Desk Review of Good Practice Cases on Urban Adaptation Plans and Designs

Building Climate Resilience Through Urban Plans and Designs Project

Prepared by EnP. Larisa Togonon-De Castro, UN-Habitat

Building Climate Resiliency through Urban Plans and Designs

UN-HABITAT FOR A BETTER URBAN FUTURE

Supported by:
Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
based on a decision of the German Bundestag

Contents

Desk Review of Good Practice Cases on Urban Adaptation Plans and Designs

1 Background and Rationale

BCRUPD primarily works to improve HLURB, DILG, and other NGAs' skills and knowledge on urban adaptation planning and design, to enable them to promote and integrate these in the institutional policies and regulations that they issue to guide LGUs. To help achieve this goal, the project will support the formulation of a guide on developing resilient urban plans and designs to promote climate change adaptation, along with training modules specifically for HLURB and DILG. These will be produced in applicable formats for use of the agencies as they support LGUs in climate change and development planning.

As a preparatory task towards developing the guide and modules, the project has conducted research to gather good practice cases on urban adaptation plans and designs.

This report covers case descriptions of planning and design projects that aim to address climate change and achieve climate resilience. Cases cut across a spectrum of interventions, from policy to planning and design, and are characterized by their climate drivers and impacts. Most of the projects are located in Europe, North America, and Asia. Similarities to Philippine context will be evident, to enable discussion on possible replication and localization.

2 Good Practice Cases

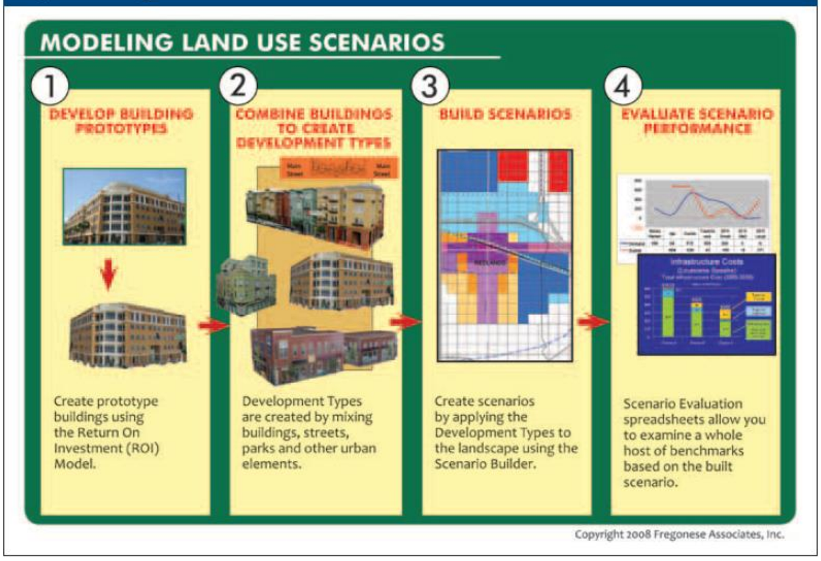
1. The Superstition Vistas, Arizona: Scenario Modeling

The project sought to demonstrate opportunities for sustainable development that could be a model for energy- and water-efficient development with a low carbon footprint.

Based on a 2007 study on the impacts of population growth and future development activities, the East Valley Partnership (EVP), a coalition of civic, business, educational, and political leaders from the East Valley of the Phoenix metropolitan area, launched Envision Tomorrow, a program that uses prototyping and scenario modelling to measure carbon footprint and plan future development accordingly, with specific focus on GHG emission reduction.

The Envision Tomorrow scenario modeling process is based on a development pattern methodology, which grew out of the ROI model that incorporates inputs, including construction and land expenses, expected rents, and sales prices, to evaluate a project financially. Combinations of varied building prototypes, along with other urban attributes such as streets, parks, and public amenities, were then created to form a variety of development types, including urban cores, traditional downtowns, town centers, business parks, neighborhood retail, traditional neighborhoods, and residential subdivisions.

FIGURE 12
Steps for Modeling Land Use Scenarios

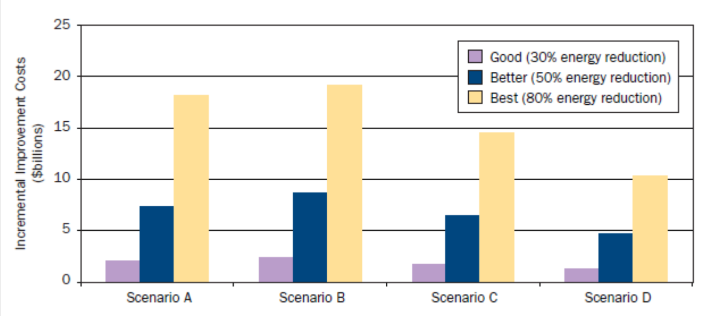


the project incorporated energy performance data into 12 prototype buildings, ranging from single-family homes to large mixed-use buildings and industrial and office complexes. This involved the development

of a base energy use assumption, along with three levels of improvement representing 30 percent, 50 percent, and 80 percent reductions in energy use for four different scenarios.
Estimates of carbon dioxide emissions were developed, as well as energy use from electricity and natural gas. In each case, both the additional costs and energy savings were estimated, allowing the team to understand the potential GHG emission implications of different scenario designs in the project.

The Envision Tomorrow user builds land use and transportation scenarios that represent a range of possible futures, essentially by digitally painting the study landscape with a range of possible development patterns based on the results of public involvement, the current trend, and coordinated land use and transportation strategies. The scenarios created can range from business-as-usual to compact development in which growth is concentrated in centers or along corridors.

FIGURE 14
Incremental Improvement Costs After Energy Reductions from Baseline



Outputs from the Scenario Builder can be fed easily into the traditional four-step transportation model. In the case of Superstition Vistas, the Pinal County transportation model was used to calculate traditional transportation outputs along with estimates of the carbon emissions from motorized vehicles.

The final scenarios are subjected to a series of tests to evaluate their individual impact on the study area's housing mix, transportation network, environmental features, open space, natural areas, and economic development. Sustainability performance measures are prioritized in these evaluations. Furthermore, using the building prototype as a methodological foundation enables measurement of indicators that were previously difficult to calculate, such as the increased value and probable rent levels for residential and commercial buildings, the amount of water consumed, the number of retail employees, and even the total area of rooftops or parking lots.

2. City of North Vancouver, British Columbia: Measuring GHG Impacts of Land Use Decisions through the Development Pattern Approach

Launched in 2007, the 100 Year Sustainability Vision was a multistage project conducted in the City of North Vancouver in 2007–2008 to develop a long-term sustainable concept plan. Guided by the Province of British Columbia's Greenhouse Gas Reduction Targets Act, the project aimed to create a plan to reduce GHG by 80 percent below 2007 levels by 2050, and to achieve zero net emissions by 2017.

The collaborative project engaged local and regional community stakeholders, city staff, utilities representatives, researchers, and others in a planning process over several months, culminating in a four-day intensive design charrette. During this process, stakeholders worked with project researchers to assess alternative development scenarios and generate a long-term, low-GHG vision for the city.

Development patterns were constructed using information from a database created by the Design Centre for Sustainability at the University of British Columbia. This database contains parcel-scale examples of streets, open spaces, and buildings across a range of densities and forms, each with visual and quantitative information, including three-dimensional digital models, site plans, and data on floor-area ratios, uses, parcel coverage, and number of residential units. These street, open space, and building cases can be assembled using spreadsheets, GIS, or other spatial modeling platforms such as Google SketchUp to generate development patterns. Replacing one case for another can generates variations of patterns, with corresponding impacts.

FIGURE 16
Parcel, Street, and Open Space Cases in a Development Pattern

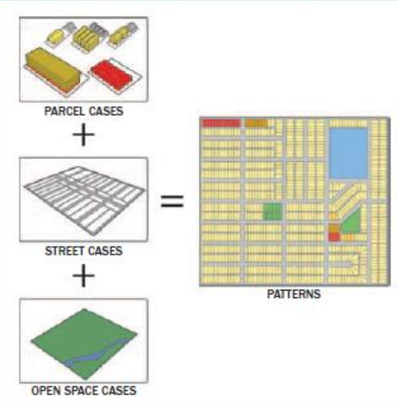
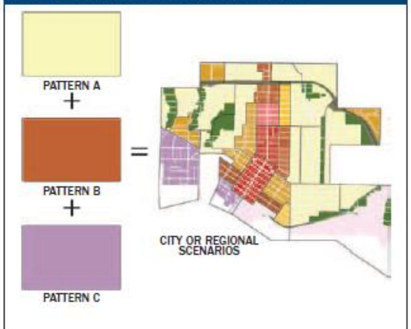


FIGURE 17
Development Patterns Assembled into Scenarios



The city decided to model energy demand and GHG emissions from the buildings in the scenarios, and therefore created building energy profiles (quantitative descriptions of energy consumption by end use and energy source) for each type of building used in the development patterns: single-family detached houses; duplexes; row houses; low-rise apartments; high-rise apartments; commercial buildings; institutional buildings; and industrial buildings.

The development pattern approach helped assess how land use, building form, transportation, and infrastructure decisions contribute to reducing energy consumption and GHG emissions, while supporting environmental, social, and economic goals.

Quantifying and spatializing GHG emissions helped create a standardized and consistent means of measuring and comparing alternative land use scenarios—from current conditions to a 100-year future.

It also allowed users to assign land use patterns at various scales, adding detail where needed ie critical areas. The “quantitative and design-based results” also suggest that the approach can inform decision-making on urban form and GHG emission reductions during a fast-paced, collaborative planning process. It also equipped the city with tools for monitoring, evaluation and adjustment over time, supporting iterative planning and decision-making.

FIGURE 18
Initial Sketch Digitized for a GIS Development Pattern Map

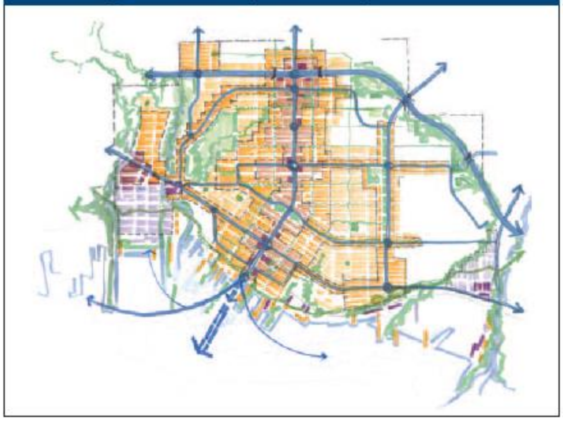
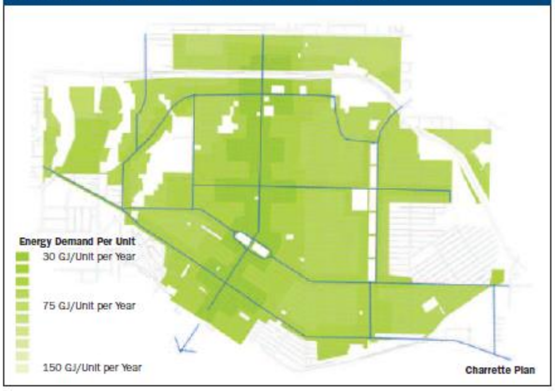


FIGURE 20
Spatialization of Energy Demand per Unit for 2007 Baseline

FIGURE 19
Development Patterns as Assigned in GIS During the Charrette

FIGURE 21
Spatialization of Energy Demand per Unit for Charrette Scenario



3. Bethemplein Water Square, The Netherlands

A classic example of designing for climate resilience is the renowned Bethemplein Water Square in the Netherlands.[i] The water square retains water during peak rainfall, preventing floods in the surrounding dense urban area. It collects water directly from rainfall, and also from rooftops of surrounding buildings. As a result, the said buildings' pipes have been successfully disconnected to the Rotterdam sewage system, relieving pressure, preventing urban flooding, and avoiding the financial burden of sewage system upgrades. While the square is a repository for water, it also serves a public space when dry. The pitted area is often used for sports and recreation, as well as performance arts. Bethemplein can hold up to 1.7 million liters of water during rainfall. It then infiltrates the soil beneath the pavement or is pumped out to canals connected to the square.

4. Mississauga, Canada: Low Impact Development Standards[ii]

Currently approved local plans project that by 2020, urban development will encompass 40% of the Credit Valley watershed, located above the Niagara Escarpment in Canada. Such rapid urban development in the face of climate change prompted the Credit Valley Conservation Authority (CVC), which manages the watershed, to commit to and impose low impact development infrastructure design standards.

Development is now governed by the Watershed Planning and Regulation Policies, which provide the parameters and guide CVC's review of official plans, zoning bylaws and planning applications. To assist and guide prospective developers, they crafted various technical guidelines that help applicants and guide consultants with the requirements set by CVC. These range from soil, wildlife, EIA, management of headwaters, floodproofing, bridge construction, slope stability, plant selection, as well as guidelines for drawings to be submitted for review. They likewise produced a *Low Impact Development Stormwater Management Planning and Design Guide* "to provide engineers, ecologists and planners with up-to-date information and direction on landscape-based stormwater management planning and low impact development stormwater management practices, and thereby help ensure the continued health of the streams, rivers, lakes, fisheries and terrestrial habitats in the CVC and TRCA watersheds."

Do you want to bet?

A 50-year event has a 1-in-50 chance of occurring in any given year and a 100-year event has a 1-in-100 chance. If you were to wager, you might like those odds. However, you may want to consider that in the last eight years leading up to 2013, the GTHA has experienced eight extreme events, five 50-year events and three 100-year events. Are you prepared for when the next perfect storm hits?

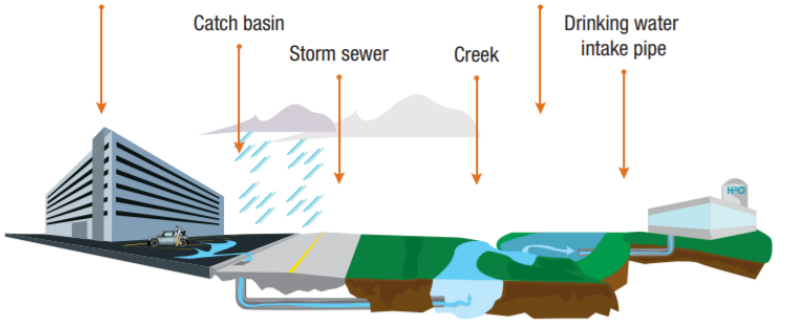
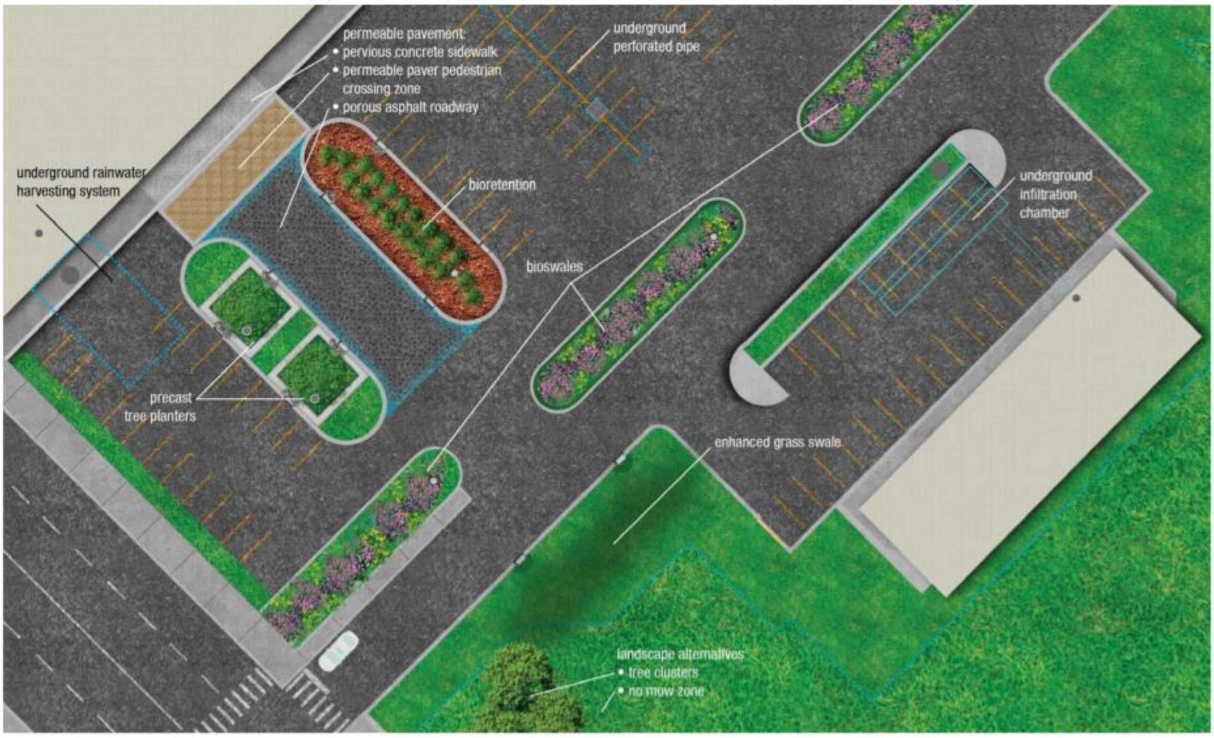


Figure 1.1.2: Conventional approach to stormwater management. (Source: CVC)

Where are the opportunities for LID retrofits on your property?



Above: pages lifted from CVC's guidelines for business and residential properties, showing the extent and depth of the authority's involvement in design for resilience (https://cvc.ca/wp-content/uploads/2013/10/SWI-Grey-to-Green-Business-Multires-Retrofits-Complete1.pdf)

After six years of constructing and monitoring LID practices, and as a result of these policies and standards, annual runoff was reduced by nearly 80%; suspended solids and phosphorus loading also decreased by 80%, and heavy metals in water by 50-90%. Remarkably, LID system filtration had a cooling effect on water of more than more than 5°C.

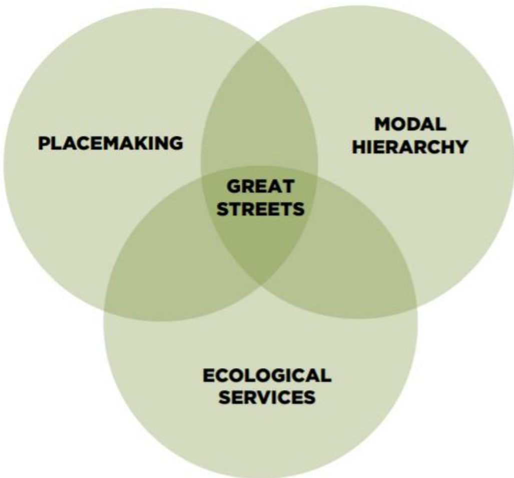
Critical to the success was the control and management of publicly owned land such as roadways, parks, and public and institutional spaces, as well as private land through regulatory and economic instruments. In 2016 Mississauga began levying a stormwater fee based on the amount of impervious surface on each residential property as determined by aerial imagery and mapping software. This raises the level of intervention that local authorities can exercise over privately owned land.

5. Chicago City: Sustainable Urban Infrastructure Policies and Guidelines

One of the primary purposes of the Chicago Sustainable Urban Infrastructure Policies and Guidelines[iii] under the Department of Transportation (DOT) is "to prepare the city's infrastructure to respond to the challenges of climate change and enact policies to reduce its negative impacts." This is inherently linked to the one of the Guidelines' core values of "climate resilience: to focus on reinforcing and reconceiving its civic facilities to cope with long-term trends and unexpected shocks." Climate resilience is embedded in the document's design philosophy and is fundamental to creating sustainable infrastructure. It also sees climate resilience as providing co-benefits particularly in reducing maintenance costs and liability over the lifetime of the infrastructure improvement. It also aligns itself with the Chicago Climate Action Plan, which assessed the impacts of climate change and concluded that Chicago needs to achieve an 80% GHG emission reduction below its 1990 level by the year 2050 to sufficiently contribute global climate change action.

The Sustainable Urban Infrastructure Policies and Guidelines established a city-wide approach for integrating environmental performance goals into infrastructure design, and are organized into eight categories: water, energy, materials and waste, place-making, economics, commissioning, urban ecology, and climate and air quality. Each category has three to six environmental objectives, which are implemented through over 60 specific requirements and 35 policies. The document is comprised of specific strategies, references and resources to help project managers, engineers and other professionals to accomplish the laid out set of sustainability goals and set of requirements.

One of the main points of the guidelines is planning, designing, building and maintaining its public right-of-way, or streets. Chicago's streets represent 23% of its land area and more than 70% of its public open space. Comprising more than 4,000 miles of streets and 2,100 miles of alleys, these mostly paved surfaces contribute significantly to environmental challenges, including stormwater management, water use, urban heat island effect, energy use, and waste management. To implement the strategies, the city integrated their guidelines on Complete Streets and Placemaking with sustainability and resilience guidelines, creating a balance of modal hierarchy, ecological services, and placemaking with good planning, design, construction, and maintenance.




Typical Streetscape Side Street


Parkway Planter


Dedicated Bus and Bike Lanes

The city also emphasized the economic impacts of resilience building. While there are cost implications to some of the requirements, such as manpower, design and construction fees, ultimately the benefits justified the cost. In fact, in many cases the adjustments led to savings, as in the use of recycled materials, energy efficient lighting, and reducing gray stormwater solutions, among others. The DoT uses the term sustainability valuation or sustainable return on investment, to describe the full cost and benefit assessment of environmental best practices on their pilot projects.

The DoT has also validated that the cost for green infrastructure can be lower than the cost for traditional grey infrastructure and achieve numerous economic and environmental benefits, including industry-wide adjustments. For instance, after the implementation of the Green Alleys program (above), the cost of permeable concrete dropped by 47% from the original pilot alley installation.

A cost-benefit analysis for the Pilsen Sustainable Street Project that included valuing the cost and benefit of ecological services and measurable quality of life improvements helped promote green infrastructure investment. It guided decision-making such as in the choices of materials, implementation and maintenance, and disposal or replacement. As a result, the winning bid for the Pilsen project was 21% less per block than the average per block cost.

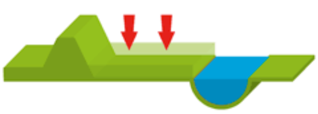
6. Netherlands: Making Room for Rivers

Almost 30% of Netherlands lies below sea level, and another 30% at risk of riverine flooding, making the country highly vulnerable. While famous for its large scale dike, sea wall and storm surge barrier projects, the country gradually recognized the long-term impacts of climate change on sea levels, temperatures, as well as greater risk of drought and potential for greater river discharge which will it aggravate their already existing flood risks. With this understanding, the government has shifted its overall stance from reactive to a more proactive approach. The new overall strategy, called the Delta Programme[iv] launched in 2008, expands the scale and integration of interventions, and departs from traditional approach of flood prevention, to a more systems-based approach. It incorporates climate change risk in its decision-making processes, analyzing water management options against objectives and under different climate scenarios. This ensures robustness of infrastructure projects as well as promotes flexibility.

One of the initiatives under the Delta Programme is **Room for Rivers**.[v] With a timeframe of 12 years (2007–2019) and implemented in more than 30 locations, it aims to “restore landscapes along the country’s rivers to create more room for floodwaters” and give space for the river to “flood safely.” This involved:

1. Lowering the flood plain: Lowering sections of the flood plain gives the river more soace during periods of high water. Over the years, sedimentation has gradually raised the level, and excavating them makes them lower.
2. Deepening the Summer Bed: The bed of IJsell rover will be dredged to make it deeper over a length of 7.5 km, creating more room for the river to flow through
3. Water retention: Under exceptional circumstance (ie storm syrge barrier is closed and the river is discharging large volumes of water to the sea), the Volkerak-Zoommeer lake will serve as temporary water storage to retain excess river water.
4. Dike Relocation: Dikes are moved inwards towards land, increasing the width of flood plains and provides more room for the river. This entails exposing land that had been protected by the dike.
5. Lowering perpendicular groynes and building attracting groynes: Groynes are structures in the river channel that ensure water stays in the channel in order to maintain high flows so boats can navigate upstream. Lowering them and building parallel barriers allows the river to drain excess water easier.

6. Depoldering: Polders are sub-sea or sub-river tracts of land that are surrounded by dikes. Depoldering, like dike relocation, entails moving the dikes inland so that water can flow into the area that was once behind the dike.
7. High Water Channel: A high water channel is a branch of a river or secondary channel used to drain high water through a different route. It is not excavated below the water table but formed by building two dikes in the landscape. It can be created in the floodplain along the river to accommodate the higher flows seen during a flood event. In some cases, these channels remain empty at all times so that they can accommodate the largest amount of water possible during floods. There can also be filled with riparian plants or other vegetation so that the water can slow down or be absorbed into the ground.
8. Removing Obstacles: Removing or modifying obstacles in the river increases the flow rate. This includes eliminating or lowering ferry pier banks, widening bridge openings, removing or lowering quays and flood-free areas.
9. Strengthening dikes: In several areas where widening is not an option due to lack of space or in areas of national or cultural importance, dikes will be strengthened instead. It is considered a last resort.



Lowering the flood plain

Deepening the summer bed

Water retention

Dyke relocation

Lowering perpendicular groynes and building attracting groynes

High water channel

Depoldering

Removing obstacles

Strengthening dykes

It In implementing these actions, the program recognizes the importance of respecting cultural, ecological, aesthetic and recreational values.

The Delta Programme is a study in critical thinking, assessing long-held values and approaches to risk, and making fundamental, long-term changes with the help of climate science. The political commitment of the government and stakeholders (including national ministries, provinces, municipalities, water boards and civil society organization) is also reflected in resources committed and used to finance the work and annual review of the work plan.

7. Netherlands: Delta Plan on Spatial Adaptation

In 2018, the Delta Programme took further steps and started the Delta Plan on Spatial Adaptation[vi], which aims to minimize the impact of waterlogging, heat, drought, and urban flooding, and ultimately design Netherlands to be "climate-proof and water-resilient" by 2050. This aim will be taken into account in the construction of new residential areas and business parks, the renovation of the existing built environment, sewer replacements, and road maintenance, using climate scenarios. The Delta Plan contains seven ambitions:

- Mapping out vulnerabilities
- Drawing up an implementation agenda
- Conducting a dialogue on risk and drawing up a strategy
- Capitalizing on linkage opportunities
- Regulating and embedding
- Promoting and facilitating
- Responding to disasters

Under the Ministry of Infrastructure and Water Management, the plan takes a systematic approach at the local and regional levels, and sets out how municipalities, district water boards, provinces, and the national government intend to expedite and intensify the spatial adaptation process. They are employing a process dubbed Analysis-Ambition-Action: analyzing climate change impacts for various functions in an area in the period up to 2050; setting concrete goals for improving water-resilience and climate-proofing in the period up to 2050, and formulating an appropriate strategy to achieve these goals; setting down the goals and the strategy in policy plans, legislation, regulations, and programmes pertaining to implementation, management and "major" maintenance.

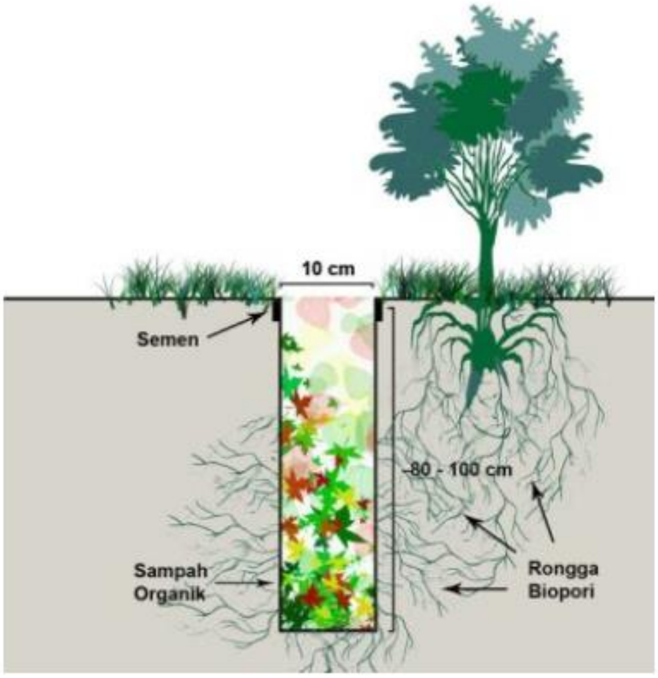
Municipalities are conducting stress tests in their own region, in collaboration with the provinces, the district water boards, and the national government. The tests, scheduled to be completed this year, uses uniform standards developed in 2018, which will identify vulnerabilities to extremes, and enable authorities to take appropriate measures. Under the plan, external developments such as climate and socioeconomic conditions are monitored, as they would have an impact on decision-making. Spatial adaptation becomes an "automatic element in all the physical interventions carried out in Netherlands". Provinces and municipalities are already embedding spatial adaptation in their Environmental Visions; the central government is doing likewise in the National Environmental Vision.

To expedite spatial adaptation efforts, the Climate-proof Together Platform was set up in 2018 to share knowledge, tools, and experience. The platform liaises supply and demand in various regions, sectors, and existing networks.[vii] The knowledge portal also features the Climate Impact Atlas, which helps visualize climate effects (heat, waterlogging, drought). The effects may also be combined with information on vulnerable groups, swimming water, or depths. The Climate Impact Atlas constitutes a sound basis for a stress test.

8. Bandar Lampung, Indonesia: Groundwater Conservation through Biopores

Bandar Lampung is home to almost 1 million inhabitants. As a gateway to Jakarta, it continues to experience rapid population growth and by 2005, it was categorized as 100% urban, despite having some areas dedicated to agriculture. Climate vulnerability assessments concluded that it was at risk to flooding and drought, and other extreme weather events. The assessment also revealed deficiencies in water supply, which led to over-extraction of groundwater, as well as poor solid waste management. Urban development has also led resulted expansion of impermeable spaces leading to rapid and excessive runoff. These will be exacerbated by climate change.

As a response, the government with the help of development partners introduced the concept of biopores, or water-absorbing pits or holes to improve water retention. Biopores are small holes or tunnels formed naturally underground by worms, termites, plant roots. The biopore project sought to replicate this in urban areas as "biopore infiltration hole", a cylindrical hole about 10m in diameter and coated with plastic/pvc pipe that is dug into the ground at a depth of 100cm, and filled with organic waste. The waste feeds soil fauna, which then create pores in the soil to increase absorption capacity. They are placed where water usually gathers: near trees, gutters, lower areas of gardens, park boundaries.



These holes have multiple benefits. While it was conceptualized to manage organic waste, the project itself intended for it be an augmented groundwater recharge method to improve soil absorption and increase infiltration (by up to 40 times), therefore increasing groundwater reserves, as well as reducing flood potential.

It also reduces health risks by eliminating rain puddles that become breeding ground for malaria and dengue. It also helps manage organic waste, as fruits and vegetable scraps are placed inside the holes and converted into compost to help increase soil fertility.[viii]

Launched in 2009, by 2014 the program succeeded in building one million biopore infiltration holes in five subdistricts, schools and government offices. It set out to build up five million more.[ix]

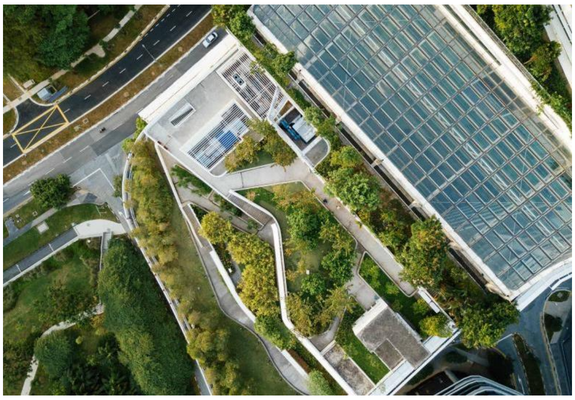
9. China: Sponge City Initiative

Launched in 2015, the Sponge City Initiative aims to reduce the intensity of water runoff by improving and distributing absorption capacity throughout the city. Initially implemented in 16 cities, it expanded to 30 cities. Many of these pilot cities were plagued by flooding due to changes in rainfall patterns and extreme rainfall, coupled with water shortage in increasingly drier dry seasons. By 2020, China aims to have 80% of its urban areas equipped to absorb and reuse at least 70% of rainwater.[x]

Yanweizhou Park in Jinhua, eastern China. Turenscape

The sponge city (SPC) promotes climate resilience through sustainable construction and development, and the integration of "ecological functions" in the built environment. Acting like a "sponge", the city's infrastructure, structures and spaces are designed such that water is able to infiltrate and be absorbed, stored, cleaned, discharged and utilized. Similar to low impact development (LID) and stormwater management concepts in the North America, SPC takes it further by integrating "source control LID systems" that that reduce or control runoff volume; wider scale urban drainage systems to distribute and discharge water; and emergency discharge systems to handle excess runoff in extreme events. This systems approach not only manages stormwater but increases availability for water supply and consumption. Part of this systemic intervention are design details such as those featured in Lingang, a planned city in Shanghai. Concrete pavements are replaced with wetlands or permeable pavements. Green rooftops and rain gardens are a standard in building design and construction. A manmade lake control water flow. The lush greenery and water elements also help manage temperature in the area.

▲ Wetland areas help to absorb rainwater in Lingang. Photograph: Helen Roxburgh



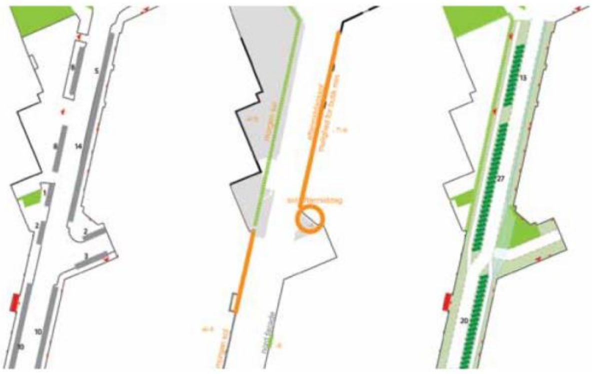
10. Saint Kjeld's, Copenhagen, Denmark: Climate Adaptive Neighborhood

Prompted by a flash flood in Copenhagen in 2011 that incurred about USD1 billion worth of damage, one area named St. Kjeld decided to convert itself into a "climate change adapted neighborhood" through design.

With the help of private consultants, they came up with a rainwater masterplan that led to the creation of open drainage systems using plants, and the conversion of surface areas into green areas, turning the whole neighborhood into a system of detention ponds, catchment basins, and channels for rainwater.

The water's way to the harbour. St. Kjeld's Neighbourhood is located in Østerbro, north of Fælledparken. We will secure an entire neighbourhood against the effects of torrential rain by creating channels in the streets that will lead large quantities of water to the harbour where it will do no damage.

They envisioned that 20% of their surface area will be turned into green areas, and 30% of their daily rainwater will be managed locally instead of transferred to the larger sewer system. St. Kjeld had its paved squares dismantled and replaced with turf, which help cool the air during hot months. The squares also act as basins to collect water during rainfall or flooding. These are connected to a pipe system that conveys water towards the sea. Asphalt roads were replaced with bike paths and pedestrian areas made of permeable pavements. Bike paths doubled as channels for the water to pass through during flooding. Sidewalks are raised in the center to allow water to run off. They have also built water towers to store excess rainwater.[xi]



Bryggervangen at Ourøgade
Today Bryggervangen is a wide street with parking lots on both sides – also on the sunny side.

Sun and shadow
The public space can be improved by concentrating parking in the shadow, along offices and supermarkets.

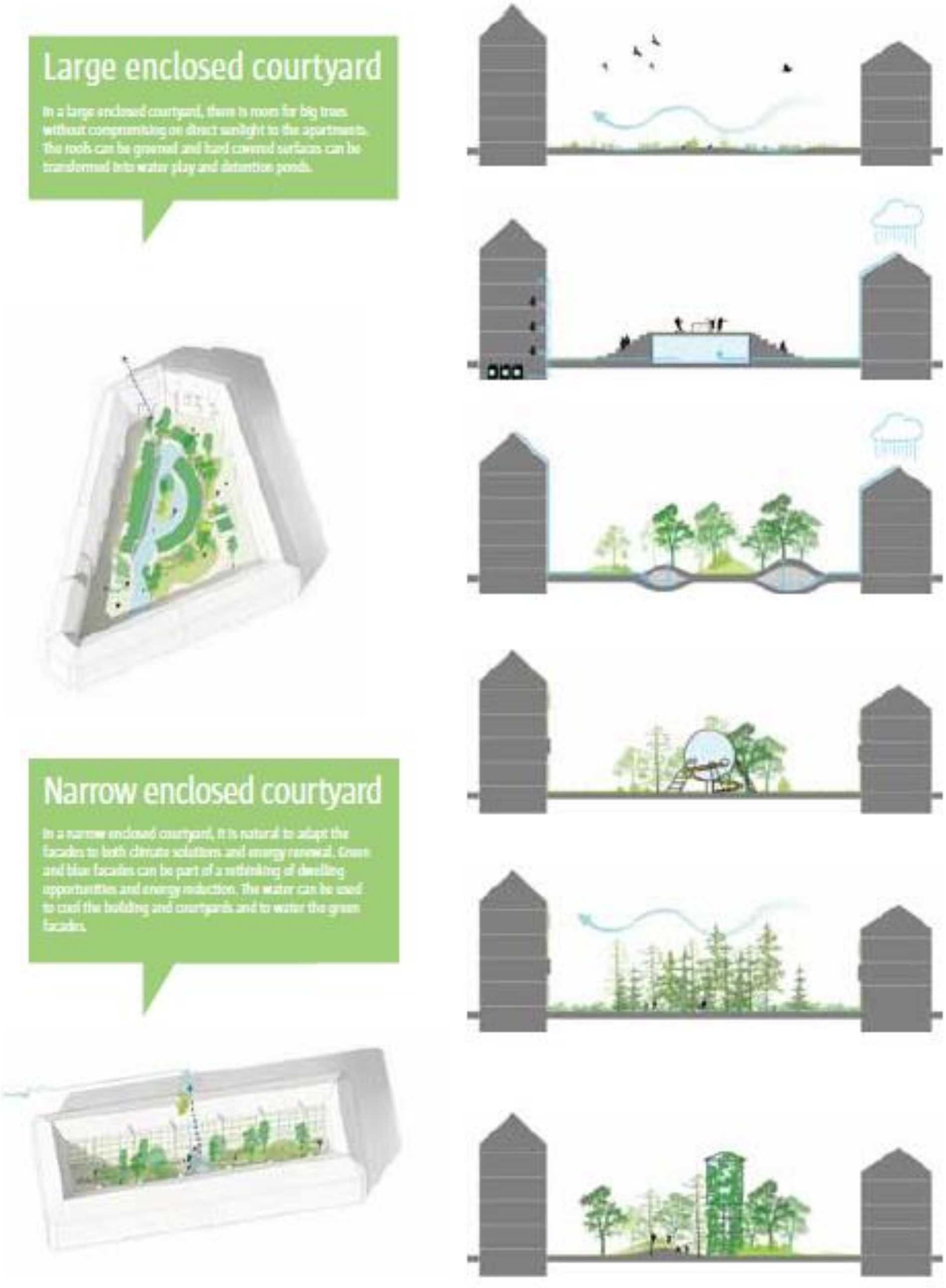
Suggestion
This way it is possible to liberate some space for a green recreational area on the sunny side of the street where people live without reducing the number of parking lots.

Asphalt. Bryggervangen at Landskronagade today.

From grey surface to green urban space.

Other neighborhood-scale features include the green stream: redesigning Bryggervangen at Landskronagade, a former asphalt area into a green space or "stream" that runs through the neighborhood, providing not just the benefits of an improved public space but also channeling rainwater to the harbor.

Meanwhile, existing courtyards are being remodeled into "green enclosed courtyards" to be able to manage rainfall locally, starting from rainwater from roof collecting in rainwater gardens, water towers or detention ponds, and channeling of excess water to the larger street channel network.



11. Quy Nhon, Vietnam: Hydrology and Urban Development Modeling for Flood-related Land Use Planning

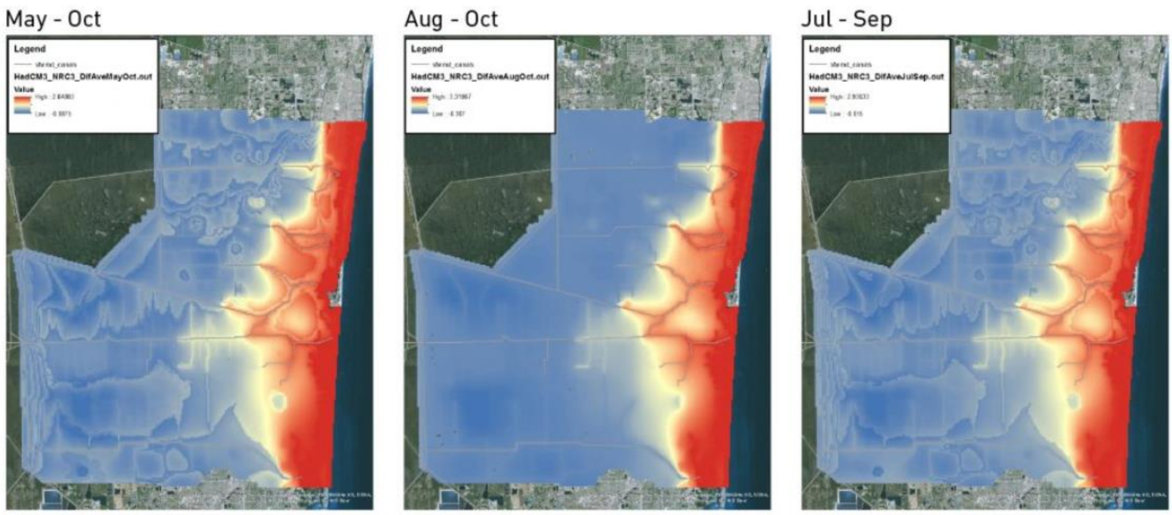
Quy Nhon has experienced urbanization in formerly rural farming areas. These same areas have historically been impacted by drought, saline intrusion, rainfall variability, typhoons and flooding, which are projected to increase and intensify due to climate change.

While runoff water used to flow over agricultural fields, because of development they were now stuck behind roads, construction sites, and other structures. The city government has recognized that current development plans do not take into account such impacts and that those most affected will include thousands of poor local residents, mainly farmers, living in small houses built at ground level.

The project aimed to identify flood scenarios and their impacts on planned urban development in Nhon Binh ward, and using historical data as well as potential impacts of climate change, develop a hydrological model for Kon and Ha Thanh river basins.[xii] This allowed them to assess the relationship between future flooding on their urban plans, including impacts of urban development on the hydrology of their estuary. Existing plans will consequently be adjusted to adapt to these projected impacts.

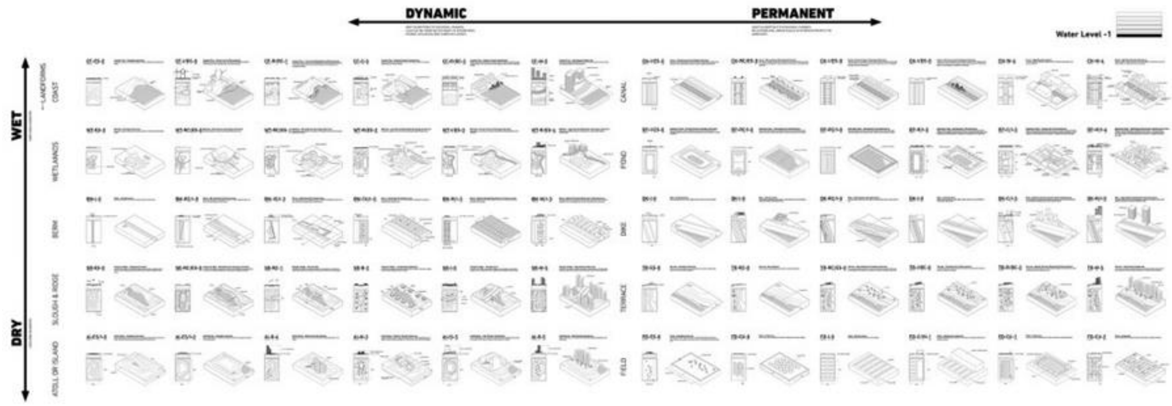
12. Miami, Florida: Flux-based Zoning

Driven by climate assessments and modelling related to sea level rise, storm surge and flooding, Miami, in partnership with MIT, identified what they call the Flux Zone—an area between substantially saturated ground with no storage capacity and areas susceptible to flooding. It is shown as a yellow gradient that follows the north-south natural topographic ridges between the coastal "red" zones and the inland "blue" zones.[xiii]



Through this, the study introduced the "third condition of zoning": within the "flux-zone," land use, topographic manipulation, and building code are interrelated and interconnected in a series of scenario-driven land use regulations. Rather than treating land as static and flat, flux zoning looks at the *section*, treating both the surface elevation and the vertical depth from surface to groundwater as key components in determining potential future land use. In this area, they introduced concepts such as clustering development along elevated transit corridors and ridges, inland "islands", and interconnected water corridors as open space.

Moreover, the study introduced a wide range of site-level, flexible development options based on various future climate scenarios, considering fluctuating groundwater table levels including tides, storm events, runoff, and combining them with permeability, building footprint, heights, foundations and related physical conditions.



[i] https://www.c40.org/case_studies/benthemplein-water-square-an-innovative-way-to-prevent-urban-flooding-in-rotterdam
[ii] https://cvc.ca/low-impact-development/lid-construction/
[iii] http://www.chicagocompletestreets.org/wp-content/uploads/2016/02/Sustainable%20Urban%20Infrastructure%20Guidelines.pdf
[iv] https://www.government.nl/latest/news/2017/09/19/delta-programme-2018-measures-to-reduce-the-impact-of-extreme-weather
[v] https://www.ruimtevoorderivier.nl/english/
[vi] https://english.deltacommissaris.nl/delta-programme/regions-and-generic-topics/spatial-adaptation
[vii] https://ruimtelijkeadaptatie.nl/english/
[viii] https://waste4change.com/biopore-infiltration-holes-prevent-flooding-and-produce-compost/
[ix] https://www.thejakartapost.com/news/2014/04/24/more-biopores-built-improve-water-retention.html
[x] https://www.researchgate.net/publication/303362681_Case_Studies_of_the_Sponge_City_Program_in_China
[xi] http://www.klimakvarter.dk/wp-content/2013/06/klimakvarter_ENG__updated-may-2013_i-opslag.pdf
[xii] ACCCRN City Projects, The Rockefeller Foundation, 2014
[xiii] https://scenariojournal.com/article/coding-flux/