performance standards and disclosures of wastes and emissions, paired with policies providing economic incentives through pricing mechanisms (e.g. grants, subsidies, tax incentives, market access, quotas, etc.) to further facilitate exchange of waste materials and energy.
- Governments refraining from implementing and enforcing policies that create barriers or economically disincentivize industries from reutilizing waste materials and heat (e.g. United States inadvertently disincentivizing industrial combined heat and power uptake).
- Establishing solid waste laws and eco-industrial park demonstrations programmes with the resources and support from organizational bodies that can help identify and connect industrial partners for waste material and energy exchanges.
- Urban spatial planning strategies that support mixed use and dense urban development allowing for energy and material exchanges to take place, and national level policies that support district energy reutilization of waste heat and eco-industrial park development.

Policy Levers and Multiple SDG benefits: Incorporating the human health benefits shown in Table 5.1, we find that resource efficient and cross-sector urban industrial symbiosis and waste-to-value strategies can support multiple SDG co-benefits, as shown in Figure 6.9. For example, cross-sector circular economy strategies offer cost-savings and new business opportunities that enhance local livelihoods in support of SDGs relating to no poverty (SDG 1); decent work and economic growth (SDG 8); and industry, innovation, and infrastructure (SDG 9). They also promote a viable management strategy of industrial waste, particularly in developing countries which returns anti-pollution benefits in support of SDGs relating to good health and wellbeing SDG 3); clean water and sanitation (SDG 6); and life on land (SDG 15). Such strategies contribute to reduced fossil fuels and associated burdens of GHG emissions, air pollution, and health risks in support of SDGs concerning good health and wellbeing (SDG 3) and climate action (SDG 13). They promote reduced material extraction and associate environmental impacts, while also promoting water reuse limiting water withdrawals, in support of SDGs related to clean water and sanitation (SDG 6), life below water (SDG 14) and life on land (SDG 15). They provide novel renewable energy options in urban regions in support of the SDG related to clean and affordable energy (SDG 7). They also provide opportunities for more equitable urban-rural interactions in support of the SDG related to reduced inequality (SDG 10). Combined, all of the pathways and linkages support sustainable cities and communities (SDG 11) and sustainable consumption and production (SDG 12).

FIGURE 6.9 **Sustainable Development Goals and industrial symbiosis pathways for addressing**

Cross-Sectoral Urban-Industrial Policy Pathways	Linkages for Impacting SDGs	SDGS	
Use spatial planning to promote circular economies through cross-sector resource and waste reutilization Co-locate industries in eco-industrial parks, applying suitable incentives institutional and regulatory frameworks Promote cross sectoral urban-industrial resource & waste reutilization through district energy and waste-to-value programs Promote urban-rural-industrial symbiotic exchange	Cross-sector circular economy strategies offer multiple co benefits: • Cost savings & new business opportunities that enhance local livelihoods • Viable management strategy of industrial waste, particularly in developing countries • Reduced fossil fuels and associated burdens on GHG emissions, air pollution, and health risks • Reduced material extraction and associated environmental impacts • Water reuse to reduce water withdrawals • Novel renewable energy options in urban regions • More equitable urban-rural interactions	• SDG #1 No Poverty • SDG #3 Good Health and Wellbeing • SDG #6 Clean Water and Sanitation • SDG #7 Clean and Affordable Energy • SDG #8 Decent Work & Economic Growth • SDG #9 Industry, Innovation & Infrastructure • SDG #10 Reduced Inequality • SDG#13 Climate Action • SDG #14 Life Below Water • SDG #15 Life on Land	**SDG #12 Sustainable Consumption & Production** **SDG #11 Sustainable Cities & Communities**


KL MONORAIL

CHAPTER 7
Governance and Finance

BOX 7.1 Highlights of Chapter 7

1. Governance for resource efficient urbanization is premised on maximizing synergies across individual urban areas, national urban systems, and urban infrastructure sectors, all of which demand sophisticated coordination of both policy making and operational urban management.
2. Ad hoc coordination—either inter-city or across levels of government—can be positive, but uncodified efforts can be limited in their effectiveness as their staying power is threatened when political priorities change. Institutionalizing and formalizing long-term coordination and cooperation processes can help shield them from potential disruption. Top-down policy directives offer an opportunity to set standards for how local governments are expected to coordinate and work with another, as well as how other levels of government are expected to coordinate with local governments for resource efficiency.
3. Urban leaders may have difficulty connecting the dots between best practice research, especially of a technical nature, and what that research means in terms of the action steps that can be taken in a given city. National governments and international agencies, including international financial institutions, have a role to play in providing technical assistance to bolster the capacity of local governments, especially small and medium size ones that may struggle with accessing professional expertise and knowledge resources.
4. Given some of the broadly shared urbanization dynamics of the region—the potential rise of 200+ small cities, similar levels of exposure to natural disaster and climate risk, high levels of slum development, and projected growth in household incomes and subsequent consumption—the ASEAN bloc could establish regional research and policy guidance centres for the study of these common urban development concerns.
5. Capacity building and technical assistance efforts can be bolstered by partnerships that allow local governments to access the expertise and competencies of local institutions, specifically universities, non-governmental organizations, and other civil society organizations. The ability of local officials to establish a partnership vision, rally coalition support, and see that vision through to completion are all elements of leadership capacity that are critical for sustainable urban development futures.
6. The high-growth macro-economic environment that will undergird rising incomes and land values across the ASEAN region position it well to finance physical, land based infrastructure investments using land value capture mechanisms and innovative public-private partnerships (PPP).
7. Governments at all levels have a responsibility to ensure that innovative financing and PPP arrangements support the public good and not just private gains. This requires safeguards including robust governance, monitoring, and evaluation institutions for overseeing the design, implementation and on-going operation of such arrangements.

7.1 Governance Challenges and Opportunities

Taken together all the strategies identified in the areas of land use planning, transportation planning, energy and buildings, and cross-sector urban industrial symbiosis have been estimated in the global *Weight of Cities* report to together have the potential to reduce urban material use by 30 to 60 per cent. This technical potential however can only be achieved if several enabling governance factors are in place. These enabling factors include:

1. Coordination across levels of governance identifying where national governments and the regional ASEAN bloc can provide resources and support, as well as identifying specific areas where national governments should devolve power to the local government units, while also providing financial support for needed infrastructure transformations.

2. Capacity building for local governments which can be done by leveraging international organization expertise, ASEAN Bloc level expertise, as well as local expertise at the level of individual cities through science, civil society, and business partnerships. Expertise can be mobilized to build local government capacity for advanced science-technical projects as well as for governance and management efforts like building code compliance enforcement, urban-level data collection, partnership development, and mobilization of financing.

3. Leadership training for cross-cutting sustainability resource efficiency, health and wellbeing, and disaster risk resilience is important for achieving SDGs.

4. Institutionalized best practices around urban planning and infrastructure design, particularly connecting environmental sustainability, health and wellbeing, and disaster risk resilience.

All of the infrastructure transformations that have been evaluated in this report can provide a net-positive return on investment on a life-cycle basis, but overcoming first-cost barriers to investment remains a challenge for many local governments. Because physical infrastructure is closely linked to land, and land values are expected to appreciate given the positive economic outlook for the

ASEAN region, land value capture mechanisms emerge as a suitable vehicle for local governments to development local partnerships and raise the capital necessary to develop sustainable infrastructure for future ASEAN urbanization.

The following chapter presents key management, governance and financing considerations—both challenges and opportunities—relative to infrastructure provisioning and resource efficient urbanization in the ASEAN region. Much of the discussion in this chapter reflects the comments of workshop participants and interviewees captured as part of the feedback workshop co-hosted with United Nations Environment, United Cities and Local Government- Asia Pacific, and the League of Cities of the Philippines, which coincided with the 3rd Annual ASEAN Mayors Forum, held in July 2017 in Manila. Participants and interviewees included a sampling of elected officials, local government association representatives, and technical staff from cities and regional organizations. ASEAN countries represented through the workshop participation or interview process include: Cambodia, Indonesia, Malaysia, Myanmar, the Philippines and Viet Nam. Urbanization specialists form China and India also participated in the workshop. The comments presented here do not represent a comprehensive or fully representative survey of all elected officials, local government association representatives, or technical staff across the ASEAN region, but they do provide a helpful regional sample that can be used to outline broad contours of many of the grounded management, governance, and finance considerations that inform urbanization and infrastructure policy in the region from a sustainability and resource efficiency perspective.

7.1.1 Fragmentation and Multi-Level Governance Coordination Challenges

A core concern of cities across the ASEAN region seeking to better manage urbanization and infrastructure provision is the often-compartmentalized nature of agencies and levels of government that are responsible for diverse policy and operational dynamics that affect urbanization and infrastructure provisioning. The literature discusses the challenge of overcoming vertical and horizontal fragmentation. Vertical fragmentation is across different levels of government, from neighbourhood associations, to city leaders, to urban-regional governance bodies, to provincial governments, to national governments. Horizontal fragmentation occurs at the same level of social organization (local, urban-regional, state, and national). Examples of horizontal relationships across sectors can include energy and transportation policy interaction, which become important in a future with electric vehicles, waste and energy sectors for industrial symbiosis, buildings and energy, or integrated slum development incorporating housing, livelihoods, land use, energy and transportation (see discussions in Chapter 3 and 4).

As one feedback workshop participant from the Philippines noted, transportation and land use planning are policy domains that in the Filipino context have only recently begun to be considered on a more integrated basis. **Where people live, where key activities of the urban-regional economy take place, and how people get around (and between) urban areas are inter-related and inter-dependent dynamism. Treating them integrally—rather than separately—from a policy and planning perspective is critical for efforts to achieve resource-efficient infrastructure outcomes in cities**. Similarly, a workshop participant from India spoke of a general dynamic in which there is no one urbanization policy that affects the future development trajectory of cities, but rather a series of policies at various levels of government and in various domains of policy-making that end up affecting how urbanization can and does take shape.

It is likely unrealistic to assume that a single unified policy could inform urbanization dynamics and growth trajectories in urban areas across a given country. However, the negative effects of compartmentalization of governance functions and policy domains that affect urban growth and development dynamics could be mitigated by an effort to review and better align both policies and operational/management dynamics—within and across levels of government. In large part, **resource efficient urbanization is premised on maximizing synergies across individual urban areas and across national urban systems. Both demand sophisticated coordination of both policy making and operational management.**

At the metropolitan scale specifically, the landscape of metropolitan or urban-region governance organizations across the ASEAN context is mixed, both within and between countries. Where such organizations are present, they vary substantially in terms of the power and levels of authority—and subsequently influence—they are able to wield over urbanization and infrastructure provisioning dynamics within their larger urban region. Where strong metropolitan governance bodies are lacking, it makes formal coordination of policies across jurisdictions within an urban region difficult. Alternatively, ad hoc collaborations and infrastructure cooperation or coordination projects between nearby cities were characterized by workshops and interview respondents as a relatively common. **While ad hoc coordination can be positive, the uncodified nature of the efforts can limit their effectiveness and threaten the staying power of such efforts as political priorities and commitment to cooperation can change between urban administrations. Institutionalizing and formalizing long-term coordination and cooperation processes can help shield them from any potential disruption**

as local political leadership changes. Even in the absence of formal metropolitan governance structures, interview respondents did report some standardized processes for inter-jurisdiction cooperation on infrastructure projects, particularly when those projects are relevant to cities cross provincial or regional borders. In such instances, regional and in some cases national government agencies are likely to step in and provide oversight for coordination across jurisdictions.

7.1.2 Capacity Building and Technical Assistance for Sustainable Development

Workshop and interview responses indicated that basic sustainable urban development principles are well mainstreamed in professional urban management arenas, even in small cities, across the ASEAN region. That said, many respondents indicated that while basic sustainable development awareness is relatively strong, to varying degrees across urban areas, there is a gap in the ability to translate that awareness into actual policy solutions. Furthermore, responses indicated that **across urban administrations there was generally less familiarity with more specific topics undergirding sustainable urban development including liveability and compact urban form. From a sustainable development framework lens, respondents reported relatively low levels of familiarity with concepts of decoupling, trans-boundary resource accounting, and resource-efficiency frames for thinking about urban growth and development in general**.

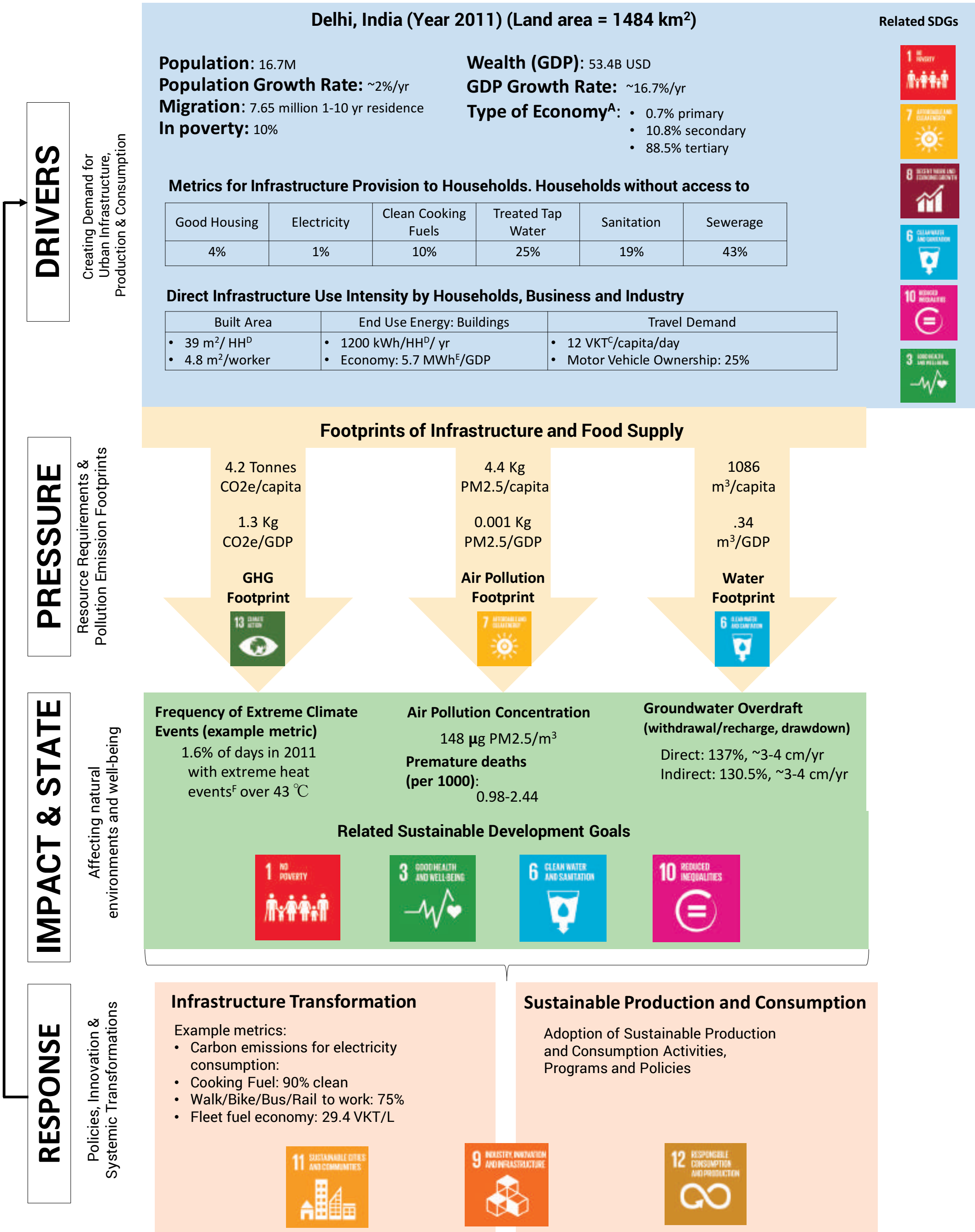
At the level of technical interventions, interview and workshop responses suggest that there are professional and technical capacity challenges, particularly for smaller local government administrations whose staffs may not have the same level of professional training and expertise as the staffs of larger city government units. Responses indicated that smaller local government administrations struggle with the capacity to manage complex infrastructure finance agreements (public-private partnerships or otherwise; see section 6.2 for an expanded discussion of financing arrangements), the capacity to undertake cost-benefit analyses regarding expensive infrastructures investments, and the capacity to oversee the deployment and ongoing management of technically complex resource-efficiency and resource recovery projects (e.g. modular waste to energy installations). Respondents expressed the need to access and develop this capacity locally to ensure ongoing commitment to and longevity of resource-efficient infrastructure investments, rather than exclusively relying on external consultants.

Research to inform traditional long-range planning efforts was another city-level capacity deficit identified by many respondents, principally as a function of constrained staff time and resources. Existing urban development and planning staff are often already pre-occupied with more immediate planning and development challenges without the time or resources to engage in longer-term planning efforts. More direct guidance about policy and technology adoption for local government administrations was identified as an additional critical need for many local government authorities. There is substantial knowledge production about sustainable urban development practices and infrastructure provisioning, but too few resources are available to help cities translate scientific and expert knowledge into policy or projects that are relevant to a given city's local context. **Connecting the dots between best practice research, especially of a technical nature, and what that research means in terms of the actions steps that can be taken in a given city can be difficult for city leaders.**

Urban data collection and reporting on natural resource use and sustainability metrics is a particular arena in which ASEAN cities would be well served by national and international capacity building and technical assistance. Only recently have data collection and reporting efforts become a priority topic among some urban administrations, which are recognizing the importance of these efforts to support performance evaluation and policy development. For cities that have recognized the importance of these efforts there are capacity and technical challenges to be overcome. Data collection and reporting efforts require resource investments of both financial resources and staff time, both of which are often constrained in many city governments. Furthermore, there are still many cities that are not readily convinced or aware of the dividends that data collection and reporting can pay for resource efficient infrastructure provision efforts. **To many cities, the benefits associated with collecting data do not appear to outweigh the cost and time required. National and international organizations have a role to play in convincing city governments of the importance of strong data collection and reporting programmes, as well as a role to play in providing them the technical assistance and capacity building training to be able to carry out strong data collection and reporting.**

While there are substantial efforts to develop standards for the collection of urban sustainability indicators across urban areas, it can be a challenge to get cities to recognize the importance of data collection and reporting efforts generally, let alone the need to learn about and comply with international standards specifically. The International Organization for Standardization's (ISO) 37120 protocol for capturing data on the sustainable development of communities, including indicators for city services and quality of life, is widely accepted as an authoritative guide to standardized urban data collection, but cities of all sizes could benefit from greater capacity building and technical assistance that would help them more fully implement the ISO 37120 protocol. The drivers, pressures, state, and response (DPSR) framework can be a useful tool for local government officials who want to better understand the way data collection and reporting efforts contribute directly to the dual mandates of providing urban services and enhancing well-being through the achievement of the sustainable development goals locally (see Figure 6.1).

FIGURE 7.1 **Drivers, pressures, impact, state and response framework related to the SDGs for Delhi. Note that the examples indicated are not exhaustive, and other drivers, pressures, states, impacts, and responses could be included in future assessment** *(IRP 2017)*



^A Primary is primary extraction, Secondary is industrial manufacturing, and Tertiary is commercial services
^B TBD: To be determined upon data availability
^C VKT: Vehicle Kilometers Traveled
^D HH: Households
^E MWH: Megawatt hours
^F Extreme heat events over 43 C° are based on temperature thresholds for Ahmedabad due to limited data availability for Delhi.

7.1.3 Fragmentation and Multi-Level Governance Coordination Opportunities

National urban policies (NUP), present an opportunity to outline common goals and a country-wide vision for urbanization and urban development. This includes goals around streamlining and codifying best practices of coordination across administrative boundaries and across levels of government. **NUPs, country wide visions, and policy directives offer an opportunity to set standards for how local governments are expected to coordinate and work with another, as well as how other levels of government are expected to coordinate with local governments**. Such documents can also help initiate a shift in local urban management communities of practice (professional associations, planning schools, individual city departments, etc.) towards an understanding of urban development dynamics as being about the interaction of various systems (even distant or disparate ones), thus requiring a systems thinking approach across the systems of a city, as well as across systems of cities. **A critical role of national urbanization policy documents, beyond serving as policy directives—is to set the tone for how urban growth and development processes are understood and correspondingly managed both locally and nationally. The creation of national urban policies will only be effective when the appropriate urban-focused legislation and supporting resources are in place to empower sub-national and local authorities to work towards realizing that country-wide vision (UN Habitat 2016a).**

Surpassing individual national level urban policy formulation, the ASEAN bloc itself could have an important role to play in encouraging greater coordination across administrative jurisdictions and various levels of government. This could take shape in a number of ways including: 1) emphasizing ASEAN-level support for cooperation and coordination among systems of cities that cross international borders, 2) setting broad standards of best practice for internal urban cooperation and coordination across levels of government within individual ASEAN member states, and 3) by formally leveraging the input and voices of urban officials in the consultative and policy-making processes of the ASEAN bloc itself. Urbanization and urban growth will be an important dynamic shaping the future development—economic, physical, social—of the ASEAN region, and as such should be accorded higher priority as a critical and explicit area of policy-making, coordination, and concern within the larger ASEAN agenda.

Developing an express focus on urban reform and policymaking would complement existing policy priorities of the ASEAN economic community, specifically, with respect to connectivity (ASEAN Secretariat 2015; see Box 7.3). Placing cities and urban reform at the centre of the ASEAN connectivity agenda could maximize returns by creating synergies within and between cities where people, goods, services, economic activity and resource use are already concentrated.

Finally, there is a role for international organizations, multi-lateral agencies, and international financial institutions to play in setting best practice standards when it comes to urban policy reform for enhanced administrative coordination and integrated service delivery, specifically for resource efficient urbanization and service delivery futures. Key international organizations that provide policy resources include: 1) United Nations Habitat, which has created resources around national urban policy development, international guidelines for urban and territorial planning, metropolitan socio-ecological

BOX 7.1 National Urbanization Policy (NUP)
(United Nations Habitat 2016a)

'A coherent set of decisions derived through a deliberate government-led process of coordinating and rallying various actors for a common vision and goal that will promote more transformative, productive, inclusive and resilient urban development for the long term.'

BOX 7.2 National Policy Centres for Urbanization Guidance

Chinese Academy of Urban Planning and Design (CAUPD)
A national research and policy advisory centre with cross-disciplinary expertise in fields including urban development, urban design, planning, landscape architecture, infrastructure development, water system management, conservation, etc. (UKNA).

Jawaharlal Nehru National Urban Renewal Mission (JNNURM)
A national urbanization mission launched by the Ministry of Urban Development to provide high-level guidance on urban governance and operational reforms for cities related to integrated service delivery, basic provision of services to the urban poor, infrastructure financing, and planned growth (Government of India, JNNURM).

BOX 7.3 Definition of Connectivity in the ASEAN Context
(ASEAN Secretariat, 2010)

'Connectivity in the ASEAN context refers to the physical, institutional and people-to-people linkages that would provide the underpinning and lubricant to achieve the goals and objectives of the economic, political-security and socio-cultural pillars of the ASEAN Community by 2015. The physical connectivity will encompass transport, information communications technology and energy while institutional connectivity would cover trade and economic areas such as trade and investment liberalization and facilitation, investment, mutual recognition arrangements and capacity building programmes. People-to-people connectivity would include tourism, education and culture.'

governance, and urban-rural linkages; 2) Energy Sector Management Assistance Programme (ESMAP), a unit of the World Bank Group with specific resources on energy efficiency in cities in low and middle income countries; and 3) the International Resource Panel of United Nations Environment, which has developed a specific work stream focusing on resource efficiency in cities.

7.1.4 Local Capacity Building and Technical Assistance for Sustainable Development Opportunities.

National governments have a role to play in providing technical assistance to bolster the capacity of local governments, especially small and medium size ones that may struggle with accessing professional expertise on a number of topics relevant to resource-efficient urbanization and infrastructure provisioning. Specifically, for complex tasks that may fall outside the rhythm of daily urban management and operations, national governments can consider establishing or strengthening existing specialized facilities for urban finance, analysis and research. Such facilities could work with individual cities to undertake complex tasks that may be relatively infrequent occurrences for smaller and medium size local governments but which nonetheless are important to get right when they do arise because of their strategic nature and potentially transformative impact on urban development trajectories and infrastructure provisioning. Such tasks can include the negotiation of complex financing arrangements for capital investments, research and cost-benefit evaluation of large infrastructure investment options for long-term planning, and technical training to build in-house expertise for the management of specific projects that involve new technology deployment. More broadly, national governments can more robustly support the general professional training of local urban development practitioners, aligning that training with the broad urbanization and urban development goals outlined in relevant national urbanization policies.

The ASEAN bloc as whole could similarly support critical capacity deficits in various policy and practice domains relevant to resource efficient urbanization and infrastructure provisioning, but potentially at a broader level**. Given some of the broadly shared urbanization dynamics of the region—the potential rise of 200+ small cities, similar levels of exposure to natural disaster and climate risk, high levels of slum development, and projected growth in household incomes and subsequent consumption—the ASEAN bloc could establish regional research centres or expand existing knowledge networks for the study of these common concerns.**

A variety of resources exist at the international level as well to help support capacity building and technical assistance efforts for resource efficient urbanization and infrastructure provision, including organizations like: the Asian Development Bank; ICLEI, Local Governments for Sustainability; United Cities and Local Government; ESMAP; and United Nations Environment. Cities increasingly need to be capable of establishing and managing productive and collaborative partnerships at the national, regional (Southeast Asia), and International level as a basic function of local government operations. Paradoxically, building and maintaining partnerships for capacity building and technical assistance is itself an urban management skill that local officials will need training and technical assistance to help learn. **Going to the effort to support the capacities of local governments for partnership development and management, directly supports SDG 17 which calls for strengthening means of implementation and to revitalize partnerships for sustainable development.**

At the local level specifically, key capacity building and technical assistance efforts can be bolstered by accessing the expertise of local institutions, specifically universities, non-governmental organizations, and other civil society organizations. Universities are often well positioned to support critical research needs of local governments, while non-governmental organizations and civil society organizations may be well positioned to facilitate subject matter expertise training, leadership training, or general programme development and implementation. Again, building and maintaining such partnerships at the local level is in and of itself an urban management skillset that often needs to be actively cultivated and developed.

Partnerships for capacity building and technical assistance can be relied on to support cities in the many technical governing challenges they face on a day to day basis. The data collection and reporting challenges discussed in the previous section are a key example of the types of capacities that partnerships can help bolster. But the role of capacity building and technical assistance should also be understood as going beyond traditionally technical tasks to include general leadership, coalition building, and advocacy training as well for urban leaders and managers. The need for building capacity in areas such as helping cities develop innovative and visionary partnerships is a type of leadership training, and underscores the role of local leadership more broadly in transitioning to sustainable urban development patterns (Bulkely and Betsill, 2003). **The ability of local officials to establish a vision, rally coalition support, and see that vision through to completion are all elements of leadership capacity that are critical for sustainable urban development futures, and it is important to note that in many instances they are abilities that can be taught and actively cultivated through capacity building and training, just as other technical skills might be cultivated.**

7.2 Financing Resource Efficient Urbanization and Infrastructure Provisioning

New forms of infrastructure provisioning will require that local governments access new forms of financing. Specifically, correcting deficits in urban infrastructure provisioning for existing populations as well as avoiding such deficits for future urban population growth will require substantial investment at all levels of government. Many of the strategies outlined in the preceding sections of this report will ultimately return net positive returns on investment when evaluated from a comprehensive life-cycle approach, but they virtually all still require upfront capital investment costs. These upfront, or first-cost investment barriers are often times insurmountable for resource constrained local governments, particularly for small and medium sized cities. While resource constraints are a familiar concern for governments worldwide when considering how best to invest in urban futures, the high-growth macro-economic environment and projected trends for the ASEAN region as a whole position it well to be able to creatively finance such urban investments (see economic trends discussion in chapter 2). Specifically, projections of rising incomes and economic growth indicate that urban areas across the region will be well positioned to leverage the already increasing value of urban land to finance infrastructure investments that will push land values even higher by deploying a range of land value capture mechanisms. Similarly, the robust economic growth and population expansion expected in the region identify the ASEAN region as a booming emerging market that will be ripe for private investments, some of which can anchor creative public-private-partnership urban development investment vehicles.

New and long-standing financing instruments alike can be put to work under the umbrella of 'green finance' or 'climate finance'—financing that is broadly directed at sustainable development projects or projects that encourage low-carbon growth and/or yield other explicit environmental benefits (United Nations Environment, 2016). National and international finance institutions have a role to play in mainstreaming sustainability considerations into design and outcomes of the projects they finance. **Explicit sustainability consideration should increasingly be thought of as a fundamental component of *all* sound, long-term urban infrastructure investment decisions rather than as a separate category of investing.**

While experimentation and innovation in the arena of infrastructure financing and investment will be needed to meet the challenge of sustainable urban infrastructure transitions in the ASEAN region, this does not relieve governments at all levels from the responsibility of ensuring that projects leveraging public funds or assets do so in support of the public good and not private gain. This requires robust safe-guards including governance, monitoring, and evaluation institutions that are capable of providing transparent oversight for all stages of a project or partnership arrangement.

7.2.1 Land Value capture

Land value capture represents a general suite of strategies that are premised on leveraging the increasing value of land to finance infrastructure and service provision or other public revenue goals (see Table 7.1). Land value capture mechanisms leverage the 'increment' between the existing value of a parcel of land and its projected increased value in the future owing to 1) increasing demand for land generally in the area in which the parcel is located, 2) infrastructure upgrades that make the land more desirable, or 3) some combination of both.

For land value capture to work as a successful financing strategy, the future value of land has to end up being greater than the current value of that land, thereby producing a positive increment, against which one can borrow money, rather than a negative increment. Accurately assessing the current value of the land and realistically projecting the future value of the land is an equally critical part of making land value capture mechanisms work. If the amount of money borrowed is greater than the actual increase in the value of the land, the mechanism will result in a loss.

These are general minimum requirements that need to be met to make financing strategies based on land value capture successful in any context. It is important to note however, that **land value capture financing mechanisms are well positioned to succeed under strong macro-economic conditions, such as those of emerging urban markets like the ASEAN region which is projected to experience substantial population and economic growth (Brookings, 2009; World Bank 2015; see economic trends discussion in Chapter 2).**

Land value capture can be a particularly important tool for financing transit-oriented-development. Given that land values in urban areas generally increase the closer that land is located to a mass transit stop, the projected increase in land value that a transit stop would generate can be used pre-emptively to finance the construction of that transit stop and surrounding development, in turn generating the anticipated increase in original property value. Beyond transit infrastructure, the provision of most services and infrastructures will generally increase the value of land that previously lacked infrastructure or services. This general principal is at the core of the land pooling schemes being experimented with in Ahmedabad and elsewhere across India to help guide urban expansion and prevent infrastructure deficits whereby residents in a designated development zone pool land and give up as much as 50 per cent to finance common infrastructure development, which in turn can substantially increase the value of their remaining land (see discussion in section 3.3.1).

Land value capture tools—particularly in-kind development combined with negotiated land readjustment efforts—have been successfully used in slum redevelopment efforts. In these instances, a developer may be allowed to develop much of the land of a former low-rise slum community sitting on valuable land, in exchange for re-housing the existing slum population on that same land, constructing multi-storey housing units to free up the rest of the site's land for market rate commercial and residential development (see discussion in 3.3.2). The profit gained by developing the rest of the plot of land at market rate is used to finance the *insitu* rehousing of the existing slum community residents.

TABLE 7.1 Types of Land Value Capture Instruments *(adapted from Baffour Awuah, 2016)*

Instrument	Meaning
Betterment Levies/Taxes	Any tax or charge on an increase in value resulting from some public action, such as the issuing of development rights or the provision of infrastructure
Sale of Development Rights	The sale of the right to convert rural land (agricultural or un-zoned) to urban use; and the right to build at greater densities than normally would be allowed by zoning rules or height restrictions.
'In kind' Contribution	This is a situation where a developer constructs an infrastructure external to his/her property because a local authority is unable to do so or not willing to do so. This is sometimes under the instruction or permission of the local authority or the developer voluntarily does it.
Public Land Leasing	If the relevant local authority owns the land, it would lease the land out for a period of time, thus generating revenue.
Land Acquisition and Resale	The purchase of land around a development, and subsequent resale of that land by the public sector or relevant authority is a method to capture the full value of the gains that an infrastructure investment may create.
Land Sales	This instrument relates to the sale of publicly – preferably city -owned land.
Property and Land Based Taxation	A tax levied on the value of a property (sometimes) including land by a local authority. A surcharge may be imposed in situations, such as if the property is located in a business improvement district. Tax increment financing (TIF) relates to arrangements where local authorities are allowed to finance infrastructure development using property tax revenue from increases in assessed values from within designated TIF districts. Land-based taxation represents taxes targeted solely at land and its appreciation as a result of infrastructure provision. The focus is, thus, on land owners.
Impact Fees and Development Charges	Impact fees are designed to cover the costs of the bulk and connector infrastructure required for a new property development or property development improvements. These charges could also be used to finance other infrastructure directly linked to property development. They are based on a formula, so that they can be applied consistently to all property developers.
Joint Development	This is a partnership arrangement particularly in the transportation sector between the public sector, private operator and developers to share the burden of transport investment.
Negotiations, Voluntary Contributions, and Land Re-Adjustment (also known as Land Pooling)	A bilateral negotiation, before the investment occurs, is used to determine a rate that property owners in the area of influence should pay for the improvement. Land readjustment is a self-financing land management tool, which emphasizes recipients of the benefits, after development, should bear its cost. It is based on a combination and integration of sound real estate and planning principles, such as sound planning policies and governance arrangements among others.

TABLE 7.2 Land Administration Factors for Effective Implementation of Land Value Capture *(adapted from Baffour Awuah, 2016)*

Administrative Factor	Key Components or Influencing Factors
Security of Tenure	Clear Definition of land ownership rights Ease of access and allocation of land Clear delineation of land boundaries Ease of registering land Ease of resolving disputes over land ownership
Effective Planning and Land Use Management Practice	Availability of master plans and sub-division planning schemes Formal processes for reviewing, approving and regulating land use Codified processes for development proposal review and approval
Effective Property Valuation system and Legislation of Value Capture Tools	Availability of suitable and applicable methodologies to assess value appreciation/value Enabling environment to undertake valuation for land value capture Clear and codified policies for land value capture
Effective Land Information Management Regime	Availability of accurate and up-to-date land records to support effective and efficient land administration

BOX 7.4 Land Value Capture and Diverse Infrastructure Investment Needs across ASEAN Contexts

Efforts to facilitate broader use of land value capture tools by both smaller and larger cities alike is an attractive option as *land value capture mechanisms are infrastructure agnostic*. They do not only work with a certain type of infrastructure provision and not another. In principle, any infrastructure investment that is expected to generate increased land values can form the basis of a land value capture tool. For the ASEAN region in which fast growth is expected but across cities of different size, economic function, and development status, land value capture can provide a flexible financing tool deployed to support the development of a wide range of infrastructure—from active transport mode, to mass transit networks, to electric vehicle charging infrastructure—depending on the needs and assets of a particular urban area.

The ultimate effectiveness of land value capture financing tools, however, is premised on strong foundations of administrative competence and control when it comes to the management of land. **Without strong urban management institutions, the certainty of land title and the rational valuation of land assets that are required to support the implementation of basic land value capture tools will be difficult to ensure.** A list of key administrative characteristics needed for successful land value capture schemes can be seen in the table below (See Table 7.2). These administrative capacities and characteristics are linked to many of the governance and capacity considerations discussed in the previous section (see Section 6.1), highlighting how **strong urban governance institutions, high degrees of management capacity and competence, and the ability to structure creative financing arrangements are linked in delivering resource-efficient urbanization and infrastructure provisioning**.

7.2.2 National Streamlining and Technical Capacity for Public - Private - Partnerships

Public-private partnerships (PPP) represent an umbrella category describing a range of financing and project governance mechanisms that rely at least in part on private investment capital or private management. In some instances, the land value capture mechanisms described in the previous section rely on PPP frameworks. **While PPPs can offer innovative long-term project governance, service provision, and financing solutions, their immediate success is not guaranteed.**[8] **The PPP vehicle used to develop Manila's light rail system is an example of the mixed results and delicate balancing act that PPPs can represent. Currently, the project is still struggling to achieve an appropriate rider fee structure that balances accessibility and affordability of the light rail system with the need to generate returns for the private entity operating the system (see Box 7.2).**

PPP's represent complex legal and financial arrangements that can be difficult to navigate even for expert practitioners and the largest city governments, let alone for smaller and medium city governments without in-house PPP experience. **National governments can play a role in developing PPP facilitation centres that can support local government units of all sizes in negotiating PPPs for urban infrastructure development and other strategic development priorities.** Such centres already exist in the Philippines and Indonesia. However, to date, these centres have concentrated on facilitating

8 There are additional potential benefits, as well as dis-benefits, of the PPP model. This discussion does not purport to serve as a primer on PPPs for urban infrastructure in general but to provide details about the viability and challenges of PPPs in the ASEAN urban context as expressed by workshop participants and interview respondents. For a more detailed discussion on PPPs for urban infrastructure see resources including the World Bank's PPP in Infrastructure Resource Center or the 2016 World Bank report, *Regenerating Urban Land: A Practitioner's Guide to Leveraging Private Investment.*

large projects that are of national significance. There is an opportunity to help build out the resources of these national PPP centres to help smaller and medium-sized local government units facilitate smaller scale, but nonetheless strategically important PPPs for urban infrastructure development. Decreasing the scale of a PPP can help partially reduce its complexity, in turn opening the door for scaling the deployment of relatively small PPPs enabled by standardized templates and streamlined processes for local governments to enter in to routine and (relatively) simple PPP agreements that they would otherwise have difficult entering in to.

While national PPP facilitation centres can help negotiate agreements for individual local governments, in some environments, they may also be able to play a coordinating and aggregating role, bringing together a cohort of neighbouring local government units to dilute the share of public risk assumed by any one public entity in a public-private partnership that spans multiple local governments (far-flung or nearby).

Finally, within local governments themselves, there is work to be done to demonstrate investment readiness or otherwise convincing the private sector that there is no reason to be hesitant about working with them as project partners. In local government environments with elected leaders, efforts to demonstrate investment readiness can include developing both a reputation and formal legal framework for honouring long-term commitments regardless of changes to political administrations. Similarly, in all local government contexts, eliminating unnecessary bureaucratic procedures, attempting to minimize regulatory uncertainty, and implementing or bolstering anti-corruption reforms can help boost private sector perceptions of a local government unit's investment readiness.

While investment readiness from the perspective of the private sector is important for encouraging investment, there are similar readiness steps that local governments should take to ensure that the public is well served by any potential PPP mechanism. Such steps include having a clear understanding of the public benefits to be gained and a plan for ensuring that those public benefits are ultimately delivered.

No PPP is risk free for either party, but a city can position itself for success by developing key performance indicators and service standards to which a private sector actor can be held accountable. **Negotiating contracts with a clear understanding of performance standards, a clear understanding of the full costs of a given project, and with clear provisions that allow cities recourse when a private entity fails to comply with performance standards are all important aspects of investment readiness from the perspective of protecting public assets and public benefits when operating within a PPP framework (World Bank, 2016a).**

Regardless of which level of government is coordinating or spearheading an urban development/infrastructure PPP, such arrangements can be politically and social charged. Strong public safeguards are necessary to build trust with urban publics and to eliminate concerns, real or perceived, of corruption, private rent seeking, undue advantage, or squandered public funds. More broadly, there may be times when a PPP arrangement simply is not appropriate for a certain project, collaboration, or service provision priority. It is up to governing authorities to be discerning about when and under what conditions financing experimentation and innovation with the private sector makes sense and when it does not.

7.3 A View towards Future Governance and Finance for Sustainable Urban Transitions

The diversity of urban areas within individual ASEAN member states and across the ASEAN economic community as a whole presents a challenge for uniformly applicable thinking about governance and finance solutions for urban sustainability transitions. **One size fits all solutions will not serve all member states and their urban areas equally. The diversity of governance and finance solutions developed and deployed will have to have to reflect the diversity of the region's urban areas**. That said, there are common tools and frameworks that are available to urban leaders across the region that can be adapted and translated to distinct local contexts, land value capture tools and public-private partnership models are just two such frameworks that outline broad financing possibilities. There are a variety of local, national, and international entities that are well positioned to support cities as they seek to adopt and deploy solutions to meet specific urban infrastructure provision needs. Building partnerships to support new programmes, policies, and frameworks for sustainable urban infrastructure provision will be a key challenge facing cities across the ASEAN region. **Having the appropriate partnerships to help deliver resource efficient urban infrastructure development and service provision will be a critical component of delivering the wellbeing and SDG gains outlined in each sectoral chapter in this report.** More broadly, SDG 17 in support of partnerships should be thought of as an enabling mechanism for creating the governance and finance frameworks at all levels that can support the technical and infrastructural solutions for delivering resource efficient urban infrastructure systems.

Moreover, the ASEAN community as a whole can work to provide common pools of expert knowledge, research, and policy guidelines on broad topics of common concern that can be adapted and translated to distinct local contexts. As the ASEAN community commits to greater connectivity—economic, physical, and social—the region's cities represent a strategic site for making investments in connectivity. The more that the ASEAN community can make urban reform, financing, and governance a cornerstone of its connectivity agenda, the better the region, its member states, its cities, and its urban residents will be served.

BOX 7.5 Public-private partnership to build Manila's Metro Rail Transit System line 3

The Metro Rail Transit System line 3 (MRT3) in Manila, Philippines, was built through a PPP between the Department of Transportation and Communications (DoTC) and the Epifanio de los Santos Avenue Light Rail Train (EDSA LRT). The DoTC initiated a bid process in 1989 and the EDSA LRT was the only bidder out of five to pass the initial prequalification phase (Mandri-Perrot, 2010).

The contract between DoTC and EDSA LRT required EDSA LRT to finance, design, construct and maintain the MRT3. However, due to legal restrictions EDSA LRT was not allowed to operate the system since it was a foreign company. As a result, DoTC not only oversaw the construction phase and but was also responsible for the operation and maintenance of the railway. EDSA LRT owned the light rail, but leased it to the DoTC. EDSA LRT received lease payments every six months. The initial plan was for DoTC to collect fares from riders and use the fares to make the lease payments. DoTC was also responsible for paying foreign exchange rates, revenue risks, maintenance costs and guaranteeing a 15 per cent increase in value (Mandri-Perrot, 2010).

The contract between DoTC and EDSA LRT was signed in 1993 and construction began on the light rail in 1997 (Mandri-Perrot, 2010). The MRT3 opened to the public in December 1999. The MRT3 was initially designed to carry at least 23,000 passengers per hour per direction and has since been expanded to carry 48,000 passengers per hour, per direction (DOTC-MRT3 Depot Office, n.d). The line is approximately 16.8 kilometres long (Mandri-Perrot, 2010).

EDSA LRT put US$190 million into the project, with another US$465 million coming from international loans (DOTC-MRT3 Depot Office, n.d). In 1999 fares ranged between 17 and 34 pesos (US$0.41 - US$0.82) depending on the distance. In the first six months, the number of passengers per day ranged from 17,000 to 45,000. Only 150 million pesos (US$3.6 million) was collected from fares, well below the six-month lease payment of US$40 million requiring a large subsidy from the government.

The fares were lowered in 2000 to below 15 pesos, slightly higher than "jeepney" fares and a rate deemed affordable to most incomes. By 2010 the number of passengers per day increased to 400,000 (Mandri-Perrot, 2010).

As of August 2017, the fare ranged between 13 and 28 pesos (MRT3, n.d.). While EDSA LRT has requested fare prices be increased, the DoTC has the ultimate say in whether fares change and the DoTC has not approved an increase in fares. Despite the increase in riders, six-month lease payments have not been able to be completely paid with fares resulting in the Manila government having to subsidize the lease payments.

The case highlights the sensitivities of needing to appropriately calibrate the cost-effectiveness of a proposed project taking into consideration construction, operation, and maintenance costs as well as realistically forecasting revenue returns. Project cost and revenue models that do not accurately capture or account for variation in the eventual costs and revenues of a project open the possibility of one party to the PPP agreement being left with the responsibility to subsidize the ongoing operation of a system.

FIGURE 7.2 Manila MRT3 *(mrt3.com)*


振和興大金行
聯成興大金行
ATM
K-Expert
EXCHANGE
WISDOM
林祥興藥
SIANG HENG HUA
TAXI
สก 5880

CHAPTER 8 Conclusions

Future urbanization in ASEAN nations is projected to bring 205 million new residents to cities by 2050. Much of the urbanization in ASEAN nations is expected to occur in cities smaller than 500,000 in population. This could result in the rapid rise of 200 new cities, towns, and urban areas.

ASEAN urbanization will take place against a backdrop of increasing air pollution, climate risks and a highly coal-reliant electricity grid. ASEAN urbanization will occur in the context of a large underserved population with 73 million urban residents across the region currently living in slums, 120 million lacking access to electricity, and 280 million lacking clean cooking fuels in these nations in 2016 (World Development Indicators; OECD/IEA, 2015).

The ASEAN region offers several natural and cultural assets that position it well to achieve a transformative vision for sustainable future urbanization. The socio-cultural assets can leverage existing vernacular building design that provide comfort with little energy use and practices that promote walking and bicycling and a high level of two-wheeler vehicle use, both of which can be leveraged with new policy innovations to develop low carbon and low polluting cities of the future.

The ASEAN nations have diverse and significant renewable energy assets that can be integrated with its natural endowments of coal and gas along with carbon capture to develop a low carbon grid across ten nations that would exemplify a high level of international cooperation. The combination of efficiency measures and renewable energy policies and strategic intensification in cities has potential to reduce resource use, fossil fuel use and enhance well-being for the large urban population and growing middle class in the ASEAN nations. Specific strategies to enable this urban transformation are detailed below.

Finally, because the region has faced climate-induced disasters in urban areas and continues to face this risk, the ASEAN urban experience is emerging as a global 'resource' for infrastructure solutions and climate change adaptation strategies, specifically in urban areas, with an eye towards both disaster resilience *and* sustainability.

8.1 Pathways

The transformative vision for urbanization in ASEAN nations will require collaborative governance, linking together policy and actions across multiple stakeholders and multiple levels of government.

At the national level, ASEAN nations should have a national urbanization policy that guides economic development and urbanization across different city sizes, therefore reducing the extremely fast rate and the pressure of large urbanization into one or two urban centres. This will help in better providing infrastructure in urban areas in a timely manner that reduces pressures that push migrants to settle in informal settlements. World Bank studies suggest that tertiary and industrial activities could be better served in larger cities, while agri-based and secondary level economic activities can symbiotically exist in smaller cities.

National level policies, data and expertise that develop redline ecosystem policy, preserving high value lands and ecosystem services will be helpful in providing climate resilience to cities. By preserving agricultural lands, we can also preserve urban livelihoods and improve urban-rural linkages. This will be particularly important in countries like Cambodia, Myanmar and Laos that are urbanizing from an agricultural base.

This report recommends the development of urban-regional development authorities that are interested in long range planning around cities, including the peri-urban area land pooling plans that provide land in a systematic method for future infrastructure expansion. These land pooling policies also enable equitable compensation for peri-urban farmers whose land has been taken up by urban areas and has been proved to be effective in India.

City land use planning should leverage the already dense nature of urbanization in ASEAN nations and focus on accessible density, that supports non-motorized travel, provides equitable access to livelihoods, while being cognizant that high levels of density are often correlated with higher air pollution. Urban land use planning should also invest in articulated density, building high-rise steel and concrete building in strategic nodal areas, accompanied by mid-rise walk-up buildings that might use vernacular climate design sensitive to local cultural tastes. Green building standards should include recommendations for vernacular buildings that use local materials and consider environmental comfort set points suited to local culture. For example, in ASEAN nations, studies indicate that people are accustomed to indoor air temperatures of 27 °C. Green building guidelines from other countries, would fix the set point at 25 °C. This has a large impact on the types of design promoted through the green building standards. Passive design features of vernacular buildings can also be leveraged to provide high energy efficiency to low income and under-served residents thereby decreasing their energy bills.

The success of green building designs depends on the participation of the building industry which can be fostered through incentives for adopting green building design as well as participation in post occupancy performance reporting such as Singapore's Building Energy Submission System building reporting programme.

City land use planning and transportation could consider different archetypical cities: the active transport oriented cities, suited for cities smaller less than 500,000 people; transit oriented cities focusing on bus rapid transit for medium sized cities; and transit-orient cities focused on metro transit for larger cities, greater than two million people. The active transport cities could leverage their existing high levels of non-motorized travel in the ASEAN nations, as well as the high ownership of two-wheelers, leveraging them with new technologies that provides electric two-wheeler vehicles and electric light-weighted cars that may be particularly suited to this region. Through these strategies, the ASEAN nations may be able to leap-frog over the car dominated designs, yielding a trans-formative vision of a sustainable cities that reflects the vernacular architecture as well as local transportation preferences for two-wheelers and bicycles in the region.

This transformative vision will also engage the residents to encourage retaining social and cultural consumer practices that are already supportive of sustainable development such as a willingness to share vehicles and practices that leverage the coastal location of the ASEAN nations to promote vernacular buildings with high ventilations supported by sea breezes.

The urbanization of the ASEAN region is poised to occur in conjunction with further industrialization. Further, the industries that will be particularly important in the ASEAN nations such as, coal, petroleum, iron and steel, cement, wood and paper and pulp manufacturing are extremely amenable to inter-industry symbiosis, as well as urban industrial symbiosis, where low-grade waste heat from industries can be beneficially reused to provide heating and cooling needs and hot water to residential and commercial buildings of cities. This can be a tremendous asset, and could reduce the heating cooling needs of buildings by a significant proportion, so long as these buildings are in high density, multi-storey formats, suited for heating and cooling.

Many of the strategies outlined here (see table 8.1) have high return on investments making them attractive for government and businesses. Therefore, with the right incentives, subsidies, and regulations, these multi-stakeholder actions, should be institutionalized through different implementation pathways reflecting the differences in governance structures of the ASEAN nations.

The next section summarizes investment and financial considerations regarding some of the strategies, as compiled from the various case studies.

8.2 Infrastructure Investment and Financing

The ASEAN region is projected to have robust and stable economic growth that accompanies the future urbanization, indicating that the economic indicators are good for investment in infrastructure. However, infrastructure typically requires upfront investment in capital, and the question arises of who provides the first cost capital. Fortunately, almost all of the strategies proposed in this report have a fairly rapid return on invest and are net lifecycle cost positive, making them attractive for private investment in collaboration with government as well as communities. Some examples of the strategies and their success stories are provided below.

Land pooling and town planning has proved to be a win-win financial situation in Indian case studies reported in the state of Gujarat. In this strategy, rural land owners pool up to 40 per cent of their land for building infrastructure, such as roads, streets, waste water treatment plants and parks that are built by private developers. The subsequent improvement in land value as the area urbanizes provides a high return on investment both for the developer, as well as the original land owner, who retained ownership of the 60 per cent of their land as it appreciated. Such appreciation and planned infrastructure expansion has proven to be effective in several Indian case studies, described in Chapter 3. The role of government in such arrangements is to ensure due process—so that rural landowners retain their land rights and are adequately protected under the law—as well as to redraw parcel boundaries to support infrastructure provisioning and planned urban expansion in ways that support goals articulated in master planning documents.

Similarly, government has an important role to play in the in the process of in situ slum rehabilitation efforts. Here again we draw upon the case studies in India, where because of the high value of land within cities, private developers are incentivized to construct mid- to high rise buildings to provide rehabilitated housing for current slum dwellers, but only if the plans have the approval of more than 70 per cent of the slum dwellers in any location. In return for their contribution for rehabilitating the land, the builders are incentivized with extra floor space in other high property value locations in the city and/or

TABLE 8.1 Key Pathways for Sustainable Urban Infrastructure Transitions in the ASEAN

Pathway #1 Undertake national and cross-ASEAN urbanization planning to balance economic growth across a range of city sizes while preserving high-value agricultural lands and ecosystem services.	• National or cross-ASEAN urbanization and economic corridor planning • Urban land use and ecologically sensitive resources database • National empowerment of urban-regional authorities
Pathway #2 Promote compact, mixed-use, accessible, and inclusive urban form through urban-regional *and* city-level planning to reduce land expansion, streamline infrastructure provision, and promote diverse sustainable mobility options.	• Enforcement of guidelines for sustainable urban regional development • Land pooling and land readjustment for guided development • Integration of macro- and micro- plans for compact form and inclusive development • Land use and transportation planning in support of 5Ds and accessible/articulated density • Planning for diverse transit strategies across a range of city sizes • Leveraging of vehicle sharing practices and new fuel technologies
Pathway #3 Develop zero slum cities through inclusive land use planning that prevents slum formation, and *in situ* (or nearby) rehabilitation of existing urban slums in resource-efficient and disaster-resilient multi-story construction.	• National 'zero slum' policies • Build-back-better slum rehabilitation efforts for upgrading to resilient and efficient housing stock • Requirements for fully integrative, non-peripheral social housing and slum rehabilitation
Pathway #4 Promote resource efficient and resilient buildings and electric-grid systems by leveraging advanced and vernacular building technologies, engaging user behaviours and cultural norms, and linking renewable energy in cities with the pan-ASEAN electric grid.	• Consider use of mid-rise and high-rise buildings • Integration of advanced technology and vernacular energy efficient design principles • Region-specific building codes • Leveraging of local cultural norms and behaviours • Best practices and models for combining disaster resilience and resource efficient design • Penetration of green building codes and appliances • Real-time monitoring for performance tracking • Incorporation of urban buildings and distributed systems in regional energy planning
Pathway #5 Promote resource efficiency at the systems level across the city through innovative and profitable exchanges of "waste" energy and materials across industries and residential-commercial sectors.	• Co-location of industries in eco-industrial parks with shared infrastructure • Institutional and regulatory frameworks to offer incentives and penalties to push for waste-to-value exchanges • Spatial planning of cities and infrastructure with circular economy principles in mind

incentivized to develop valuable properties adjacent to the slum rehabilitated zones, in the land freed up by the construction of multi-story social housing. This mode of slum rehabilitation requires that government play an active role in the process. Input and consent from the current slum residents is essential for the long-term success of the project. Similarly, appropriately robust incentives are needed to provide sufficient financial returns such that private developers will take on such projects.

Ideas of value capture that are represented in the town planning scheme example have also been applied to finance transit planning. In the value capture approach, as the property values improve along transit corridors, or bicycle pathways or water ways, property taxes associated with these enhancements are able to pay for common infrastructure, again reducing the investment cost burden on the local government. The investment approach is also favourable in green buildings and electric vehicle ownership. In both of these cases, the lifecycle analysis shows that substantial energy and water savings accrues to the user of the green buildings and vehicles. The upfront cost of green buildings and electric vehicles is slightly higher than conventional vehicles and buildings and must be offset with suitable subsidies or tax breaks for adoption. However, over time, tax increments associated with operating these vehicles or the properties can offset the original subsidies provided, presenting the government with revenue neutral options.

Strategies around urban industrial symbiosis have proven to save money for the industries engaged. It is important that local and federal government do not prohibit or restrict the beneficial exchange of energy and materials. Such restrictions inhibited the adoption of industrial symbiosis in the United States. It's also important that information brokers are available to develop the networks among the industries to facilitate the exchange of resources and money to implement symbiosis. Studies in using waste heat and district heating have been found to be cost positive in several examples of forth generation district energy systems implemented in the EU. For waste heat, a cost analysis shows that payback can happen within ten years, indicating that it can be a viable business activity that can be stimulated through government incentives.

Similar to industry networks, social networks among households and individual users of vehicles and buildings are equally as important, to create the norms that retain the low consumption lifestyles that have been so important both in decreasing energy use and creating liveable communities in cities in Asia. Taken together, a combination of infrastructure transitions along with sustainable consumption and production practices, has the potential to result in substantial reduction in energy and material use as well as recycling of materials in transformed cities of the future in ASEAN nations, supporting high standards of living and quality of life while advancing local, regional, and global sustainability.

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무교동사거리

Appendix A
Available Data for Select Cities in ASEAN Countries

TABLE A.0.1 **Available Data for Select Cities in ASEAN Countries** *(Baynes, 2017)*

Spatial Data	City	Bangkok	Singapore	Ho Chi Minh City	Manila
from the Lincoln	Country	Thailand	Singapore	Viet Nam	Philippines
Atlas of Urban Expansion	Region	Southeast Asia	Southeast Asia	Southeast Asia	Southeast Asia
Study date 1	T1 Date	1994	1990	1989	1993
Study date 2	T2 Date	2002	2002	1999	2002
	Time elapsed (years)	7.21	12.57	10.93	9.00
	CBD Latitude	13.74	1.28	10.80	14.59
	CBD Longitude	100.54	103.85	106.71	120.97
	Built-Up Area T1	68303.08	17594.47	7282.71	42783.81
	Built-Up Area T2	102593.27	24524.18	21032.56	63316.92
	Urban Built-Up Area T1	30177.52	9168.11	4297.53	26653.17
	Urban Built-Up Area T2	58906.48	16832.99	13143.99	44944.23
	Suburban Built-Up Area T1	35042.33	8042.17	2295.09	13795.66
	Suburban Built-Up Area T2	41252.96	7287.51	7169.57	16247.44
	Rural Built-Up Area T1	3083.22	384.19	690.09	2334.98
	Rural Built-Up Area T2	2433.83	403.69	719.00	2125.25
	Population T1	8238696.84	3005361.85	3579381.86	14044055.35
	Population T2	9761696.79	4309796.66	4309449.30	17335085.04
	Built-Up Area Density T1	120.62	170.81	491.49	328.26
	Built-Up Area Density T2	95.15	175.74	204.89	273.78
	Urbanized Open Space T1	92113.45	20784.99	7431.28	43427.35
	Urbanized Open Space T2	111952.99	20322.33	18691.01	51245.91
	Captured Open Space T1	7023.77	1535.56	282.91	2086.91
	Captured Open Space T2	9751.14	877.15	1296.76	3237.06
	City Footprint T1	160416.53	38379.46	14713.99	86211.16
	City Footprint T2	214546.25	44846.52	39723.57	114562.83
	City Footprint Density T1	46.31	78.58	249.00	152.45
	City Footprint Density T2	43.81	89.59	109.31	144.95
	City Footprint Ratio T1	2.35	2.18	2.02	2.02
	City Footprint Ratio T2	2.09	1.83	1.89	1.81
	Openness Index T1	0.54	0.49	0.44	0.44
	Openness Index T2	0.46	0.41	0.38	0.35
	Proximity Index T1	0.73	0.60	0.62	0.59
	Proximity Index T2	0.75	0.61	0.71	0.60
	Cohesion index T1	0.71	0.74	0.65	0.62
	Cohesion index T2	0.74	0.74	0.76	0.64
	New Development T1 - T2	34290.19	6929.71	13749.85	20533.11
	Infill T1 - T2	7832.12	1674.94	1100.19	6214.44
	Extension T1 - T2	22891.40	4600.02	10450.65	12608.72
At T2	City footprint density (persons/ ha)	45.50	96.10	108.49	151.32

Spatial Data	City	Bangkok	Singapore	Ho Chi Minh City	Manila
	Built up area density (persons/ ha)	95.15	175.74	204.89	273.78
	Urban built up area density (persons/ha)	165.72	256.03	327.86	385.70
	Leapfrog T1 - T2	3566.67	654.75	2199.00	1709.95
	Definition	City			
Emissions	Study Year	2005.00			
Chapter 2 of	Population	5658953.00			
=	Energy (excluding Aviation and Marine)	42.61			
Also	Aviation	10.85			
World Bank Updated GHG Intensity Table	Marine	0.00			
	Energy	53.46			
million CO_2-e tons	Industrial Processes	0.00			
	AFOLU	0.00			
	Waste	6.98			
	Total (excluding Aviation and Marine)	49.59			
	Total	60.44			
CO_2-e tons/capita	GHG from Energy (excluding Aviation and Marine)	7.50			
	GHG from Aviation	1.90			
	GHG from Marine	0.00			
	GHG from Energy	9.40			
	GHG from Industrial Processes	0.00			
	GHG from AFOLU	0.00			
	GHG from Waste	1.20			
	GHG from Total (excluding Aviation and Marine)	8.80			
	GHG from Total	10.70			
MIT - Database	energy/capita(kgoe)	1526.00	7260.00	617.00	499.00
From A Global Typology of Cities	energyClass	2.00	3.00	1.00	1.00
(approx study date 2005)	population	5658953.00	4588600.00	3015743.00	1581082.00
	GDP2000US$	17751.00	51656.00	13200.00	13423.00
	populationDensity(/sqkm)	8084.00	6582.00	21541.00	2575.00
	climate	1.00	1.00	1.00	1.00
	electricity/capita(KWhr)	1899.00	8507.00	573.00	569.00
	FossilFuels/capita(tons)	1.15	0.00	0.23	0.35
	IndustrialMinerals/capita(tons)	0.18	0.00	0.05	0.15
	ConstructionMinerals/ capita(tons)	7.91	0.00	2.00	5.40
	Biomass/capita(tons)	3.08	0.00	1.84	2.17
	Water/capita(Kl)	71.00	99.00	49.00	123.00
	DMC/capita(tons)	12.32	0.00	4.13	8.06
	CO2/capita(tons)	10.86	14.37	7.28	3.48

Table A.0.2 Air pollution Data for Select ASEAN Cities *(WHO, 2015)*

Nation	City	Annual mean, µg/m³	WHO Safe Air Guidelines, µg/m³
Indonesia	Bandung	33	10
Malaysia	Bayan Lepas	18	10
	Kuantan	14	10
	Kuching	14	10
	Petaling Jaya	25	10
	Senai	16	10
	Tanah Rata	10	10
Myanmar	Kathar	42	10
	Kyauk Pa Daung	50	10
	Kyaukphyu	76	10
	Mawlamyine	69	10
	Meiktila	33	10
	Namkham	71	10
	Namtu	17	10
	Nyaung Oo	51	10
	Pyay-Aunglan	25	10
	Pyin Oo Lwin	78	10
	Sagaing	44	10
	Taungoo	76	10
	Taungtha	44	10
	Yenangyaung	67	10
Philippines	Baguio City	44	10
	Cebu	28	10
	Dagupan City	27	10
	Davao City	11	10
	Manila	17	10
	San Carlos City	32	10
	Urdaneta	24	10
	Zamboanga City	26	10
Singapore	Singapore	18	10

Nation	City	Annual mean, µg/m^3	WHO Safe Air Guidelines, µg/m^3
Thailand	Bangkok	24	10
	Chiang Mai	25	10
	Chiang Rai	27	10
	Chon buri	18	10
	Khon Kaen	28	10
	Lampang	29	10
	Lamphun	24	10
	Mae Hong Son	23	10
	Nakhon Ratchasima	28	10
	Nakhon Sawan	32	10
	Nan	25	10
	Narathiwat	16	10
	Nonthaburi	25	10
	Pathum Thani	27	10
	Phayao	23	10
	Phra Nakhon Si Ayutthaya	31	10
	Phrae	31	10
	Phuket	13	10
	Rayong	23	10
	Sa Kaeo	26	10
	Samut Prakan	28	10
	Samut Sakhon	30	10
	Saraburi	31	10
	Songkhla	24	10
	Surat Thani	22	10
	Yala	13	10

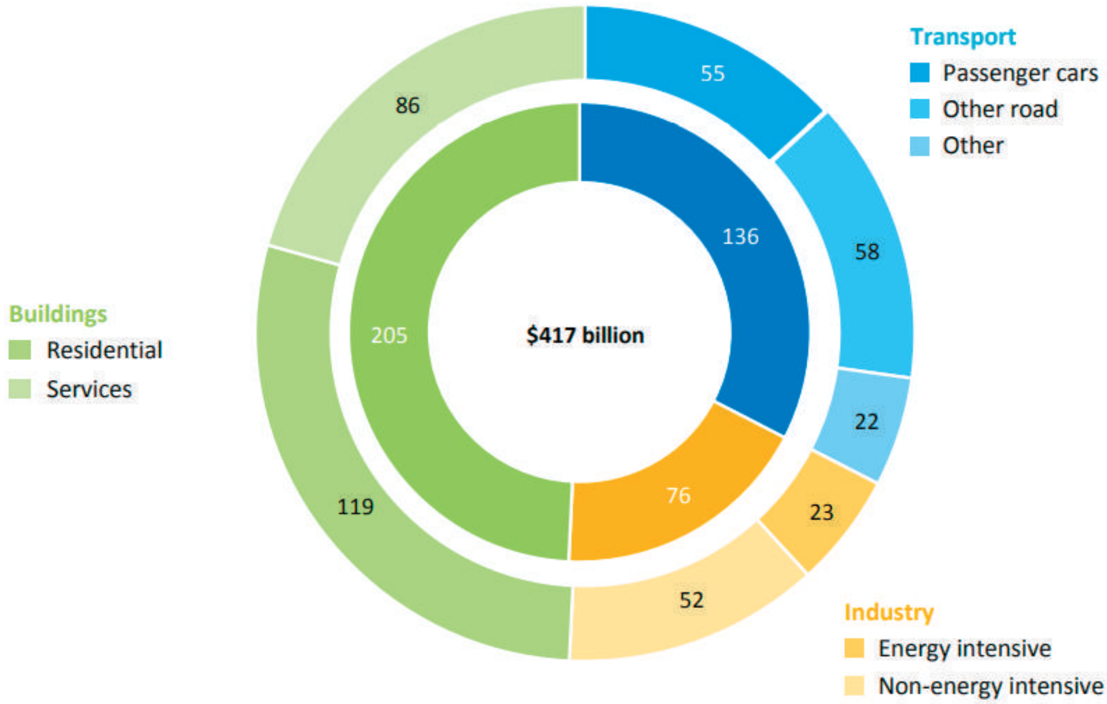
Appendix B
IEA New Policies Scenario

The New Policies Scenario is the main scenario used in the World Energy Outlook (WEO) 2015 report and the basis for the 2040 ASEAN energy use projections included in this Chapter. The New Policies Scenario takes into account the energy markets policies adopted as of mid-2015, together with relevant policy proposals, even if specific measures needed to put them into effect have yet to be fully developed (OECD/IEA, 2015).

The following are a few key assumptions made in the New Policies Scenario (OECD/IEA, 2016b):

- ASEAN nations are assumed to put in place cap-and-trade schemes to limit CO2 emissions. All regional markets have access to offsets, which is expected to lead to a convergence of prices.
- Import prices of fossil fuels increases. For example, the average crude oil import price in Southeast Asia comes close to US$110/barrel (in year-2014 US dollars) in 2030 and steam coal export price rises from US$61/tonne in 2014 to just over US$80/ton (in year-2014 US dollars).
- All net-importing countries and regions phase out fossil-fuel subsidies completely within ten years.
- Annual efficiency investment in Southeast Asia countries increase by about three-times from today's level (faster than growth experienced by annual investment in energy supply), to about US$23 billion in 2030s, mainly due to a more widespread adoption of mandatory energy management programmes in the industrial sector.

FIGURE B.0.1 **Cumulative energy efficiency investment in Southeast Asia in the New Policies Scenario** *(OECD/IEA, 2016b)*



Appendix C
Building efficiency policies, regulations and standards in ASEAN Countries

TABLE C.0.1 **Building efficiency policies, regulations and standards in ASEAN Countries**

Policy and Regulation	Codes and Standards	Remarks
Brunei		
Building Control Order 2014 (Enforced-Nov 2015) Building Control Regulations	Building Control Order 2014 (Enforced-Nov 2015) Building Control Regulations	PBD 12 covers space, light and ventilation; structural, construction, and fire requirements; electrical installations; earthworks, road, and water; and drainage and sewerage
Indonesia		
Building Energy Codes (Mandatory): Law No. 28/2002 (regarding buildings) National Energy Efficiency Standards (SNI) for Building	Applicable Standards (Mandatory) SNI 03-6389-2000: Energy Conservation for Building Envelope of Buildings SNI 03-6390-2000: Energy Conservation for Air Conditioning Systems in Buildings SNI 03-6197-2000: Energy Conservation for Lighting Systems in Building Structures SNI 03-6196-2000: Energy Auditing Procedure for Buildings Building Rating Tool (Voluntary) GREENSHIP – Green Building Council of Indonesia (GBCI)	Applicable sectors: residential and commercial buildings
Malaysia		
Uniform Building ByLaws (1984) Building (Federal Territory of Kuala Lumpur) By Laws Street, Drainage and Building Act (1974)	Voluntary: MS 5125: Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings Building Energy Efficiency Technical Guideline for Passive Design, Building Sector Energy Efficiency Project (BSEEP), Public Works Department, Malaysia ASHRAE 90.1: Energy Standards for Buildings Except Low-Rise Residential Buildings Building Rating Tool (Voluntary) Green Building Index (GBI) – Greenbuildingindex Sdn Bhd GreenRE – Real Estate and Housing Developers' Association, Malaysia (RHEDA)	No mandatory regulation related to energy efficiency or green features (except Uniform Building By-Laws gazetted in Selangor)

Policy and Regulation	Codes and Standards	Remarks
Singapore		
Building Control (Environmentally Sustainability) Regulations, 2008	Mandatory: Code for Environmental Sustainability of Buildings SS 530: Code of Practice for Energy Efficiency Standard for Building Services and Equipment SS 531: Code of Practice for Lighting of Work Places SS 553: Code of Practice for AirConditioning and Mechanical Ventilation in Buildings SS 554: Code of Practice for Indoor Air Quality in Air Conditioned Buildings BCA Code on Envelope Thermal Performance for Buildings ASHRAE 90.1: Energy Standards for Buildings Except Low-Rise Residential Buildings AHRI 550/590: Performance Rating of Water Chilling Packages Using Vapour Compression Cycle ASHRAE Guidelines 22: Instrumentation for Monitoring Central Chilled Water Plant Efficiency Building Rating Tool (Mandatory) Green Mark – Building and Construction Authority (BCA)	Requirements: New building works with gross floor area of 2,000 m^2 or more Increasing the gross floor area of an existing building by 2,000 m^2 or more Building works to an existing building which involve a gross floor area of 2,000 m^2 or more achieved a minimum Green Mark certified rating or higher rating as mandated by the Government Land Sales Programmes
Thailand		
Energy Conservation Promotion (ENCON) Act (1992, 2003 – 1st Revision, 2007 – 2nd Revision)	Mandatory: The Building Energy Code of Thailand (1995, 2009) Energy Efficiency Standard of Equipment and Machinery Required to meet standards for six green criteria: building envelope-OTTV, RTTV, lighting, hot water generating system, air conditioning, renewable energy, and overall performance Building Rating Tool (Voluntary) Thailand Rating Energy and Environment System (TREES) – Thai Green Building Institute (TGBI) Thailand Energy and Environment Assessment Method (TEEAM) –Ministry of Energy Adaptation of German Sustainable Business Council (DGNB) by Thai Association of Sustainable Construction (TASC)	Applicable to new and retrofitted building only Buildings larger than 2,000 m^2 Building type: hospital, academic institute, office, condominium, hotel, department store, entertainment service, theatre, and exhibition building
Viet Nam		
The Building Control Decree Building Code of Viet Nam (BCV)	Mandatory: Energy efficiency under Building Code through Decree No. 102/2003/ND-CP on Thrifty and Efficient Use of Energy Building Rating Tool (Voluntary) LOTUS – Viet Nam Green Building Council	Building type: Hotel, high-grade office, foreign affairs office, retail, high-grade condominium, dwelling house, public building (education building, cultural building, medical building, sports building, commercial building, and office building)

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