Training Manual

EbA - Ecosystem-based Adaptation for Urban and Peri-urban Spaces: Using Nature-based Solutions as a Key Climate Change Adaptation Strategy for Advancing Sustainable Development in Jamaica

Urban Ecosystem-based Adaptation Training Programme under the UNEP CityAdapt Project

CityAdapt
RECONNECTING CITIES WITH NATURE
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Contents

This manual has been compiled in 2023 from a range of existing training materials on EbA, nature-based solutions and environmental valuation.

(See References)

Background and Introduction

The Nature Conservancy (TNC) is collaborating with the project "Building climate resilience of urban systems through Ecosystem-based Adaptation (EbA) in Latin America and the Caribbean" or CityAdapt which is funded by the Special Climate Change Fund of the Global Environmental Facility (SCCF/GEF) and executed by the United Nations Environment Programme (UNEP) Office for Latin America and the Caribbean to:

1. Mainstream urban ecosystem-based adaptation (EbA) into medium and long-term urban development planning.
2. Implement urban EbA interventions to reduce the vulnerability of local communities.
3. Build the knowledge and capacity of key stakeholders and raise awareness of urban EbA.

Jamaica is one of three countries in Latin America and the Caribbean to benefit from the CityAdapt Project, which targets select communities within Kingston and St. Andrew to increase climate resilience over the medium to long term through the integration of EbA in management and implementation of sustainable urban and peri-urban planning and design. Urban EbA is an approach that uses provisioning, regulating, and supporting ecosystem services as part of a holistic adaptation strategy in urban settings. One of the central aims of the urban EbA approach is to help vulnerable urban communities cope with extreme weather events and other climate change impacts while simultaneously supporting ecosystems to keep generating regulatory, carrier, production services that provide a range of benefits crucial for human well-being in cities and towns[1].

This training manual has been designed to build the capacity of public and private sector stakeholders who are involved in urban and peri-urban development, natural resources conservation, management and restoration, academia, and climate change adaptation. By building the capacity of these key stakeholders in the public and private sectors in ecosystems-based adaptation (EbA), with emphasis on urban and peri-urban ecosystems, projects and programmes being designed and implemented in urban and peri-urban spaces will be better able to use and harness EbA and ecosystem services as part of a strategy for reducing natural hazard risks and adapting to climate change. Importantly, it also will contribute to more sustainable patterns of urban development. Engaging with academia also will help to increase knowledge among students in EbA, thereby increasing the cadre of persons with this knowledge and capacity. The training programme also will explore how EbA solutions are a key climate change adaptation strategy for urban and peri-urban areas and necessary for building resilience of the people that reside in these areas. The training programme will incorporate case studies from other urban and peri-urban areas and illustrate how they are integrating conservation, management and where required, the

[1] Adapted from the CityAdapt, POLICY BRIEF Urban Ecosystem-based Adaptation in Asia-Pacific. Available at: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjg_cGQqLP6AhWIn4QIHaNiAscQFnoECBIQAQ&url=https%3A%2F%2Fcityadapt.com%2Fwp-content%2Fuploads%2F2021%2F07%2F1.-Urban-EbA_general.pdf&usg=AOvVaw25AOD2stOsSYlUPa2opfe7

restoration of ecosystems and degraded landscapes into a strategy for EbA for reducing the vulnerability of urban areas to natural hazards and the impacts associated with climate change.

Ecosystem-based adaptation can help to solve many of the challenges faced in urban areas such as those linked to rapid urbanization, undesirable levels of poverty, informal and squatter settlements, spatial fragmentation, and climate change. For instance, urban and peri-urban forests which include trees, and associated vegetation in and around urban areas, are nature-based solutions, providing several ecosystem services to urban areas, thereby contributing to more resilient, healthy, and vibrant urban communities. Urban forests for example can have a cooling effect in urban areas (which often have higher temperatures) by providing shade and through water evaporation from soil or transpiration from the trees and plants themselves. Climate change will likely increase the frequency and intensity of heat waves. Globally, heat waves are already having impacts on human health and older persons who reside in urban areas. Situations such as these call for governments, including local governments to support and develop adaptation strategies including EbA to solve many of the urban and peri-urban challenges associated with climate change.

Other ecosystems such as wetlands and mangroves can increase natural flood defences inland, acting as giant sponges to quickly “soak up” water from excess rainfall events that may be due to climate change, with these ecosystems being even more critical due to increasing developments which oftentimes increase water run-off as a result of these new impermeable spaces. Restoration of watersheds and reforestation can hold back desertification and recharge groundwater supplies providing access to potable water for urban residents; and rivers and streams provide natural drainage to reduce flooding.

Peri-urban areas also need ecosystem services to support, for example, the livelihoods of small fishers and farmers who in turn through activities such as peri-urban farming are able to provide food for urban populations.

The Learning Product

EbA for Urban and Peri-urban Spaces: Using Nature-Based Solutions as a Key Climate Change Adaptation Strategy for Advancing Sustainable Development in Jamaica

Course Description

This course, "**EbA for Urban and Peri-urban Spaces: Using Nature-Based Solutions as a Key Climate Change Adaptation Strategy for Advancing Sustainable Development in Jamaica"** has been designed to build the capacity and increase knowledge of the practical application of ecosystem-based solutions (EbA) in the context of a changing climate among public and private sector stakeholders that are working in the areas of ecosystems management and climate change, urban planning and development and natural resources management. The training programme explores how EbA is a key climate change adaptation strategy for urban and peri-urban areas and necessary for building resilience of the people that reside in these areas. It incorporates case studies from other urban and peri-urban areas and illustrates how these countries and urban and peri-urban spaces are integrating conservation, management and restoration of ecosystems and degraded landscapes towards reducing the vulnerability of urban areas to natural hazards and the impacts associated with climate change.

The training programme also is designed for academic institutions and will target lecturers from relevant faculties at the University of the West Indies, the University of Technology, Northern Caribbean University among others. The inclusion of academia is expected to allow for the institutionalization of the training programme as well as the mainstreaming of EbA into supporting existing courses at the universities, where this content may not already be included.

Participants of this training programme will be exposed to various topics including, environmental management, ecosystems in Jamaica, economic concepts and tools and techniques for undertaking natural resource valuation. The course content will be divided into four modules and will be delivered over a five-day period.

Target Group

The target group for this course will include:

- Professionals in the public and private sector who are involved in urban and peri-urban development, natural resources conservation, management and restoration, academia, and climate change adaptation.
- Faculty of tertiary level institutions that would be able to include EbA approaches into existing courses that they teach (e.g. faculty from the Geography Departments, Urban and Regional Planning, Spatial Planning, natural resource and environmental management etc.).

Course Objectives or Learning Outcomes

Upon completion of this course, participants will be able to:

Knowledge

- Understand the contribution of ecosystems and biodiversity to socio-economic development and the economic, social, and environmental benefits of EbA to sustainable development.
- Understand the importance and benefits of valuing natural resources and of incorporating NRV techniques in the management of Jamaica's natural resources.
- Understand the linkages between NRV and EbA.
- Understand the benefits of using EbA in urban and peri-urban spaces.
- Understand the rationale for incorporating EbA in development planning.
- Understand the linkages and relationships among EbA environmental conservation and management, disaster risk reduction and other climate change adaptation strategies.
- Understand the different EbA approaches and their application.
- Understand how EbA fits in with other tools of climate change adaptation.
- Understand the importance of mainstreaming and integrating EbA into national development and policy planning processes.

Performance

- Explain the importance of EbA for climate change adaptation and sustainable development.
- Be able to undertake at this broadest level the total economic value (TEV) of a natural resource using the defined steps.
- Know how to apply EbA in urban and peri-urban planning.
- Be able to apply the techniques of NRV to undertake the valuation of ecosystems.
- Know how to mainstream EbA in policy development processes and be able to identify the entry points for mainstreaming EbA.
- Be able to apply the techniques of NRV to undertake the valuation of ecosystems.

- Define the dynamics, components and requirements of urban and peri-urban resilience and sustainability, with reference to risks, vulnerability, and strategic management.
- Explain how EbA works, including the challenges, opportunities, and additional benefits beyond adaptation of securing healthy ecosystems.
- Analyze the benefits of peri-urban ecosystem for urban resilience and approaches to the application of EbA.
- Delineate linkages at various levels - sectoral, local, urban, rural, etc. for mainstreaming EbA into development planning.

Attitude

- Appreciate the importance of protecting and sustainably using natural resources alongside and as part of socio-economic development and other types of development, as a component of the pool of resources available for development.
- Appreciate EbA as a tool of climate change adaptation on par with other development tools and approaches.

Course Modules

This course is divided into five modules as follows:

Module 1 – Module 1: Jamaica's Multi-Hazard Environment and Setting the Context for Scaling up the Use of EbA in Jamaica

- Topic 1: Jamaica's Multi-Hazard Environment
- Topic 2: A Brief Analysis of Jamaica's Natural Hazard Landscape
- Topic 3: State of the Jamaica's Biodiversity and Ecosystems (Discussion)
- Topic 4: Climate Change and its Impacts
- Topic 5: Future climate change projections and scenarios for Jamaica
- Topic 6: Urban and peri-urban issues and challenges in Jamaica

Module 2 – Introduction to EbA

- Topic 1: Introducing EbA and
- Topic 2: Key Terms and Concepts related to EbA
- Topic 2: The Contribution of Ecosystems and Biodiversity to Socio-economic Development and Linkages with EbA
- Topic 3: Review of Ecosystem Services - Regulatory, Production, Information and Carrier Functions of Ecosystems and their Role in Disaster Risk Reduction and Climate Change Adaptation

- Topic 5: Using Ecosystems (mangroves, forests, watersheds, coral reefs, seagrass beds etc.) to Reduce Disaster Risks and Support Climate Change Adaptation in Urban and Peri-urban Communities
- Topic 6: The Economic, Social, and Environmental Benefits of EbA to Urban and Peri-urban Areas
- Topic 7: Ecosystem-based Adaptation Options in Urban Areas and Intended Outcomes
- Topic 8: What does Effective EbA Look Like

Module 3 – Practical Applications of EbA in Urban Planning and Design

- Topic 1: Practical application of EbA in urban and peri-urban planning, project design including review of case studies and cost benefit analysis as well as practical examples of the use of these EbA measures in urban and peri-urban spaces. Some of these include:
    - Urban Forests
    - Urban Farming
    - Open Green Spaces
    - Building Solutions
    - Green Corridors
    - Natural Inland Wetlands
    - Mangrove Forests among others
- Topic 2: Introduction to Cost Benefit Analysis for EBA

Module 4 - Creating the Enabling Environment for the Mainstreaming of EbA

- Topic 1: Mainstreaming and Integrating EbA in National Policy Development Processes and Project Design
- Topic 2: Mainstreaming Gender in EbA
- Topic 3: The Inclusion of Ecosystem-based Adaptation in Countries' National Adaptation Plans (Climate Change)
- Topic 4: Financing EbA

Module 5 – Natural Resource Valuation for EbA

- Topic 1: The Importance of Valuing Ecosystems – An Introduction to Natural Resource Valuation
- Topic 2: Linking NRV and EbA – The Importance
- Topic 2: A Review of Environmental Valuation Methods
- Topic 3: Introduction to Undertaking Total Economic Value (TEV) as a means of Assessing the Health of Ecosystem
- Topic 4: Undertaking the TEV of Forests, Watersheds, Coastal Resources, Mangrove Forests, Coral Reefs, etc.
- Topic 5: Introduction to Environmental Valuation Methods

Module 1: Jamaica's Multi-Hazard Environment and Setting the Context for Scaling up the Use of EbA in Jamaica

Overview of Module 1:

Module 1 is structured around 6 topics as follows:

- Topic 1: Jamaica's Multi-Hazard Environment
- Topic 2: A Brief Analysis of Jamaica's Natural Hazard Landscape
- Topic 3: State of the Jamaica's Biodiversity and Ecosystems (Discussion)
- Topic 4: Climate Change and its Impacts
- Topic 5: Future climate change projections and scenarios for Jamaica
- Topic 6: Urban and peri-urban issues and challenges in Jamaica

Objectives of Module 1:

At the end of this module, participants should be able to:

Describe	Jamaica's risk profile with respect to natural hazards
Share	Using examples, how climate change is impacting economic and social sectors in Jamaica
Examine	Trends in the occurrence of hazards, loss and damage
Define	EbA
Examine	Future climate change projections and scenarios and discuss the possible impacts on the country's developmental prospects
Describe	Urbanization, its causes and linkages with risks and resilience
Be	Able to identify urban and peri-urban challenges affecting Jamaica and some of the factors contributing to, or exacerbatng these challenges

Topic 1: Jamaica's Multi-Hazard Environment

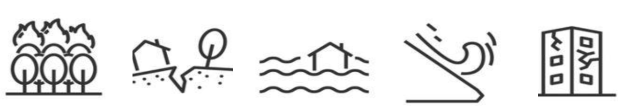
Table 1 below, adapted from the most recent classification of hazards by Sendai[2], shows the hazards that Jamaica is exposed to:

Natural Hazards	Manmade Hazards	Biological/Health Related Hazards
Meteorological and Hydrological: • Tropical cyclones (tropical storms and hurricanes) • Rainfall, including severe rainfall events • Lightning	**Chemical:** • Oil spills • Other Chemical Spills related to spills from industry that go on to	**Biological:** • Human disease outbreaks, epidemics, pandemics • Animal (livestock) and plant (agricultural) epidemics

[2] International Science Council and UNDRR, 2020. Hazard Definition and Classification Review: Technical Report.

Natural Hazards	Manmade Hazards	Biological/Health Related Hazards
• Extreme heat and increasing temperatures, sometimes causing spontaneous combustion resulting in forest/bush fires? • Floods • Drought • Sea-Level rise **Geohazards:** • Earthquakes • Tsunamis **Environmental:** • Land degradation • Coastal erosion • Soil erosion • Landslides (secondary natural hazard often compounded by man • Saharan dust • Alien invasive species (e.g., Sargassum, Lionfish) • Coastal inundation/flooding • Coral reef degradation	contaminate rivers and sometimes cause fish kills • Transboundary movement of hazardous materials/ wastes **Technological** • Road, aviation and marine and nautical accidents • Industrial accidents • Infrastructure failures • Aging infrastructure • Fires (bush and forest fires) **Societal:** • Fires • Crime and violence • Cybercrimes/cyber security • Societal unrest	• Other biological/physical hazards such as poisoning, eutrophication, air pollution, water pollution

Discussion



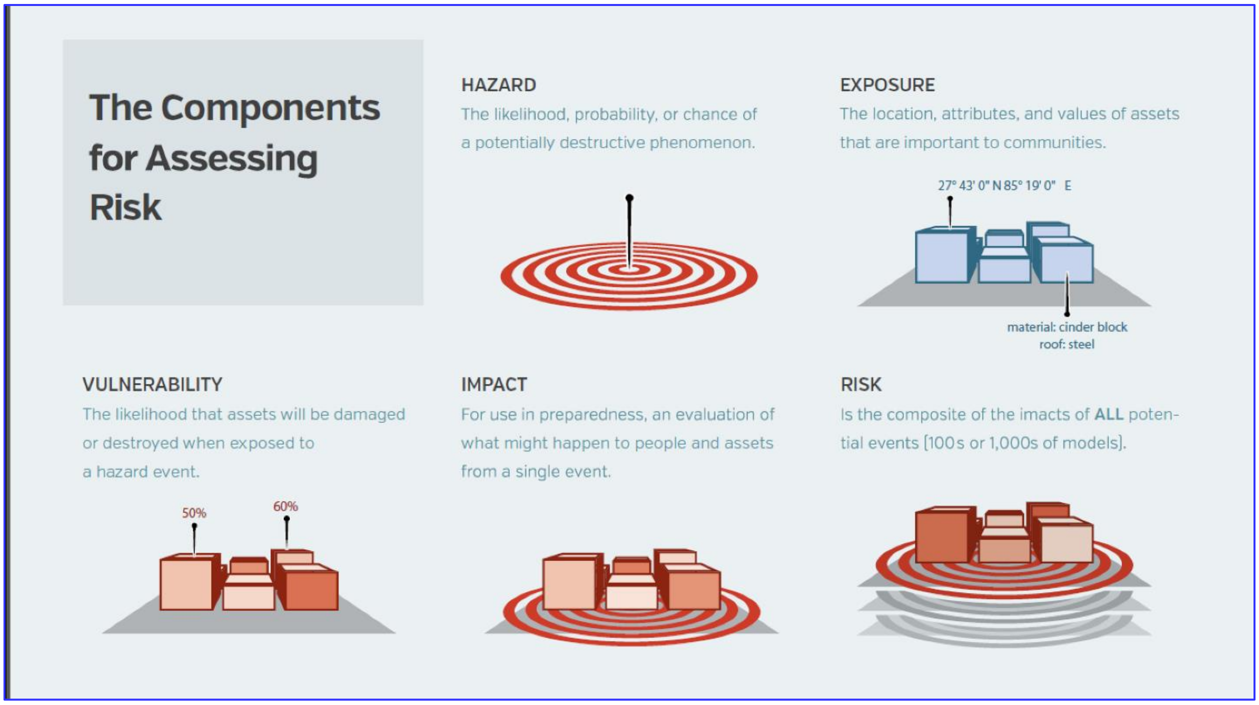
1. What are the different hazard types affecting Jamaica?
2. Consider how each hazard affects Jamaica according to economic impact (fiscal indicators such as debt-to-GDP), social impact (# of persons affected per 100,000, loss of lives etc.), environmental impacts (loss of ecosystem services)
3. Share the top 5 hazards affecting Jamaica

4. Discuss how climate change may be influencing the multi-hazard environment that Jamaica exists in

Topic 2: A Brief Analysis of Jamaica's Natural Hazard Landscape

Figure 1: A Community in Jamaica following Heavy Rainfall

The Key Components of Risk



- Risk is a function of three components—hazard, exposure, and vulnerability.
- **Hazard:** the likelihood and intensity of a potentially destructive natural phenomenon, such as ground shaking induced by an earthquake, wind speed associated with a tropical cyclone or rainfall volume from a rainfall event.
- **Exposure:** the location, attributes and value of assets that are important to various communities, such as people, buildings, factories, farmland, and infrastructure that are exposed to the hazard.

- **Vulnerability:** the reaction of the assets when exposed to the forces produced by a hazard event. For example, a building's vulnerability to an earthquake increases with the intensity of ground shaking and decreases with improved conformity to seismic design standards.
- Exposure and vulnerability, not just hazard levels, drive the scale and impacts of any hazard or a hazard becoming a disaster.

- Disaster risks are the potential disaster losses (in terms of lives, health status, livelihoods, assets and services) which could occur to a particular community or a society over some specified future time period (UNISDR, 2009 NB. Now called UNDRR).

- Disaster risk arises when hazards interact with physical, social, economic, and environmental vulnerabilities. For example:
  - Economic – Agriculture (fisheries, livestock, crops) tourism
  - Social- Education, health
  - Environmental - sensitivity of wetlands to increase salinity, land degradation, watershed degradation, loss of coral reef
  - Physical- poor design and construction of building, population density levels

- It is important to emphasize that exposure and vulnerability, not just hazard levels, drive the scale and impacts of any disaster

Discussion

- Based on the assessment of risk, have your responses to the top 5 hazards changed?

- What factors are driving vulnerability in Jamaica and the Caribbean?

Jamaica's Natural Hazard Risk Profile:

- Jamaica, like other small island and coastal states, is susceptible to a range of primary and secondary hazards which impacts the advancement of its developmental goals.

- Jamaica, like other Caribbean states, is highly exposed to extreme weather events and climate risks, and the island's location, geology, and geography - makes it highly exposed to several natural hazards including tropical cyclones (tropical storms and hurricanes), landslides, earthquakes, drought, floods, storm surges and tsunamis.

- The Global Facility for Disaster Reduction and Recovery (GDFRR) has cited Jamaica to be the third most exposed country in the world to multiple hazards, with over 96 per cent of the country's gross domestic product (GDP) and population at risk from two or more hazards (GDFRR, 2018).

- The country's exposure is attributed to its location in the Atlantic Hurricane Belt, the geophysical orientation of its low-lying coastal zones, and its mountainous topography.

- Jamaica's vulnerability is further exacerbated by its relatively long coastline and the large concentration of economic activity in its coastal zones. More than 60 per cent of the country's population live within 5Km of the coastline.

- Over the period 1999 – 2017[3] Jamaica was affected by 15 hydrometeorological events which resulted in 67 persons losing their lives.

[3] DaLA Reports (PIOJ and Ministry of Industry, Commerce, Agriculture and Fisheries)

- The associated economic costs of these 15 hydrometeorological events ranged from 0.1 per cent to 6.8 per cent of GDP.
- Hurricane risk is considered to be more significant than the earthquake risk for Jamaica, with average annual losses (AAL) from hurricanes estimated as being US$67.3 million (0.5 per cent of GDP) and from earthquakes US$36 million (0.3 per cent of GDP) (World Bank, 2016).
- Jamaica is particularly vulnerable to drought but also is impacted by excess rainfall events.
- Earthquake risk is a very prominent natural peril in Jamaica. Jamaica is located on the boundary of two main tectonic plates – the North American plate to the north and the Caribbean plate to the south, while Kingston is located in an area with a high concentration of local faults (Munich Re, 2019). The Earthquake Unit at the University of the West Indies (UWI) records more than 200 earthquakes each year on average being felt across the island. For example, in 2018, 286 earthquakes were recorded and in 2017, 279.

Some Impacts of Natural Hazard Events in Jamaica

- These natural events have impacts not only on the population but on almost all economic industries and sectors – tourism, agriculture, education, and health among others.
- Most of the island's critical economic and social assets including housing stock are located along the coast, increasing the vulnerability especially to hydro-meteorological hazards.
- The hazards over the years to which Jamaica has been exposed have had implications for public finance, increasing expenditure, reducing domestic revenue and in turn resulting in increased domestic and external borrowing.
- Table 1 below shows some selected hydrometeorological events and their impacts on the country's GDP[4].

Table 1 Selected Hydrometeorological Events and their Impact on GDP in Jamaica.

Natural Hazard Event	Year	Category Storm	Impact (% GDP)
Hurricane Michelle	2001	4	0.8
Excess Rainfall Event – May/June Flood Rains	2002		0.7
Hurricane Charley	2004	4	0.02
Hurricane Ivan	2004	3	8.0

[4] PIOJ. 2018. Assessing the Costs of Disasters on Jamaica's Infrastructure

Natural Hazard Event	Year	Category Storm	Impact (% GDP)
Hurricanes Dennis & Emily	2005	4	1.2
Hurricane Wilma	2005	5	0.7
Hurricane Dean	2007	4	3.4
Tropical Storm Gustav	2008		2.0
Tropical Storm Nicole	2010		1.9

Source: DaLA Reports (PIOJ and Ministry of Industry, Commerce, Agriculture and Fisheries)

- According to Moody's Analytics[5], among the 20 most vulnerable countries globally, more than half represent small island states across the Caribbean and Pacific Regions. These 20 countries bear average losses between 2.1% and 20.1% of their respective GDPs every year. The countries in the Caribbean that are referenced by Moody's include Belize, **Jamaica,** The Bahamas, and St. Vincent and the Grenadines.
- These events also caused damage to communities and infrastructure, injuries and in some cases loss of life. For example, Hurricane Sandy in 2012 resulted in 291 injuries and 1 death. Social sectors such as health and educational institutions as well as housing stock were impacted. In fact, 48.1 per cent of the total costs associated with that event can be attributed to damage to health, housing, and education sectors[6].
- Hurricane Ivan in 2004 exceeded US$350 million in damage and loss (MFPS, 2018).
- Tropical Cyclones Zeta and Eta in 2020 caused loss of lives and significant damage, particularly to the country's road network. Three discrete but significant rainfall events associated with these two storms occurred within a two-week period. The high levels of inundation which caused severe flooding and landslides in several parts of the country could be attributed to the fact that each of these rainfall events occurred within a short period of time of each other and that the country's ecosystems such as forests and watersheds are degraded in several areas and unable to carry out several vital functions that could reduce the impacts of these hazard events[7].
- Over the period 2018 to 2020, three lives were lost from climate related events[8].
- The World Bank's Country Risk Profile for Jamaica (2016) indicates that Jamaica has suffered significant losses from hurricanes, and goes on to state that if Hurricane Gilbert,

[5] Bahamas, Jamaica Among Most at Risk From Climate Change: Moody's. Available at: https://www.bloomberg.com/news/articles/2017-12-05/bahamas-jamaica-among-most-at-risk-from-climate-change-moody-s#xj4y7vzkg
[6] PIOJ. Vision 2030 Jamaica: Socio Economic Policy Framework 2018 – 2021.
[7] CCRIF SPC. Event Reports Tropical Cyclones Zeta and Eta in Jamaica. 2020
[8] PIOJ. 2022. Voluntary National Review on the SDGs to the UN High Level Political Forum

which struck Jamaica in 1988 were to happen in 2016, it would have caused a loss of US$1.3 billion, amounting to 9.6 per cent of the country's 2016 GDP9. Hurricane risk is considered to be more significant than earthquake risk for Jamaica, with average annual losses (AAL) from hurricanes estimated at US$67.3 million (0.5 per cent of GDP) and earthquakes US$36 million (0.3 per cent of GDP) (World Bank, 2016).

- Natural hazards also affect critical economic infrastructure such as bridges, roads, and vulnerable groups as well as economic sectors (e.g., agriculture and fisheries, construction, and tourism) and already degraded ecosystems.

Discussion

- How have these natural hazard events affected the work and budgets of your organizations?
- What new projects or programmes have been included in your strategic plans to reduce vulnerability and enhance resilience?
- Identify some of the underlying causes of vulnerability across key economic sectors – hazards and impacts

Topic 3: State of the Jamaica's Biodiversity and Ecosystems (Discussion)

Discussion topic – Evaluate each of the 20 statements below and suggest changes, or determine based on your areas of expertise the accuracy of the statements and provide examples and/or data where relevant.

1. Jamaica's main economic activities - tourism, mining, agriculture, and fishing - rely significantly on the country's rich natural resource-base.
2. Jamaica's natural capital is showing signs of degradation.
3. Jamaica's coral reefs are in decline with mean coral cover at 10-meter depth, declining to as low as 3%
4. The low coral cover is as a result of:
    a. Coral diseases
    b. Coral bleaching
    c. Storm/hurricane damage
    d. Excessive nutrients from sewage pollution
    e. Siltation and poor watershed management practices
    f. Over-fishing and indiscriminate fishing practices
    g. Inappropriate recreational practices
    h. Coastal pollution
    i. Death of sea urchins

[9] https://www.worldbank.org/en/news/press-release/2018/11/08/jamaica-champions-climate-and-financial-resilience-in-the-face-of-natural-disaster-risks

5. Jamaica's reefs are more degraded than the rest of the Caribbean.
6. Environmental challenges faced by Jamaica include - deteriorating air and water quality, poor management of solid, liquid and hazardous wastes, loss of biodiversity, watershed degradation and net loss of forest cover and increasing incidence of fires.
7. Coastal mangroves, wetlands and seagrass beds which provide breeding, feeding and nursery grounds for fish and shrimp face significant threats.
8. Several beaches on the western end of Jamaica could disappear in the next five to 10 years.
9. Beach erosion is a naturally occurring phenomenon but is being exacerbated by man-made factors and climate change.
10. Recreational coastal and marine water quality is influenced by several factors including the discharge of sewage and industrial effluent into the coastal and marine waters, non-point source discharges from agricultural activities, urban runoff and modifications of natural systems (including the destruction of wetlands), urbanization and the growth of informal settlements in coastal areas.
11. An estimated 30% of original mangrove forests in Jamaica have been lost. Coastal wetlands are increasingly threatened by infrastructure development and conversion from natural habitat to other uses.
12. Approximately 336,000 hectares (ha) or 30% of Jamaica is classified as forest. Within this area, 94% shows evidence of human disturbance.
13. About 35% of all forests, and over 73% of closed broadleaf forest are protected.
14. Most of the country's forest reserves are located in areas of rugged terrain such as the John Crow Mountains, Blue Mountains and Cockpit Country as well as the dry, hilly uplands in the south, west and northwest sections of the country.
15. Cockpit Country supports the largest number of globally threatened species of any key biodiversity area in the Caribbean Islands Hotspot.
16. Deforestation has led to the deterioration of more than a third of Jamaica's watersheds, drying up streams and rivers. Each of Jamaica's 26 watershed management units has portions considered to be degraded, while 10 of these units are considered severely degraded.
17. Jamaica is an important contributor to biodiversity in the Caribbean Basin, which has the fifth highest concentration of endemic species out of the eight "hottest hot spots" on Conservation International's list of biodiversity hot spots.

18. Seawater/saltwater intrusion of coastal aquifers is caused by over-pumping of the aquifer, pumping below sea level and poor well design. The intrusion caused by over-pumping of wells is common particularly near densely populated areas where the groundwater is oftentimes affected by improper or inadequate sewage disposal and wastewater treatment.
19. The quality of water found in many of Jamaica's rivers is threatened, due to overburdening with waste.
20. Discharges from the agricultural, industrial and mining sectors? also contribute significantly to water pollution.

Topic 4: Climate Change and its Impacts

- Climate Change changes the magnitude and frequency of extreme weather events.
- Climate Change changes average climatic conditions and climate variability, affecting underlying risk factors.
- Climate Change generates new threats, which a region may have no experience in dealing with.
- Climate-related risk is unique in character and irreversible, in that no technology that currently exists can prevent or end climate change.
- The Caribbean experience has shown that climate change is systemic, in that its materialization transforms the functioning of the entire economy.
- Climate change is impacting:
    - Sea level
    - Ecosystems
    - Public health
    - Agriculture
    - Water resources
    - The poor

- Impacts of Climate Change on Agriculture - Most of the world's population depends on agricultural activities. Impacts of climate change include:
    - Raising sea levels- increased potential for flooding of farmlands and salinity of ground water.
    - Amplifying extreme weather events- extreme weather events such as hurricanes and droughts.
    - Shifting climate zones towards the poles- average temperature are expected to increase more near the poles.
    - Reduced soil moisture- higher air temperature will cause higher soil temperature which will accelerate the decay of soil organic matter.

- Impacts of Climate Change on Tourism - Climate change could cause serious repercussions on the tourist industry through accelerated erosion and flooding causing:
    - Loss of beach
    - Loss of amenity value
    - Infrastructure damage
    - Structural damage to cruise ship ports
    - More intense weather activity destroying the coastal zone
    - Increased stress on coastal ecosystems from land-based sources of pollution, storm water run-off and siltation
    - Loss of coral reefs due to hurricanes and bleaching due to higher temperature

- Impacts of Climate Change on Water Resources - Climate change impacts on water resources include:
    - Alterations in regional precipitation and evaporation patterns.
    - Leaching and intrusion of salt water

Tabletop Discussion

- Can you provide examples of how climate change is impacting Jamaica?
- How do these impacts experienced by Jamaica compare with other SIDS?

Topic 5: Future Climate Change Projections and Scenarios for Jamaica

- Climate change is expected to increase the frequency and severity of hydrometeorological hazards – tropical cyclones and droughts as well as rainfall events. Small island states have been identified by the UNFCCC as among the most vulnerable to climate change, particularly the impacts from sea level rise and increased frequency and intensity of hurricanes. The anticipated impact of climate change on the Caribbean is highly disproportionate to the region's small contribution to global greenhouse gas emissions.

- Climate change is already adding to the severe and steadily worsening risk exposure, driven by factors such as topography, exposure to coastal hazards, economic significance of particularly vulnerable sectors, location, and degraded ecosystems.

- Whilst there is a reduction in losses of human lives, economic and non-economic costs (damage and losses) due to natural disasters continue to increase. People affected by disasters, their vulnerability and risks to multiple hazards are increasing.

- Climate change and variability, in combination with non-climate drivers such as deforestation, land degradation, have altered the country's ecosystem functions and agro-ecological systems thus affecting several sectors, as well as access to water both in terms of quantity and quality, livelihoods etc.

- In SIDS such as Jamaica where large sections of the population rely on natural resources (land for farming, sea for fishing etc.) for their livelihoods, it can be agreed that there are various climatic and non-climatic stressors that affect both the livelihood and surrounding natural resources. Climate change is one of the major causes of changes and deterioration in ecosystem services and its impact will most likely increase in the future. Noteworthy, functioning ecosystems help people and the natural world adapt to climate change effects.

- The Intergovernmental Panel on Climate Change (IPCC) has high confidence that the effects of climate change will intensify. This is supported by several other studies including reports out of The UWI Climate Studies Group Mona (CSGM) which articulate that Jamaica's temperatures will continue to get hotter, rainfall outside of the Hurricane Season will become more variable and less, hurricanes will likely be more intense and be accompanied by higher rainfall rates and increased maximum winds and sea level will continue to rise resulting in population displacement, loss of land, negative impacts to tourism and agriculture among others.

- The studies from the CSGM indicate a likely increase in the intensity of extreme weather events due to climate change and an increase in the Intensity of storms by 2.0 to 11.0 per cent with a shift in distribution toward higher wind speeds and potential damages[10].

- Impacts from natural hazards due to climate change will likely become greater, commensurate with growth in Jamaica's population and economy. As a result, the country

[10] PIOJ. 2022. Voluntary National Review on the SDGs to the UN High Level Political Forum

can expect extreme weather events to become more frequent and more intense and result in greater economic losses.

- On the revenue side, smaller economies like Jamaica's often have lower–than–expected revenue generation, consistent with other Latin America and Caribbean (LAC) countries. Low revenue generation, combined with the increased cost associated with the impacts of natural hazards, result in high levels of public debt for these small economies pushing them further away from advancing their sustainable development prospects.

- Economic modelling done to inform the development of Jamaica's Long-Term Low Carbon and Climate Resilient Strategy, shows that as climate change intensifies, the risks posed by different climate hazards will exacerbate Jamaica's economic vulnerability, particularly in coastal locations (World Bank, 2021).

- Globally, climate change is increasingly being linked to urban concerns as it exacerbates more risks in the infrastructure or resource deficit urban environments. Rapidly developing smaller cities, other urban centres and towns are becoming even more vulnerable to climate change impacts due to their limited infrastructural and institutional capacities, limited finances and fiscal space of municipalities.

Tabletop Discussion

- Based on the projections presented above, what are the implications for: economic sectors (tourism, agriculture, industry) and on people and infrastructure

Topic 6: Urban and Peri-Urban Issues and Challenges in Jamaica

- Jamaica is categorized as a Caribbean Small Island Developing State (SIDS) with a population of 2,726,0006[11], almost a quarter of which lives in the capital city, Kingston.

- The population of Kingston, St. Andrew and Portmore is 765,000, or 26 per cent of the population of Jamaica.[12]

- Overall, 52 per cent of the country's population lives in urban areas. Increasing urbanization, coupled with low levels of urban planning, puts urban and peri-urban areas at risk from the increasing frequency and intensity of natural hazards, especially hydrometeorological hazards exacerbated by climate change.

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[11] PIOJ. Economic and Social Survey of Jamaica, 2020

[12] Stimson Centre. 2020. CORVI Risk Profile Kingston Jamaica. Available at: https://www.stimson.org/2020/corvi-risk-profile-kingston-jamaica/

- The following table shows a profile of Kingston's Metropolitan Area (KMA) and Jamaica's Other Urban Centres, many of which can be assumed to form the immediate urban-rural interface in Jamaica.

Indicators/Characteristics	KMA	Other Urban Centres	Jamaica
Poverty (% of population)			
• 2018	9.2	12.0	12.6
• 2019	4.7	13.4	11.0
Food Poverty			
• 2018	2.9	3.9	3.5
• 2019	0.4	6.5	4.0
Safe and Affordable Drinking Water			
• 2018	98.3	89	
• 2019	98.4	87.2	
Access to Improved Adequate and Equitable Sanitation and Hygiene			
• 2018	91.8	81.4	81.5
• 2019	97.6	86.1	86.2

- The rapid, and oftentimes inadequate and poorly planned expansion of urban areas in developing countries such as Jamaica leaves urban populations exposed to the effects of natural hazards which are oftentimes exacerbated by climate change.

- Although several benefits have been derived from Jamaica's pattern of development, this development also has contributed to a myriad of challenges including:
    - fragmented subdivisions
    - unbalanced regional development,
    - urban sprawl,
    - limited availability of affordable housing,
    - squatting,
    - inequality and poverty,
    - environmental degradation,
    - congested towns due to the increasing dependence on automobiles for example[13].

- Urban sprawl for example, leads to further encroachment on the limited remaining natural areas. Also, in urban areas there are several impermeable surfaces covered in asphalt and concrete which impact hydrological processes by preventing the flow and absorption of rainwater into the ground and/or disturbing natural water courses which lead to flooding, lack of infiltration and limited or no replenishment of groundwater. Newer developments have begun to consider approaches to allow for some level of rainwater percolation in urban areas.

[13] PIOJ. Urban Planning and Regional Development Sector Plan (Revised 2018), under Vision 2030 Jamaica

- Climate change presents a significant challenge for urban systems – water and wastewater systems, infrastructure, among others.

Key Points for Discussion

- Where are Jamaica's urban and peri-urban areas (provide examples)?
- What are the implications of some of Jamaica's patterns of development presented above?
- Can you rank the issues and challenges presented above – from 1 to 5 with 5 being the best-case scenario?
- How is climate change contributing to these existing challenges in urban and peri-urban spaces?
- How is climate change exacerbating these challenges posed by the country's current pattern of development? Can you provide examples?
- What systems and mechanisms have been put in place in urban and peri-urban spaces to reduce current and future vulnerability? Any best practice examples

Case Study for Discussion: City Based Assessment and Risk Profile of Kingston

The Stimson Centre's city-based assessment[14] or risk profile of the threat posed by climate change to Kingston indicates that due to degraded ecosystems, Kingston is not able to fully capitalize on an array of ecosystems services provided by coral reefs, sea grass beds, and mangrove forests which impacts Kingston's ability to combat climate risks. It goes on to state that flooding after rainfall is worsened because of degraded watersheds surrounding the city and by poor waste management practices within the city.

https://www.stimson.org/2020/corvi-risk-profile-kingston-jamaica/

Presentation by Stimson Centre

- Urban resilience means adaptation to risks and their associated dynamics and business continuity coupled with sustained improvement towards meeting the development needs of the city/urban area, in the backdrop of climate change and other related risks that make up the multi-hazard risk environment.

[14] Stimson Centre. 2020. CORVI Risk Profile Kingston Jamaica. Available at: https://www.stimson.org/2020/corvi-risk-profile-kingston-jamaica/

Module 2: Introduction to EbA (Ecosystem-based Adaptation)

Overview of Module 2:

Module 2 is structured around 9 topics as follows:

- Topic 1: Introducing EbA
- Topic 2: The Contribution of Ecosystems and Biodiversity to Socio-economic Development and Linkages with EbA
- Topic 3: Review of Ecosystem Services - Regulatory, Production, Information and Carrier Functions of Ecosystems and their Role in Disaster Risk Reduction and Climate Change Adaptation
- Topic 4: Key Terms and Concepts related to EbA
- Topic 5: Using Ecosystems (mangroves, forests, watersheds, coral reefs, seagrass beds etc.) to Reduce Disaster Risks and Support Climate Change Adaptation in Urban and Peri-urban Communities
- Topic 6: The Economic, Social, and Environmental Benefits of EbA to Urban and Peri-urban Areas… Towards sustainable Development

- Topic 7: Advantages of EbA to urban and peri-urban planning and development and defining EbA for urban and peri-urban resilience
- Topic 8: Ecosystem-based Adaptation Options in Urban Areas and Intended Outcomes
- Topic 9: What does Effective EbA Look Like

Objectives of Module 2:

At the end of this module, participants should be able to:

Describe	The profile of urban and peri-urban areas and support provided by peri-urban areas to urban areas
Examine	The list of benefits - products and services - provided by the natural enivronment and ecosystems
Examine	Nature-based solutions and the linkages to climate change
Know	The different types of NbS and EbA approaches
Examine	The relationships among EbA, environmental conservation and management, disaster risk reduction and climate change adaptation
Explain	The characteristics of resilient cities
Understand	How ecosystems are key to social and economic development and the linkages among ecosystems, climate and hazard resilience and sustainable urban development
Understand	The linkages between EBA and EcoDRR

Topic 1: Introducing EbA

Ecosystem based adaptation (EbA) *uses biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative* effects of climate change *at local, national, regional and global levels*

- It is widely agreed that the conservation, rehabilitation, and management of biodiversity and ecosystems increases resilience to several natural hazards and climate change and has the potential to provide low-cost and long-term solutions to protect lives, livelihoods, and infrastructure.

- EbA is a subset of nature-based Solutions (NbS, also known as: Nature-based Approaches, NbA) and is an umbrella concept that includes Ecosystem-based Adaptation approaches to climate change (EbA) and to Disaster Risk Reduction (EcoDRR).

- EbA is 'the use of biodiversity and ecosystem services as part of an overall strategy to help people adapt to the adverse effects of climate change,'[15] as part of an overall adaptation strategy.
- Ecosystem-based adaptation represents a suite of cost-effective approaches to reduce the vulnerability of urban and peri-urban communities to climate change.
- EbA approaches involve among other things protecting, maintaining, and rehabilitating ecosystems such as wetlands, forests, and agroecological systems.
- EbA approaches also include activities such as reforestation, especially in urban poor communities.
- EbA can also be defined as a strategy for adapting to climate change that harnesses nature-based solutions and ecosystem services. For instance, protecting coastal habitats like mangroves provides natural flood defenses; reforestation can hold back desertification and recharge groundwater supplies in times of drought; and water bodies like rivers and lakes provide natural drainage to reduce flooding.[16]
- Since EbA focuses on the benefits humans derive from biodiversity and ecosystem services, and how these benefits can be used in the face of climate change, it is characterized as a people-centric concept. "Hybrid solutions" include a range of 'green-grey' measures, e.g. mangrove restoration combined with the construction of a dyke, to 'green-brown' measures, using a combination of classical EbA with the use of natural material, instead of grey, e.g. cut bamboo stilts, or earth dams.
- EbA is an increasingly popular and tested strategy for addressing the linked challenges of climate change and poverty in developing countries, where people are more dependent on natural resources for their lives and livelihoods.
- EbA is the use of natural capital by people to adapt to climate change impacts, which can also have multiple co-benefits for mitigation, protection of livelihoods and poverty alleviation
- EbA options increase the resilience and capacity of selected ecosystems to naturally adapt to changes, including climate induced changes, over time.

[15] https://wedocs.unep.org/bitstream/handle/20.500.11822/28174/EBA1.pdf?sequence=1&isAllowed=y
[16] https://www.unep.org/explore-topics/climate-action/what-we-do/climate-adaptation/ecosystem-based-adaptation

- Effective EbA is where ecosystem-based approaches replace or augment conventional adaptation approaches to deliver superior outcomes for people and communities.

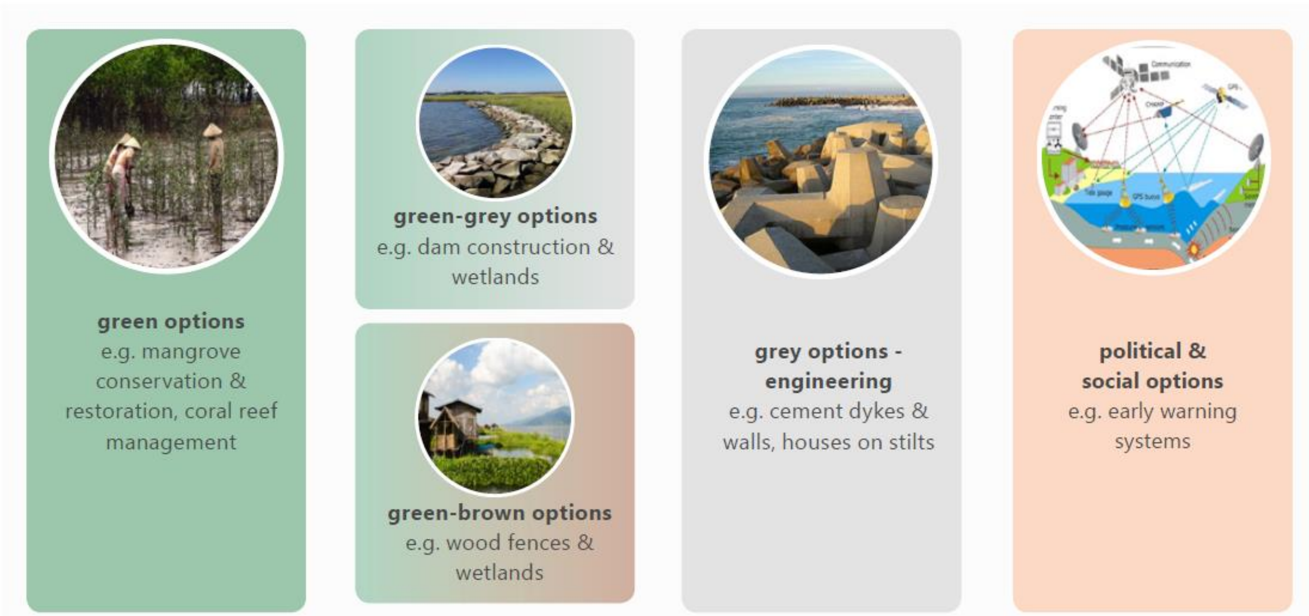


Figure 2: Strategies for Climate Change Adaptation

Topic 2: The Contribution of Ecosystems and Biodiversity to Socio-economic Development and Linkages with EbA

- Environmental quality is inextricably linked to economic and social well-being, as a healthy environment – able to carry out its functions unencumbered – contributes to social and economic development as natural resources and ecosystems provide a range of goods and services.

- The list of benefits provided by nature is vast. Ecosystems provide food, fresh water, climate and flood regulation, and recreational and aesthetic enjoyment. Forests store carbon, provide timber and other valuable products as well as habitat to a wide array of species. Wetlands purify water, offer protection against floods, produce oxygen, store carbon dioxide, and help to regulate climate. Mangroves protect coasts and coastal populations from storms and tsunamis. Coral reefs provide breeding grounds for fish and attractions for tourists. Rivers provide fish, water and facilities for recreation and also other ecosystem functions such as holding and circulating water.

- A healthy environment and its associated ecosystems provide services such as nutrient cycling, flood control, climate control, soil productivity, forest health, pollination services, waste assimilation and natural pest control among others.

- Environmental well-being contributes to economic well-being when the environment is able to properly carry out its functions. The economic benefits of healthy functioning ecological services, nutrient cycling, flood control, climate control, soil productivity, forest health, pollination and natural pest control underpin the everyday functioning of the environment and many jobs.

- Economic activity itself does not present a threat to the environment. It is the speed and scale of this economic activity which presents a threat to the integrity of the environmental support system that underpins economic activity.

- While economic activity is essential for the provision of human well-being, economic activity that does not take into account its effect on the environment through the overexploitation of materials and the unmanaged generation of wastes, will ultimately not only endanger further economic activity, but will result in negative impacts to human economic and social well-being.

- The concept of sustainability has been described as living off the interest of natural capital without harming the principal. The greatest threats to ecosystems are the conversion of land and water habitats for agricultural uses or their destruction by over-harvesting; how we produce human food, animal feed, and fiber will largely determine the preservation of biodiversity and ecosystems.

- The Linkages in a Nutshell:
    - Ecosystem-based adaptation (EbA) is the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change as part of an overall adaptation strategy.

Case Example: Environmental Services Vital to Agriculture

Environmental services vital to agriculture include:

- Soil Forming and Conditioning – Invertebrates develop upper soil layers through decomposition of plant matter, making organic matter more readily available, and creating structural conditions that allow oxygen, food and water to circulate.

- Waste Disposal – Ecosystems recycle, detoxify and purify themselves, provided that their carrying capacity is not exceeded by excessive amounts of waste and by the introduction of persistent (synthetic) contaminants. (Nutrient filtering by mangroves can be likened to oxidation ponds of traditional wastewater treatment plants).

- Pest Control – Predator-prey populations create a self-regulating balance, whereby biological (inter-species) competition keeps more pests in check than could ever be accomplished through the use of pesticides.

- Biodiversity – Ecosystem stability depends on the results of competition between different species for food and space. It is this competition that increases species diversity.

- Pollination – 220,000 out of 240,000 species of flowering plants are pollinated by insects.
- Carbon Sequestration – Because biomass has the capacity to store carbon, where the soil is not tilled, or where minimum tillage is practiced, soil contributes to carbon retention.
- Habitat – The provision of space, shelter, and food for many important macro- and microorganisms, such as earthworms.

Case Example: The Importance of Pollination

Pollination by animal vectors is required for the reproduction of many flowering plants. About 220,000 out of an estimated 240,000 species of plants for which the mode of pollination has been recorded require an animal such as a bee or a hummingbird to accomplish this task. This 220,000 plant species include both wild plants and about 70 per cent of the agricultural crop species that feed the world. Over 100,000 different animal species (bats, bees, beetles, birds, flies, butterflies etc.) are known to provide these free pollination services that assure the perpetuation of plants in croplands, meadows, forests etc. Pollination services offered by nature refers to contributions made to crop seeds, fruit and fibre as a result of effective pollination of flowers by animal vectors.

Pollinators are essential to the protection of plant populations. In instances where pollinators are threatened, the plants that depend on these pollinators may become threatened as well. Even cultivated food crops can benefit from pollination by wild and managed animals.

Key Points for Discussion

- The diversity of nature not only offers man a vast power of choice for his current needs and desires. It also enhances the role of nature as a source of solutions for the future needs and challenges of mankind. Your thoughts.

Topic 3: Review of Ecosystem Services - Regulatory, Production, Information and Carrier Functions of Ecosystems and their Role in Disaster Risk Reduction and Climate Change Adaptation

- 4 functions of the natural environment
  - Regulatory functions
  - Carrier functions
  - Production functions
  - Information functions
- The regulatory functions of the natural environment refer to the capacity of the environment to regulate ecological processes and life support systems, thereby providing and maintaining a healthy environment. Regulatory functions include:
  - Protection against harmful cosmic influences (especially ultraviolet rays)
  - Maintenance of bio-geochemical cycles (biospheric balance)

  - Regulation of the local and global climate
  - Regulation of run-off and flood prevention (watershed protection)
  - Recharging water catchment and ground water
  - Prevention of soil erosion and sediment control
  - Formation of topsoil and maintenance of soil fertility
  - Production of biomass and fixation of solar energy
  - Storage and recycling of nutrients
  - Storage and recycling of organic matter
  - Storage and recycling of human wastes
  - Pollution control
  - Maintenance of biological control mechanisms
  - Maintenance of migration and nursery habitats
  - Maintenance of genetic and biological diversity
  - Seed dispersal
  - Pollination
- The carrier or supporting function of the natural environment refers to the ability of the natural environment to provide the space and suitable substrate necessary for human activities. Carrier functions include:
  - Natural habitats
  - Recreation and tourism
  - Cultivation
  - Energy conversion
  - Human habitation/settlements
  - Infrastructure
  - Military defence
  - Other uses of environmental space
- Production functions (provisioning) of the natural environment refers the resources supplied by the environment – including organisms and their parts and products that grow in the wild but can be used directly for human benefit. Many of the products of the natural environment can be traded in economic markets. For example, the annual world fish catch is approximately 100 million metric tonnes and is valued at between US$50 billion to US$100 billion.

- The natural environment also produces vegetation which is used directly by humans for food, fuelwood, fibre, pharmaceuticals and industrial products. Approximately 15% of the world's energy consumption is supplied by fuelwood and other plant material. In developing countries this biomass provides about 40% of energy consumption. In addition, natural products are extracted from many hundreds of species and contribute diverse inputs to many industries – gums, essential oils and flavourings, resins and oleoresins, dyes, tannins, vegetable fats, waxes, insecticides, etc. Products from the environment include:
  - Oxygen
  - Water
  - Food

  - Genetic resources
  - Medicinal resources
  - Ornamental resources
  - Raw materials for clothing, construction and industrial use, etc.
  - Fuel and energy
  - Fodder and fertilizer
- The information function or cultural function of the natural environment focuses, to a large extent, on the capacity of the environment to maintain mental sanity by providing areas for recreational and relaxing activities. For many, nature is a source of inspiration, peace and rejuvenation. Information functions include:
  - Aesthetic
  - Spiritual and religious information
  - Historic information (heritage value)
  - Cultural and artistic inspiration
  - Scientific and educational

- Ecosystem services are also important in reducing social, economic and health-related vulnerabilities.
- A decline in ecosystem services impacts the resources available to people and communities which can lead to increased vulnerability to hazards and decrease in resilience.
- Ecosystems that offer nature-based solutions (NBS) also known as green infrastructure may help reduce the risks of grey infrastructure and serve as livelihood support systems for communities and entrepreneurs.
- Peri-urban ecosystems provide resources, buffers and capacities that help reduce vulnerability in urban areas.
- It is important that policy makers mainstream peri-urban ecosystem-based opportunities into development and spatial planning, policies, and other key activities being undertaken by government, businesses, and communities.

Ecosystems Support to Disaster Risk Reduction – Some Examples

Ecosystem	Main Services and Functions	The Cost to Society of Degraded Ecosystems	State of the Ecosystem in Jamaica
Watersheds	• Recharging water catchment and groundwater • Formation of topsoil and sediment control	• Increased land degradation and reduced capacity for agricultural production • Loss of topsoil, causing Reduced productivity of land,	

Ecosystem	Main Services and Functions	The Cost to Society of Degraded Ecosystems	State of the Ecosystem in Jamaica
	• Regulation of run-off and flood prevention	increased siltation of rivers and reservoirs due to soil erosion • Reductions in the flow of rivers and increased flooding • Siltation causing reduced storage capacity of reservoirs and dams • Reduction in water quality and quantity (availability) • Higher bill payments for treatment of water due to increased energy consumption • Increased marine and coastal contamination and degradation that adversely affects the tourism industry • Loss of habitat for flora and fauna as well as loss of biodiversity	
Wetlands	• Flood control • Groundwater replenishment • Shoreline stabilization and storm protection • Sediment and nutrient restoration and export • Water purification • Reservoirs of biodiversity • Recreation and tourism • Reservoir of genes	• Reduction in frontline defence (wind action, wave action and currents) against incoming tropical cyclones (storms and hurricanes), that can then result in damage through flooding and direct destruction of property and even loss of life • Loss of fish and shellfish dependent on wetlands as spawning grounds • Habitat loss for many species of plants and animals and also loss of biodiversity, • Flooding • Land erosion • Loss of materials for construction, fishing and craft	

Ecosystem	Main Services and Functions	The Cost to Society of Degraded Ecosystems	State of the Ecosystem in Jamaica
		• Loss of water purification services – as wetlands play a significant role in purifying water. High levels of nutrients such as phosphorous and nitrogen, commonly associated with agricultural run-off, are effectively removed by wetlands. This is important in preventing eutrophication further downstream, a process that leads to rapid plant and algal growth followed by depleted oxygen levels that affect other species.	

Topic 4: Key Terms and Concepts related to EbA

Terms to explored in this section includes:

- Urban and Peri-Urban Areas
- Nature-based Solutions
- EbA for Climate Change Adaptation
- Green Infrastructure
- Blue-Green Infrastructure
- Green-Grey Infrastructure
- Resilience
- Resilient Cities
- Ecosystem-based Disaster Risk Reduction
- Exposure
- Risk
- Vulnerability

Urban and Peri-Urban Areas

- The symbiotic relationship of urban and peri-urban areas and their systems form the backdrop in understanding urban carrying capacities and in accounting for their supportive and assimilative strengths.

- Urbanization is synonymous with modern age development. Urbanization results in altering the natural environment and ecosystems and ideally should consider sustainability principles to ensure the overall well-being of city systems.

- Profile/Characteristics of Urban Areas
    - Engines of economic growth and economic hubs
    - Are able to provide opportunities for people and business
    - Dense habitation, infrastructure, businesses, and fast-paced human activities
    - Has increasing demands for services and goods – water-energy-food nexus
    - Contribute to climate change through greenhouse gas emissions
    - Susceptible to the effects of climate change and its effects and climate change is increasingly linked to urban concerns as it exacerbates more risks to infrastructure, people and communities
    - Many environmental and biogeochemical challenges exist within the urban landscape such as stormwater runoff and flood risk, chemical and particulate pollution of urban air, soil and water, urban heat island, and summer heatwaves.
    - Cities, which are rapidly urbanizing and experiencing unplanned development leads to a significant decline in ecosystems and resilient capacities of city systems.

- Urban ecosystems include green infrastructure in cities, such as parks or gardens, as well as natural areas immediately surrounding urban centres, such as wetlands or forests. They help to regulate run-off and water flows, and provide services important to human health, such as air purification, noise reduction, urban cooling, and mental health benefits.

- Peri-urban areas are considered as transitional zones from rural to urban regions and represent a wide range of uses, such as water catchments, forestry, recreation, productive farming, and offer a unique ambience and lifestyle. Industrial agglomerations, waste treatment plants, recycling, warehouses, agriculture-markets, labour market, goods transit, transportation yards, ecotourism, and several other businesses are common in peri-urban areas.

- Generally, peri-urban is neither geographically nor conceptually well-defined and consists of complex hybrid systems blending the essence of urban and rural communities.

- A peri-urban area is an ever-changing zone of both interaction and transition due to its geographic location at a city's edge where complex socio-economic processes take place.

- A Peri-urban ecosystem is a fast-changing, semi-natural ecosystem, which provides natural resources for growing cities in terms of water bodies, open and green lands, and orchards. Located between the outer limits of urban and regional centres and the rural environment; peri-urban ecosystem provides a range of services, such as water catchments, forestry, recreation, and productive farming, as well as offering a unique ambience and lifestyle.

- Peri-urban ecosystems provide resources, buffers and capacities that help reduce vulnerability in urban areas. As such, it is important to mainstream peri-urban ecosystem-based opportunities into development policies, planning and actions.

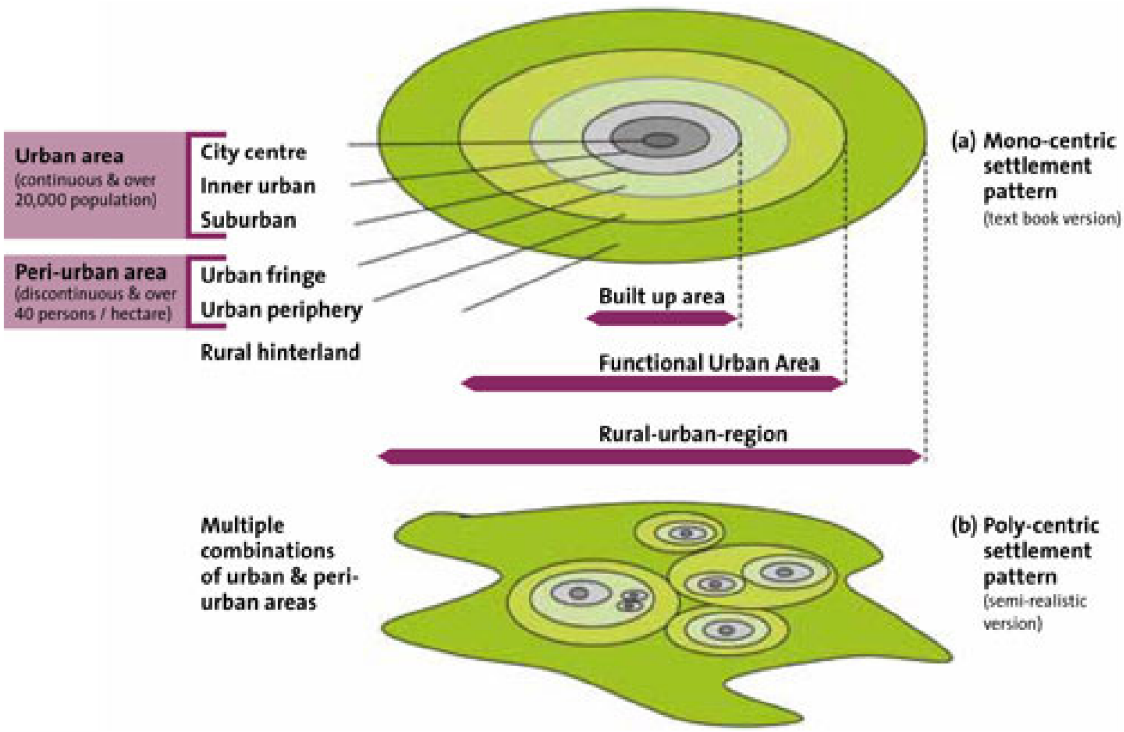
- In pursuing urban resilience there is need to recognize the role of ecosystems, particularly those in the peri-urban areas. Resilience in peri-urban areas is crucial for a city's functioning, input-output support systems and managing urban resilience and sustainability.

- Peri-urban areas serve the cities through supporting capacities - ecosystem services, rural-urban connect and input-output systems- and assimilating capacities towards urban discharge and waste.

- Examples of urban and peri-urban ecosystems include urban trees and biodiversity parks, plantations, nurseries, urban agriculture, wetlands, rivers, etc., but small-scale ecological practices like home gardens, green rooftop, etc. can also be defined as urban and peri-urban ecosystems.

- People living in peri-urban areas are generally poor and marginalized and largely depend on wage-earning opportunities in urban areas and primary production-based livelihood (agriculture, aquaculture, orchards, horticulture, etc.) which are sensitive to climate change impacts.

- The outward expansion of cities and urban centres, changes in land use patterns and occupations have transformed the rural hinterland into semi-urban areas. Inhabitants in these peri-urban regions are highly vulnerable and increasingly threatened by the deteriorating quality of ecosystems leading to resource scarcity and a host of other problems.



Source: Piorr et al., 2011

Figure 3: An Example of Peri-Urban Sprawl in Europe

Support Provided by Peri-Urban Areas to Urban Areas

- Ecosystems provide a multitude of physical and environmental services to cities and their residents which also help in enhancing the city's resilience.

- However, the cities, which are rapidly urbanizing, expanding and experiencing unplanned development is leading to a threatening decline in ecosystems services, which in turn affects not only the livelihoods of those directly dependent on it but also the resilience and sustainability of cities and surrounding peri-urban ecosystems.

- The functions of peri-urban ecosystems include among others:

Ecosystem Services	Description
Peri-urban agriculture and good security	• Agriculture services provided by peri-urban areas play a varied role in urban sustainability as well as resilience, ranging from food security to disaster management. • Urban and peri-urban agriculture, particularly in developing countries, play a crucial role in diversifying urban diets and providing environmental services in urban and peri-urban areas (Nambi et al., 2014). • Conversion of agricultural spaces in the peri-urban regions impacts the city adversely and lack of policy framework for peri-urban agriculture impacts urban locales and marginalized and vulnerable groups.
Water security	• Water is usually conveyed from the nearest source to the city (for example from St. Thomas to Kingston), with peri-urban ecosystems playing a vital role in providing cities with drinking water as they ensure flow, storage and purification of water (TEEB, 2011). • Healthy watersheds ensure both water quality and quantity to meet the needs of urban areas. • Healthy vegetation and green spaces in the city vicinity influence the quantity of water availability.
Energy security	• Peri-urban areas can be the location of cogeneration and waste-to-energy plants at the edge of the urban areas which allows a convenient and efficient energy transmission to the consumers and at the same time does not affect densely populated areas.
Health security	• Peri-urban ecosystem provide various health benefits including air purification, noise reduction, urban temperature regulation, etc. • Air pollution from domestic heat, industries, transportation and solid waste burning affects environmental quality and human health in cities. • Vegetation and green spaces help in removing pollutants from the atmosphere and thus improve the air quality of the region. • Trees and soils help in reducing stress-causing noise pollution from heavy traffic, construction works and other human activities through absorption, deviation, reflection and refraction of sound.
Economic security	• Urban and peri-urban agriculture provides food and nutritional security, enhances livelihoods security for urban and rural poor.

Ecosystem Services	Description
	• For marginalized communities, agriculture forms a key part of diverse livelihood strategies such as a source of income from selling products or as employment.

Loss of Ecosystem Services in Urban and Peri-Urban Areas

- Peri-urban ecosystems are becoming increasingly at risk of environmental degradation and loss of ecosystems goods and services as consumption and waste in peri-urban areas increase due to rapid urbanization and increasing human activity. These ecosystem services are key to supporting urban and peri-urban populations, and include:

Ecosystem Service	Loss of Service as a Result of:
Provision of water	• Pollution of rivers destroys accessible sources of surface water • Dumping of sewage and solid/liquid waste in peri-urban areas contaminates groundwater • Population growth increases the demand for water supply, and water tables drop as underground aquifers do nor recharge at the same rate as use • Population growth is exerting stress on both surface as well as groundwater and this stress will aggravate with changing climate and unplanned urbanization. • Policies related to water conservation are key to ensure the overall conservation of water resources • Land conversion including concretization by real estate developers are destroying the natural recharge zone of aquifers.
Flood buffers	• Construction on open spaces/green belts prevent natural drainage and exacerbate floods, with acute waterlogging and floods compounding the risk of property damage
Waste assimilation and treatment	• Infilling and destruction of wetlands undermine the ability of the ecosystem to filter refuse • Effluents from peri-urban industry, excessive untreated human waste, and garbage pollute the remaining waterways/wetlands

Ecosystem Service	Loss of Service as a Result of:
Food production	• Expansion of the urban fringe, industry and housing developments (both formal and informal) replace productive agricultural land, which often displaces small farmers and can lead to lower volumes of food production and higher food prices, particularly in cities that are highly dependent on nearby agricultural supply.
Climate and air quality regulation	• The clearing of vegetation slows the process of filtering toxic compounds from the local atmosphere. Peri-urban land supports green vegetation cover that absorbs air pollution and ambient heat. As landscapes that used to be permeable and shady become dry and solid, a "heat island" effect can occur, leading to higher temperatures in a region.

- Persons living in peri-urban ecosystems are vulnerable and increasingly threatened by the deteriorating quality of the ecosystem leading to resource scarcity and a host of other problems.

- The poor are disproportionately affected by the loss of peri-urban ecosystems due to their propensity to live in peri-urban areas, their high ecosystem dependence and the economic impacts of land-use changes. The economic impacts of land-use change are disproportionately absorbed by the poor, small scale farmers and fishers, women, and children especially those that are directly involved in peri-urban agricultural activities.

- The destruction of peri-urban ecosystems has a disproportionate impact on the poor, small scale fishers and farmers, and women, as they are less likely to have an alternative source of food, nutrition or income.

- The impacts of unplanned or poorly planned urbanization coupled with extremes of climate change and environmental degradation are not the same for all peri-urban residents as noted above. These groups are disproportionately affected by the decline of peri-urban ecosystems due to their propensity to live in peri-urban areas, and their high dependence on ecosystem services.

Tabletop Discussion/Group Exercise

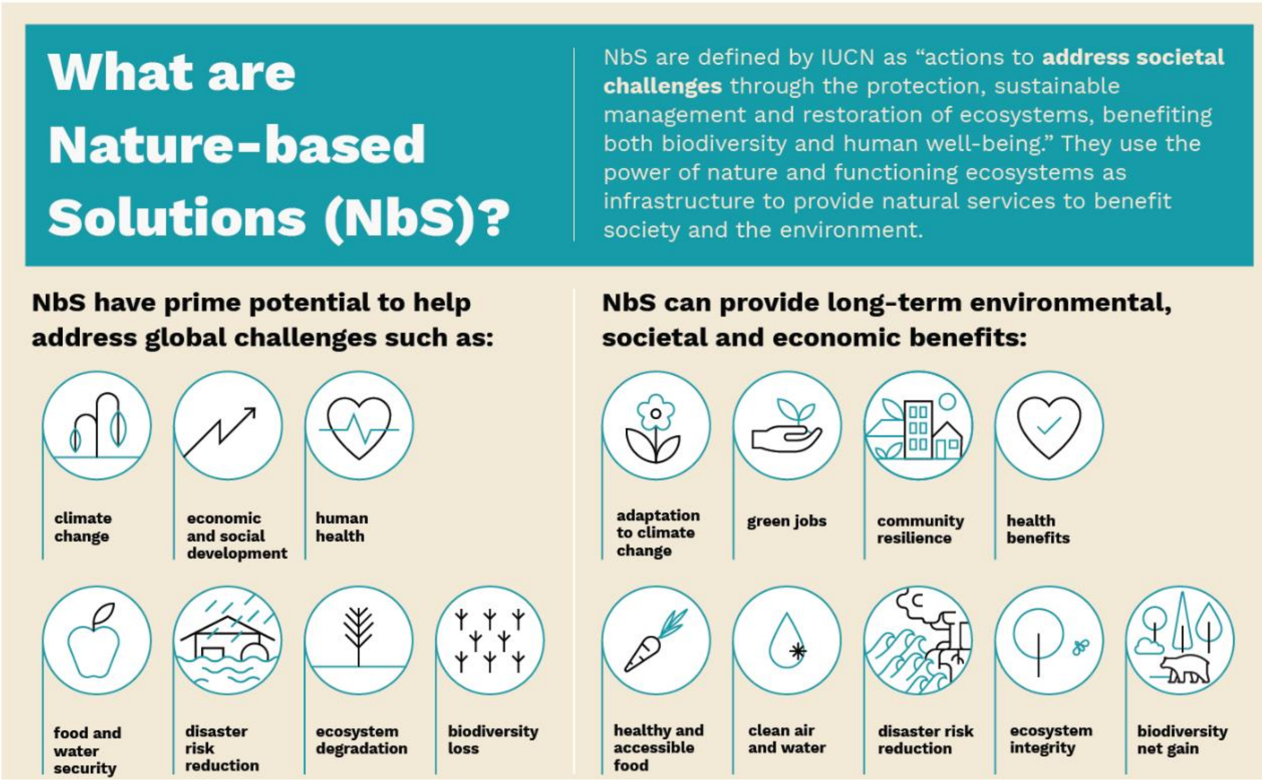
- List some of the vulnerable groups in Jamaica and specifically in peri-urban spaces
- Identify and assess some of the needs of communities living in and/or dependent on peri-urban ecosystems in Jamaica.
- What are some of the impacts of unplanned urbanization and changing climate on the identified vulnerable communities?
- Can you suggest some climate-resilient livelihood strategies for vulnerable communities in Jamaica, making reference to these communities?

Examples of EbA in Five Ecosystems

CLIMATE CHANGE IMPACT TARGETED	EBA MEASURE	ELEMENTS OF OUTCOME INDICATORS
Wetlands: Flooding and increased invasive species resulting from extreme rainfall, raising temperatures and increasingly frequent and severe storms	Wetland rehabilitation to reduce flood damage, enable groundwater recharge, improve water quality, and enhance food and income security	Frequency and severity of floods Measures of flood damage Agricultural yields and income
	Wetland protection to encourage growth of spawning nursery grounds and allow vegetation regeneration for flood protection	Measures of species abundance and diversity Measures of water quality Frequency and severity of floods Measures of flood damage Agricultural yields and income
Mountains: Flooding and sediment deposition resulting from extreme rainfall, rainfall variability and increasingly frequent and severe storms	Riparian reforestation/rehabilitation along riverbanks to slow runoff and capture sediment before it reaches the watercourse, thus limiting downstream damage to property and livelihoods	Frequency and severity of floods Sediment load Measures of flood damage (to infrastructure, households, crops)
Drylands: Drought, desertification and soil erosion due to increasing temperatures, reduced and more variable rainfall, and increasingly frequent, severe wind and sand storms	Establishment of a multi-use desert Green Belt to increase water availability, improve soil quality, provide shade and windbreaks, thus improving food and income security	Extent of protective vegetation cover Measures of wind/sandstorm impact Measures of soil quality Water availability Agricultural yields and income (home consumption and market)
Urban: Flooding and soil erosion resulting from extreme rainfall and increasingly frequent and severe storms	Urban reforestation to slow runoff and stabilize soil, thus protecting infrastructure and buildings from flooding, undermining and siltation	Frequency and severity of floods Measures of soil erosion Measures of flood damage to infrastructure and buildings
Coasts: Sea level rise, flooding, coastal erosion and saline intrusion resulting from rising temperatures and increasingly frequent and severe storm surges	Mangrove restoration/ rehabilitation to reduce wave energy, erosion and storm surge water levels, thus limiting coastal flooding, saline intrusion and damage to property and livelihoods	Extent of coastal erosion Frequency and severity of floods Salinity levels in groundwater and farmlands Agricultural yields and income Measures of flood/storm damage

Source: Ecosystem-based Adaptation Briefing Note Series (UNEP 2019)

Nature-based Solutions



- Eba is a subset of nature-based solutions (NbS).
- Nature-based Solutions or Nature-based Approaches is an umbrella concept that includes Ecosystem-based Adaptation approaches to climate change (EbA) and to Disaster Risk Reduction (EcoDRR). It is essentially an umbrella term and conceptual framework for ecosystem-related approaches.
- NbS goes beyond the traditional biodiversity conservation and management principles.
- NbS supports the achievement of a country's development goals such as those related to food security, disaster risk reduction, access to clean water, or health benefits.
- Processes of NBS may involve stormwater infiltration and evapotranspiration.
- Approaches to NBS include restoration, issue-specific, infrastructure, management and protection. NbS addresses several societal challenges and contributes to human wellbeing and conservation and protection of biodiversity as well as environmental sustainability.

- Approaches to NBS and some examples are presented in the table below.

NbS Approaches	Examples
Ecosystem restoration approaches	• Ecological restoration • Ecological Engineering • Forest landscape restoration
Issue-specific ecosystem-related approaches	• Ecosystem-based adaptation • Ecosystem-based mitigation • Climate adaptation services • Ecosystem-based disaster risk reduction
Infrastructure-related approaches	• Natural infrastructure • Green infrastructure
Ecosystem-based management approaches	• Integrated coastal zone management • Integrated water resources management
Ecosystem protection approaches	• Area-based conservation approaches, including protected area management

- Nature-based solutions for urban resilience can be applied across spatial scales and settings in and around cities.

EBA for Climate Change Adaptation

- Climate change impacts such as increased rainfall intensity, storm surges, flooding and urban heat island effects will affect urban systems and the populations and services they support. Adaptation will be required to cope with these effects.

- Some examples of climate change adaptation strategies for urban and peri-urban areas:
    - Agriculture innovation: Peri-urban areas can be a catalyst for agricultural innovation and water resources management, and hence, proper management can be a win-win situation to both, i.e., urban communities as well as rural communities on the city fringes.
    - Green infrastructure, green spaces and resource efficiency: a network of interconnected green spaces that serves as an infrastructure (similar to electricity, water infrastructure) providing ecological services of climate resilience, disaster risk reduction, wildlife conservation and resource preservation.
    - Valuation of ecosystem services to help mainstream strategies for peri-urban ecosystems and resilience into planning, policies, laws and programmes.

Green Infrastructure (GI)

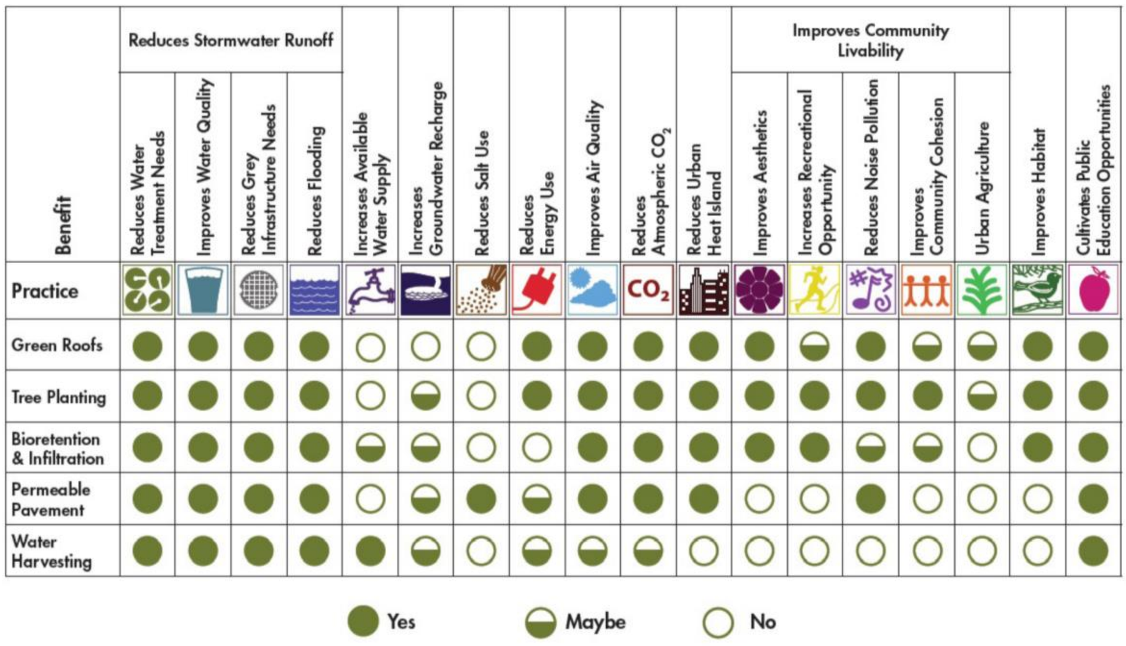
- Green infrastructure focuses on ecology and the provision of ecosystem services in cities.

- Green infrastructure, also is defined as vegetation systems intentionally designed to promote environmental quality, can reduce the intensity of heat islands by providing shade and evapotranspiration cooling.

- GI also include rivers, wetlands and lakes and also green roofs and green walls, etc. GI is therefore multifunctional.

- Benefits of green infrastructure include:
    - Health and well-being: Increasing life expectancy and reducing health inequality; improving levels of physical activity and health; improving psychological health and mental well-being.
    - Climate change: Heat amelioration; reducing flood risk; improving water quality; sustainable urban drainage; sustainable transport; improving air quality.
    - Land regeneration: Regeneration of previously developed land; improving quality of the place; increasing environmental quality and aesthetics.
    - Wildlife and habitats: Increasing habitat area; increasing populations of some protected species; increasing species movement.
    - Economic growth and investments: Inward investments and job creation, land and property values; local economic regeneration.

- Stronger communities: Social interaction, inclusion, and cohesion; community engagement; education and participation; a sense of place; experiencing nature



Benefit	Reduces Stormwater Runoff											Improves Community Livability						
Practice	Reduces Water Treatment Needs	Improves Water Quality	Reduces Grey Infrastructure Needs	Reduces Flooding	Increases Available Water Supply	Increases Groundwater Recharge	Reduces Salt Use	Reduces Energy Use	Improves Air Quality	Reduces Atmospheric CO_2	Reduces Urban Heat Island	Improves Aesthetics	Increases Recreational Opportunity	Reduces Noise Pollution	Improves Community Cohesion	Urban Agriculture	Improves Habitat	Cultivates Public Education Opportunities
Green Roofs	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Maybe	Maybe	Yes	Yes
Tree Planting	Yes	Yes	Yes	Yes	No	Maybe	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Yes
Bioretention & Infiltration	Yes	Yes	Yes	Yes	Maybe	Maybe	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Maybe	No	Yes	Yes
Permeable Pavement	Yes	Yes	Yes	Yes	No	Maybe	Yes	Maybe	Yes	Yes	Yes	No	No	Yes	No	No	No	Yes
Water Harvesting	Yes	Yes	Yes	Yes	Yes	Maybe	No	Maybe	Maybe	Maybe	No	No	No	No	No	No	No	Yes

Yes Maybe No

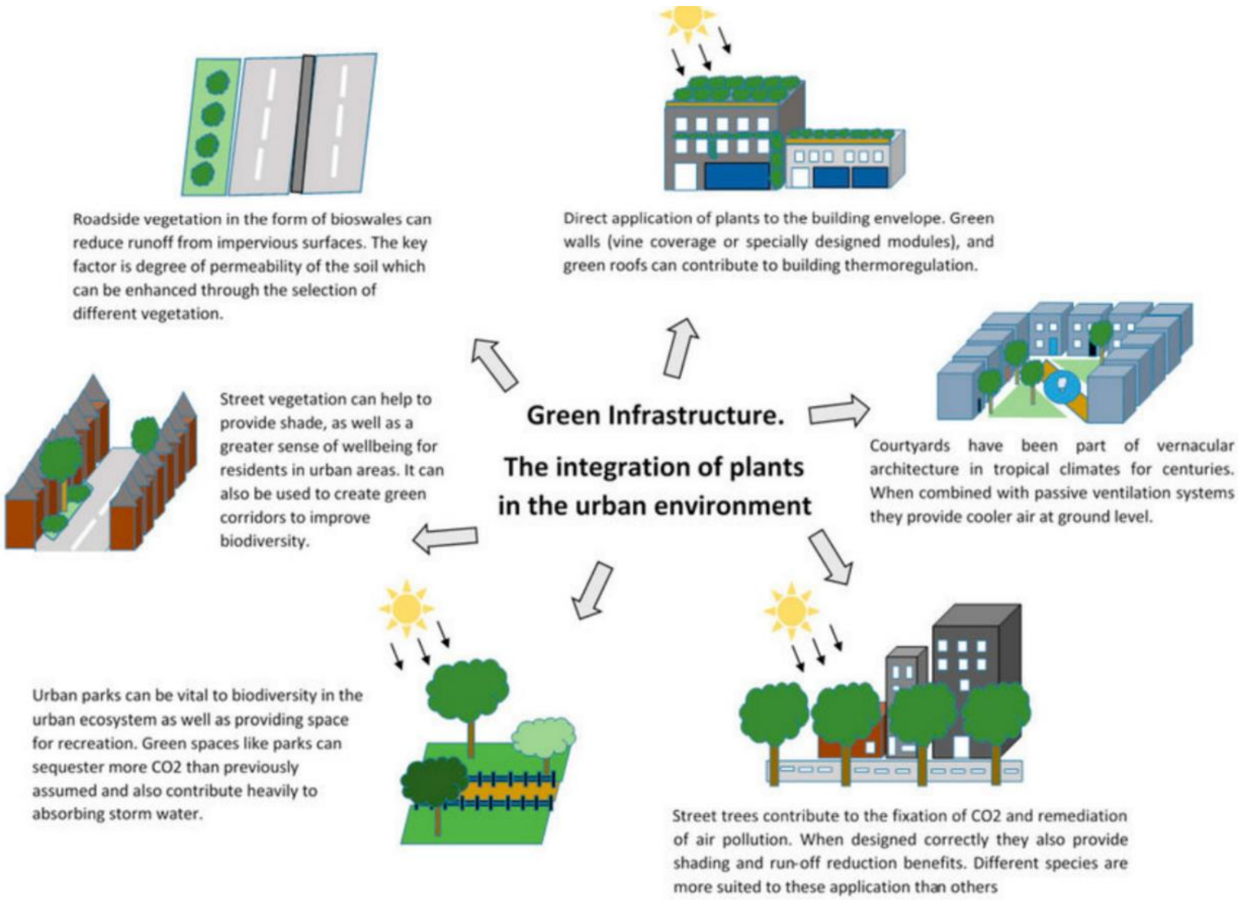
Source: www.powerhousegrowers Image via CNT, American Rivers.

Figure 4: Snapshot of Benefits of Green Infrastructure

- The GI concept differs from the objectives of greenways which focuses on aesthetics and spaces for recreational purposes.
- Poorly designed or managed GI can be a source of pollution and compromise urban biodiversity.
- GIs are among the best practices in local governance when combined with traditional grey infrastructure to achieve greater urban sustainability and resilience.

Application and integration of green infrastructure in cities:

Figure 5: Importance of the Application of Green Infrastructure in Cities



- The figure below shows the steps in developing a green infrastructure plan for cities.

Source: Kramer, M., 2014. Enhancing sustainable communities with green infrastructure. Office of Sustainable Communities, US Environmental Protection Agency.

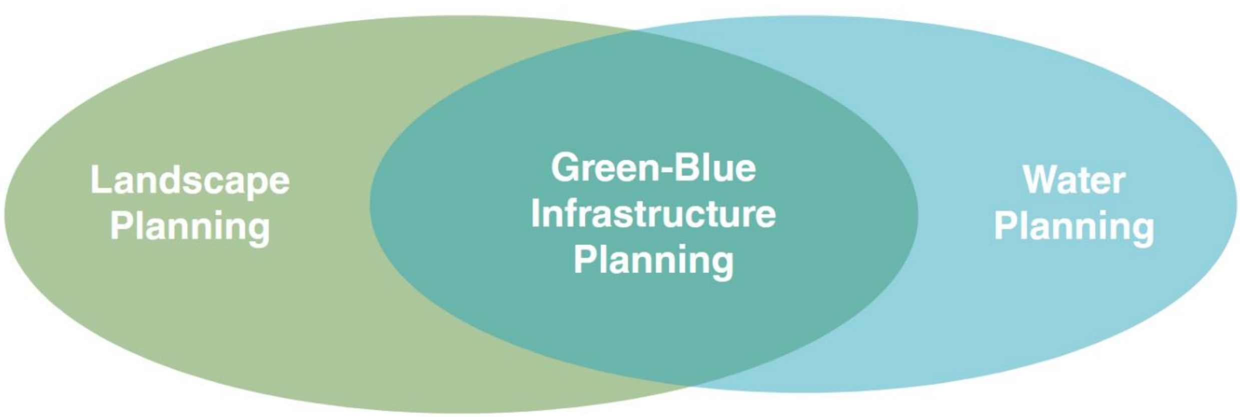
Figure 6: Steps in Developing a Green Infrastructure Plan

Tabletop Discussion/Group Exercise – GI

- Provide examples of green infrastructure in urban areas in Kingston
- Discuss how the steps identified in the GI infrastructure plan can be applied to Kingston or another urban area.
- Any missed opportunities?

Green Blue/Blue-Green Infrastructure

A green-blue city is an urban area that is designed to successfully incorporate natural systems that provide the ecological and amenity value associated with urban greening, and also provide stormwater management. Often "green" assets (trees, parks, gardens) and "blue" assets (Water Sensitive Urban Design (WSUD), drainage areas and flood storage) are planned separately. However, often the same asset can provide multiple services that benefit both "green" and "blue" objectives. By purposely planning for green-blue infrastructure that achieves multiple objectives, cities and towns can benefit from efficient infrastructure,
greater collaboration and heightened benefits.



The term 'green-blue infrastructure' refers to the use of vegetation, soils and natural processes in an urban context to simultaneously deliver landscape and water management benefits.

Local governments need to build a deeper understanding of their own water management, and open space assets and the future needs of their jurisdictions. Often, either explicitly through published strategies, or implicitly through officer knowledge and ongoing work, there is an established understanding of both the opportunities and constraints affecting delivery of green-blue infrastructure at a local level.

However, the opportunities are most commonly examined with regard to a single outcome, e.g. stormwater management, water security, flood management, tree health, recreation needs or biodiversity. The inherent multi-functionality of natural systems requires an equally integrated approach to identify, prioritize and deliver initiatives that will create greener and more successful cities. The planning of green-blue infrastructure aims to do just that; to explore synergistic opportunities for integrated greening and water management outcomes and to create a framework for collaboration between council departments and key industry and community groups to deliver a new blue-print for cities and towns.

Green-blue infrastructure elements

Green-blue infrastructure can be delivered at a range of scales, from building scale initiatives to precinct scale or regional features. Regardless of scale, these systems will all typically have the following characteristics in common:

- Vegetation, providing amenity and habitat
- Soil, of adequate volume, nutrient content and drainage characteristics
- A link to rainwater, stormwater or recycled water supply, with a frequency and quantity sufficient to support vegetation and soil health

In addition, some systems may provide additional water management functions:

- Water treatment capacity, utilising natural process to filter local water supplies and reduce pollutants entering local waterways.
- Water storage capacity, using volumes within soils or above ground space to provide detention of stormwater.

The following table presents different types of green-blue infrastructure which can be used across the urban realm.

Green-blue infrastructure element		Description
Green roofs		Green roofs are building roofs which have be partially or completely covered in vegetation which is planted into a growing medium sitting above a waterproof membrane. Harvested rainwater can be used for irrigation.
Green walls		Green walls are a vertical garden on the side of a building which comprises vegetation planted within a growing medium which is attached to the wall. Rainwater or greywater from the building can be used to support plant health.
Street trees		Trees planted in growing medium underneath sidewalks which can be designed to be passively irrigated from stormwater runoff from pavements and roads. These can also be designed to enhance stormwater pollutant removal with the inclusion of special filter media. Permeable paving can also be used to channel stormwater into underground soil areas to support trees.
Gardens		Gardens comprise vegetation planted into a growing media (soils). Stormwater can be directed into gardens to provide passive irrigation, or an active irrigation system can be provided, fed by alternative water sources.
Raingardens		Raingardens are garden beds which are designed to capture, detain and treat stormwater runoff as it filters through the underlying filter media before it is discharged at the base of the system either into the surrounding soils or into the local stormwater network.
Swales		Swales are shallow, vegetated open channels that convey and treat stormwater. The vegetation can vary from mown turf to sedges.
Parks		Parks are public open space areas which provide the local community with a range of recreational activities. These could be irrigated using an alternative water supply or designed to provide stormwater detention and infiltration.

Green-blue infrastructure element		Description
Sports grounds		Sports grounds are large open space areas which support active recreational activities. These could be irrigated using an alternative water supply or designed to provide stormwater detention and infiltration.
Urban agriculture		Urban agriculture is the local production of food products. This can include community gardens which are open to the public, or commercially viable small-scale urban farms. Suitable alternative water sources can be harnessed for irrigation.
Green corridors		Green corridors are linear green spaces that can provide a range of connectivity services including natural habitat and recreational pathways. These areas are typically located along waterways or other easements.
Ponds and lakes		Ponds and lakes are open water bodies which are designed to permanently hold water. They can be fed by a stormwater supply or a recycled water supply. Vegetation can be included around the edge or in shallow sections.
Wetlands		Wetlands are heavily vegetated water bodies. These systems can either be natural features in the landscape or can be constructed to treat stormwater. They can appear as natural systems or integrated as hard edged features in urban areas.
Waterways		Waterways are channels that capture and convey flows from catchments. They include streams, creeks and rivers and can be natural or modified systems (e.g. rock edged or even concrete lined)
Forests		Forests are large areas of dense plantings of trees, shrubs and ground covers. They can be remnant, regrowth or newly created urban forests. Forests play an important part in the water cycle, creating pervious area to absorb stormwater.

- Green-blue infrastructure planning seeks to ensure cities are healthy, prosperous, and resilient, with ten core objectives.

Healthy – making the best of our local environment

1. To support year-round passive and active recreation
2. To protect and enhance local waterways and aquatic environments
3. To support urban biodiversity

Prosperous – making changes to better our city

4. To improve the amenity of the urban environment
5. To create stronger connections between communities and nature
6. To improve the functionality of urban places
7. To drive increased tourism and visitation

Resilient – making sure we are ready for challenges

8. To make use of alternative water supplies locally to prepare for drought
9. To reduce the impacts of flooding
10. To provide pleasant and cooling environments during hot weather

- The relative importance of these objectives will change depending on the local needs and challenges of your city. It is likely that many of these objectives and the broader values they represent are share by multiple stakeholders.

- The achievement of these objectives necessitates cross-disciplinary working and draws on a comprehensive understanding of many aspects of urban design and natural ecosystems.

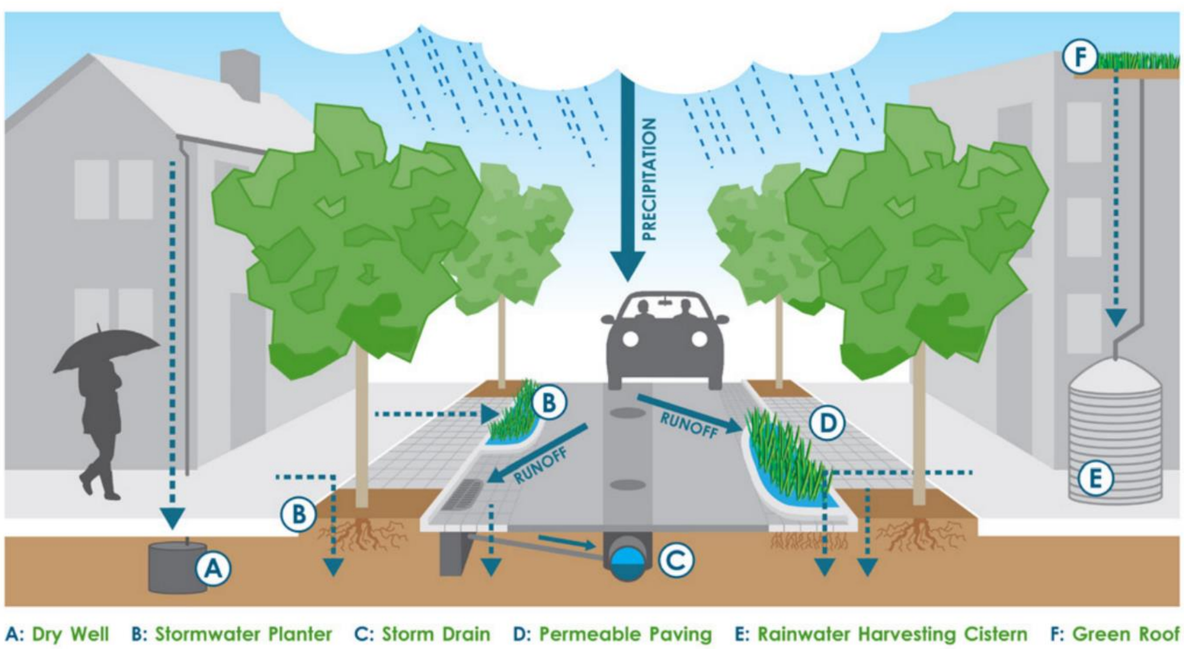
Tabletop Discussion/Group Exercise – Green/Blue, Blue/Green Infrastructure

- Provide examples of blue/green infrastructure in urban areas in Kingston
- Any Missed Opportunities

Green-Grey Infrastructure

- Green-grey infrastructure combines conservation and/ or restoration of ecosystems with the selective use of conventional engineering approaches to provide cities with solutions for climate change resilience and adaptation benefits.

- An example of green-gray infrastructure is where natural coastal ecosystems – such as mangroves, salt marshes, inter-tidal flats, seagrasses, and coral reefs – are combined with gray infrastructure such as breakwaters, to combine the values of wave attenuation and flood control of natural ecosystems with the benefits of engineered structures.



Source: http://tomorrow.norwalkct.org

- In addition, the conservation and restoration of natural coastal ecosystems can extend the lifespan of gray infrastructure, while also supporting fisheries, regulating water quality, and sequestering carbon. The combined solution can therefore be more comprehensive, robust, and cost-effective than either solution alone.

- Some of the benefits of green-grey infrastructure include:
  - Ecosystems are conserved and/or restored to provide measurable social, environmental, and economic benefits
  - Includes selective integration of a conventional engineering approach
  - Provides climate resilience and/or risk reduction benefit.

- Key Critical elements that define the green-grey approach are:
  - Using science and engineering to produce operational efficiencies
  - Using natural processes to maximize benefits (i.e. ecosystem services)

  - Increasing the value provided by projects by including social, environmental, and economic benefits
  - Using collaborative processes to organize, engage, and focus interests, stakeholders, and partners

Resilience

- Resilience is the ability of systems, agents and their interrelations to prevent, reduce, cope and withstand shocks or stresses and bounce back quickly to normalcy after a disaster or crisis, by integrating adaptation and sustainability with disaster risk management.

Resilient Cities

- Urban and peri-urban ecosystems play a crucial role in city resilience and sustainability. Resilient cities taken into account ecologically-sound urban planning designs to harmonize development with ecosystem services to attain natural capital benefits.

- UNDRR has proposed ten actions to make cities more resilient. These are:
  1. Organize for disaster resilience
  2. Identify, understand and use current and future risk scenarios
  3. Strengthen financial capacity for resilience
  4. Pursue resilient urban development and design
  5. Safeguard natural buffers to enhance the protective functions offered by natural ecosystems
  6. Strengthen institutional capacity for resilience
  7. Understand and strengthen societal capacity for resilience
  8. Increase infrastructure resilience
  9. Ensure effective disaster response
  10. Expedite recovery and build better

- The concept of resilient cities entails considering cities as dynamic systems.

- The resilience of a city depends on the overall performance and capacity of its systems, and not solely on its ability to manage disaster risk, reduce greenhouse gas emissions, or adapt to climate change and impacts thereof.

- Maintaining the health of the peri-urban ecosystem is crucial to developing the resilience of the urban and peri-urban regions. Changes in ecosystem services affect people living in urban areas both directly and indirectly.

- One of the choices to adapt and improve the resilience of peri-urban ecosystems is the ecosystem-based disaster risk reduction approach.

Ecosystem-based Disaster Risk Reduction (EcoDRR)

- Ecosystem-based DRR is a more sustainable approach to DRR and climate change adaptation.
- Eco-DRR refers to the use of the natural environment and its ecosystems to buffer the impacts of changing climate, extreme weather events and related hydro-meteorological hazards.
- The basic objective of Eco-DRR is to maintain the resilience of natural ecosystems and their services and help communities survive and cope with extreme events.

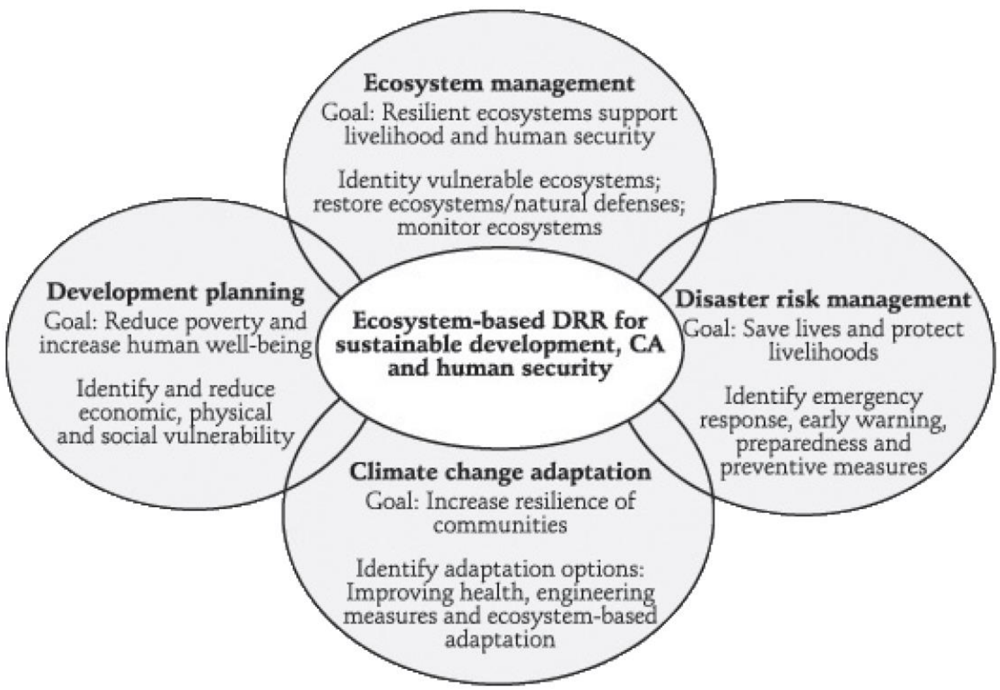


Figure 7: Concept of EcoDRR

- The Sendai Framework for Action (SFDRR), Agenda 2030 and the SDGs as well as Paris Climate Agreement has emphasized building resilience to climate change and its impacts by protecting natural ecosystems.
- EcoDRR has been very well placed into the SDGs. For example, Goal 11 refers to urban ecosystems and emphasizes making cities inclusive, safe, resilient and sustainable by implementing integrated policies and plans for resource use efficiency and adaptation to climate change. SDG 13 is related to climate action, while SDG 15 focuses on life on land

and emphasizes integrating the ecosystem-based approach in local planning and developmental processes (UN, 2016).

- Approaches and tools to mainstreaming EcoDRR to support urban resilience include:

Approaches	Pathways	Tools	Entry Points
Development planning	City development planning	Land use planning	Data, information and knowledge on peri-urban and urban growth and disaster risks
Urban governance	Infrastructure planning	Life cycle analysis	Tools and approaches used for urban planning
Institutional mechanisms	Urban planning	Social impact assessment	Development processes associated with urban infrastructure and services
Law	Regional planning	Natural resource accounting	Institutional capacity building and strengthening
Development plans and programmes		Environmental auditing	Community development Processes
Sectoral plans and policies		Risk and vulnerability analysis	Tapping the private sector
		Development regulations	Catalyzing finances
		Zoning regulations	
		Environmental impact assessment	

The Linkages between Resilience and Adaptation in Urban and Peri-Urban Areas

- Achieving resilience and adaptation in urban and peri-urban areas requires that the following actions be undertaken:
  - Promotion of climate-resilient livelihoods strategies in combination with income diversification and capacity building for planning and improved risk management
  - Disaster risk reduction strategies to reduce the impact of hazards, particularly on vulnerable households and individuals.
  - Capacity development for CSOs and government entities so that they can provide better support to communities, households, and individuals in their adaptation efforts.
  - Advocacy and social mobilization to address the underlying causes of vulnerability, such as poor governance, limited control over resources, or limited access to basic services.

The relationships among EbA, Environmental Conservation and Management, Disaster Risk Reduction and Climate Change Adaptation

- Rapid or unplanned urban development and expansion can degrade the integrity of urban green spaces and surrounding ecosystems, with infrastructure, housing or croplands replacing wetlands and forests. This reduces ecosystem service flow and provision to urban areas and increases the vulnerability of local communities. For example, unplanned urban expansion can lead to reduced water infiltration, more flooding, soil erosion, and water pollution in rivers and other open waters.

- NBS use a set of structural and non-structural interventions that protect, manage, restore, or create natural or nature-based features.

- Alongside other benefits, NBS can reduce the impact of natural hazards in cities, such as flooding, erosion, landslides, drought, and extreme heat (Ozment et al. 2019; Sudmeier-Rieux et al. 2021).

- NbS can also complement gray infrastructure such as storm drains, embankments, and retaining walls. In many cases, integration of NBS has proven to be cost-effective (Raymond et al. 2017).

Topic 5: Using Ecosystems to Reduce Disaster Risks and Support Climate Change Adaptation in Urban and Peri-urban Communities

- To tackle current and future challenges related to climate change, working with nature rather than against it is often more resource-efficient, sustainable, and beneficial. Every dollar invested in adaptation can generate up to 10 dollars in benefits. NbS for adaptation have the potential to restore natural resources, foster economic growth, create jobs, and improve human health and well-being.

- Ecosystems can regulate risks and buffer impacts in many ways, including through regulation of coastal and surface flooding, temperature regulation, and erosion control. Some examples of how ecosystems contribute to more resilient urban areas are provided below.

- Green spaces cool urban areas/cities and counter their 'heat island' effect. Increased temperatures and more frequent and intense heat waves are especially harmful for cities, which are on average 3–8°C warmer than surrounding rural areas. This so-called urban heat island effect is mainly caused by the heat emitted by buildings, industry, and transport, as well as by a lack of shading and cooling effect of vegetation. Tree canopy cover, other foliage and well-irrigated grassed areas can lower surface temperature by around 15°C, green walls and roofs cool adjacent rooms by about 2°C, and green areas lower the urban heat island effect by 1°C, on average. This phenomenon is known as the 'park cool island effect'.

CASE EXAMPLE: BARCELONA

Barcelona's efforts to increase tree coverage from 5% to 30% reduced temperatures so successfully that it saved USD 10 million in annual utility bills from air conditioning in buildings, and also improved air quality

- Green spaces, trees and plants, contribute to cleaner air quality in urban areas and can effectively contribute to reducing respiratory diseases such as asthma. The clean air provided by urban trees in the Chinese city of Guangzhou, for example, is estimated to create benefits worth an USD 9.2 million annually.
- Ecosystems are essential for regulating water run-off in urban areas as these areas are characterized by a high degree of concrete that impedes water percolation from rainfall. This disturbance of the natural water cycle leads to heavier run-offs, which can cause flooding during heavy rain events. Ecosystem-based measures, such as water-permeable pavements which can prevent urban areas from flooding by slowing stormwater run-off.

Figure 8: Water Permeable Pavements

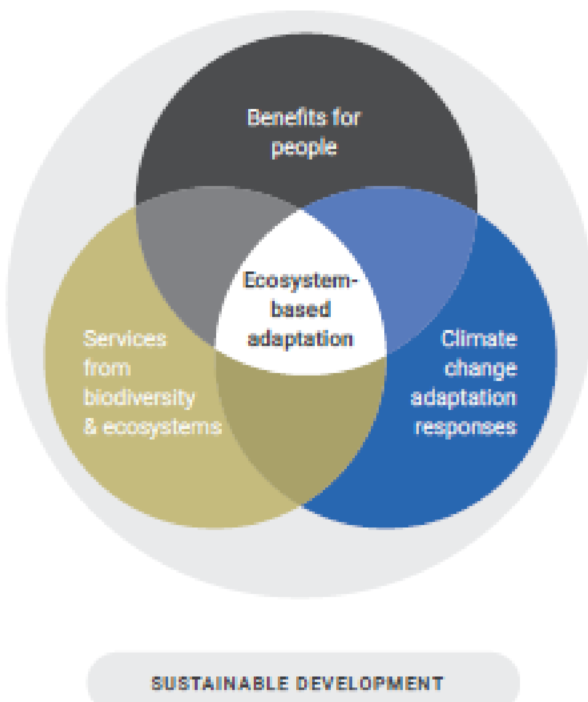
- Habitat creation leads to resilient urban biodiversity. Urban EbA measures provide habitat for plants and animals, thereby protecting and enriching biodiversity, ecosystem health, and the ability to provide cherished ecosystem services like water regulation or air purification.

CASE EXAMPLE: SINGAPORE

An example is the canal naturalization of Singapore's Bishan-Ang Mo Kio Park; changes in its bank-side vegetation increased the number of insects associated with clean water and encourage more complexity in both terrestrial and aquatic biodiversity. This is important, as a high level of biodiversity is more resilient to disturbances such as climate change, allowing ecosystems to survive and continue functioning.

Topic 6: The Economic, Social, and Environmental Benefits of EbA to Urban and Peri-Urban Areas…Towards Sustainable Development

Integration of EbA in the Context of Sustainable Development



Source: UNEP (2021). Rwanda GEF-LDCF NAP Project: LTRP Proposal

Case Example of the Benefits of EbA to Cities and Urban Areas

Tabletop Discussion

- How can we apply EbA to Urban and Peri-Urban Areas in Jamaica? Consider the urban and peri-urban areas identified earlier.

Topic 7: Ecosystem-based Adaptation Options for Cities and Intended Outcomes

EBA REMEDY	URBAN CHALLENGE	OUTCOME INDICATORS	ECOSYSTEM SERVICE
Urban reforestation: Boulevards, greenbelts, arboretums, grove cooperatives	Flooding and soil erosion Air quality Shade	Severity of flooding Soil erosion metrics Flood damage metrics	Supporting: nutrient cycling, soil formation Provisioning: clean air, fuel Regulating: climate, flooding
Green space creation: Parks, conservation areas, stream restoration, community gardens, groves	Heat islands, heat stress Droughts Air quality Shade	Canopy cover Microclimate temperature and humidity	Supporting: nutrient cycling, soil formation Provisioning: clean air, heat relief, fuel Regulating: climate, water purification Cultural: aesthetic, educational, spiritual, recreationa
Flood risk management zones: Walkways, bikeways, community gardens, playing fields	Flooding Transportation blockage	Infrastructure damage due to flooding; Compare commuting times	Supporting: nutrient cycling, soil formation Provisioning: transport corridors, food growing space Regulating: climate, flood Cultural: aesthetic, educational, recreational
Rainwater harvesting: Grey water supply, run-off diversion, urban gardens, community gardens,	Drought Flooding	Measure of rain accumulated and diverted from drains; usage domestically or for specific purpose	Supporting: nutrient cycling, soil formation Provisioning: water, food Regulating: climate, flood Cultural: aesthetic, educational
Permeable pavements Aquifer recharge and water storage, runoff diversion, walkway safety	Drought Flooding Land subsidence	Groundwater levels; recharge rates; run off; subsidence rates as compared to baselines	Provisioning: water Regulating: flood, water shortages Supporting: nutrient cycling, soil formation Cultural: aesthetic, recreational
Water purification: Urban gardens, water features in parks, artificial wetlands	Water and sanitation	Measurement of contaminant counts as sediments settle, algae and bacteria, etc.	Supporting: nutrient cycling, soil formation Regulating: climate, flood, water purification Cultural: aesthetic, recreational
Nature connecting corridors: Conservation areas, bird and plant habitats, pollinators, water features, community gardens	Biodiversity loss Habitat fragmentation Water quality	Inventory of biodiversity Measure water and air quality	Supporting: nutrient cycling, soil formation Regulating: climate, flood, water purification Cultural: aesthetic, spiritual, educational, recreational
Urban design/layout: Zoning for air circulation and 15-minute city; resilience design; planning connectivity; green spaces; food production	Urban canyons Air pollution Food deserts	Compare wind speeds and air pollution before and after or unrestored vs. restored	Supporting: nutrient cycling, soil formation
Green ventilation corridors: Conservation areas, green hinterland	Inversion layer formation Heat islands	Measure temperatures at bottom of corridor vs. blocked areas	Supporting: nutrient cycling, soil formation Provisioning: clean air, heat relief Regulating: climate, flood Cultural: aesthetic, recreational, educational
Urban utility services: Composting biodegradable by-products; extracting biogas; production of biosolids from water treatment processes; providing quality fertilizer to food producers	Accumulation of biological waste and subsequent pollution Health issues from decomposing material	Amount of fertilizer sold to outlying farm enterprises; amount of fuel produced; savings of circular economy approach over dumping or landfill	Supporting: nutrient cycling, soil formation, primary production Provisioning: clean water, air, fuel, fertilizer Regulating: climate, disease regulation, water purification Cultural: aesthetic, educational

Source: Based on UNEP (2021b)

Tabletop Discussion

- Discuss the advantages of EbA to urban and peri-urban planning and development in the Jamaica context.

- How can we define EbA for urban and peri-urban resilience in Jamaica?

Topic 8: What does Effective EbA Look Like[17]?

- **Human-centric:** EbA emphasizes human adaptive capacity or resilience in the face of climate change.

- **Harnesses nature's capacity to support long-term human adaptation:** EbA involves maintaining ecosystem services by conserving, restoring, or managing ecosystem structure and function, and reducing non-climate stressors.

- **Draws on and validates traditional and local knowledge:** Draw on traditional knowledge about how best to implement EbA.

- **Based on best available science**: EbAs project must explicitly address an observed or projected change in climate parameters and so should be based on climatic projections and relevant ecological data at suitable spatial and temporal scales.

- **Benefits the world's poorest**, many of whom rely heavily on local natural resources for their livelihoods.

- **Community-based** and incorporating **human rights-based principles**: Like community-based adaptation, EbA should use participatory processes for project design and implementation. People should have the right to influence adaptation plans, policies and practices at all levels and to be involved with framing the problem and identifying solutions.

- **Cross-sectoral and intergovernmental collaboration**: EbA requires collaboration and coordination between multiple sectors (such as agriculture, water, energy and transport) and stakeholders. EbA can complement engineered approaches — for example, combining dam construction with floodplain restoration to lessen floods.

- **Operates at multiple geographical, social, planning and ecological scales**: EbA can be mainstreamed into government or management processes, such as national adaptation or watershed-level planning, provided that communities remain central to planning and action.

[17] Sources: Reid et al. (2009); Andrade et al. (2011); GEF (2012); ARCAB (2012); Girot et al. (2012); Ayers et al. (2012); Travers et al. (2012); Jeans et al. (2014); Reid (2014a and 2014b); Anderson (2014); Faulkner et al. (2015); Bertram et al. (2017).

- **Minimizes trade-offs and maximizes benefits** with development and conservation goals to avoid unintended negative social and environmental impacts. This includes avoiding maladaptation, whereby adaptation 'solutions' unintentionally reduce adaptive capacity.
- **Provides opportunities for scaling up and mainstreaming** to ensure the benefits of adaptation actions are felt more widely and for the longer term.
- **Involves longer-term transformational change** to address new and unfamiliar climate change-related challenges and the root causes of vulnerability, rather than simply coping with existing climate variability and climate-proofing business-as-usual development.

Viewing of Videos:

https://www.unep.org/news-and-stories/video/what-ecosystem-based-adaptation

Module 3: Practical Applications of EbA in Urban Planning and Design

Overview of Module 3:

Module 3 is structured around 2 main topics as follows:

- Topic 1: Practical application of EbA in urban and peri-urban planning, project design including review of case studies and cost benefit analysis as well as practical examples of the use of these EbA in urban and peri-urban spaces. Some of these include:
    - Urban Forests
    - Urban Farming
    - Open Green Spaces
    - Building Solutions
    - Green Corridors
    - Natural Inland Wetlands
    - Mangrove Forests among others
- Topic 2: Introduction to Cost Benefit Analysis for EBA

At the end of this module, participants should be able to:

Know	**The different types of EbA**
Apply	**The different types of EbA to urban and peri-urban areas in Jamaica**
Examine	**The functions of each of the EbA types**
Know	**The natural processes supported by each of the EbA types**
Be	**Able to identify the cost considerations for each EbA type**
Visualize	**Each of the EbA types**

Topic 1: Practical Application of EbA in Urban and Peri-urban Planning

Some of the practical applications of EbA include:

- Urban Forests
- Urban Farming
- Open Green Spaces
- Building Solutions
- Green Corridors
- Natural Inland Wetlands
- Mangrove Forests

These are described below:

Urban Forests

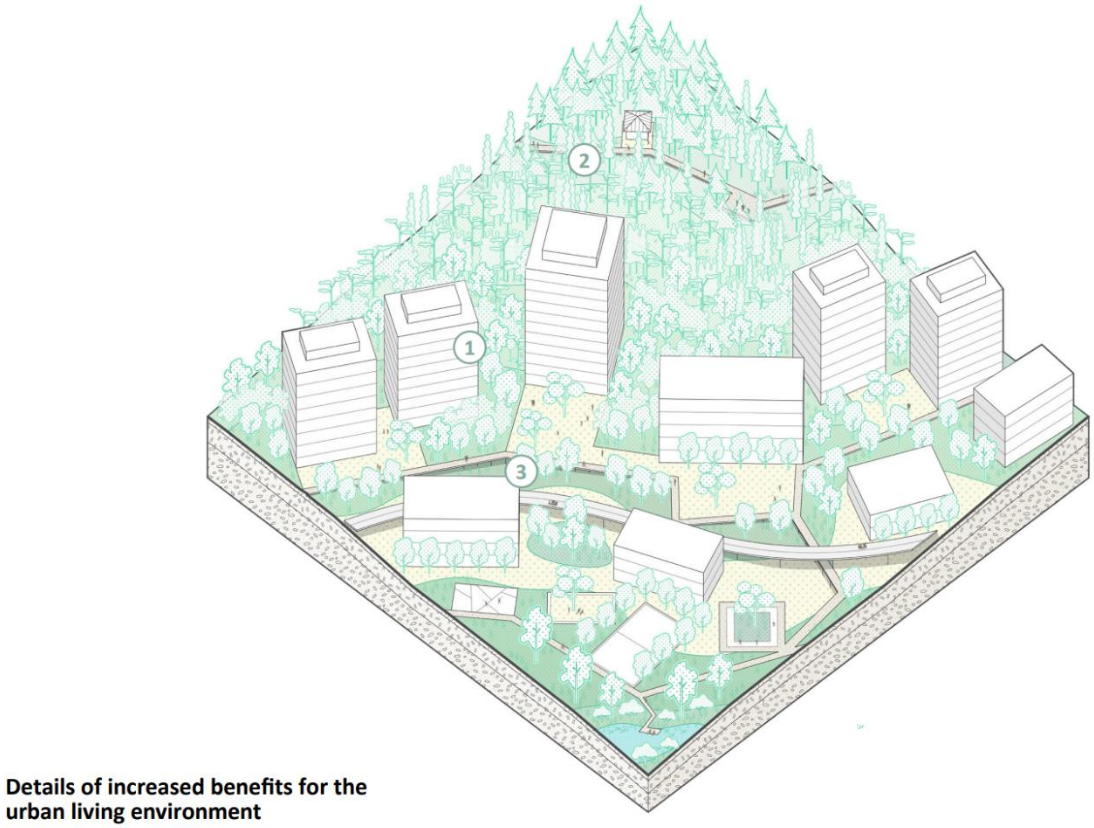


Figure 9: Visualization of an Urban Forest

- Urban forests are complex ecosystems with a remarkable capacity for regeneration and resiliency (FAO 2016). Urban forests are located within cities or at the rural–urban interface. In most contexts, urban forests survive and thrive as fragments of the larger regional landscape mosaic or emerge as pockets of successional outgrowth on vacant or abandoned land.

- Urban forests adapt to adversity and have the ability to survive in hostile conditions. Varied in size and composition, they demonstrate remarkable resilience under a great deal of stress from pollution, compacted soils, and disrupted hydrological cycles.

- An urban forest encompasses the trees and shrubs in an urban area.[18] This includes trees in yards, along streets and utility corridors, in protected areas, and in watersheds. This includes individual trees, street trees, green spaces with trees, and even the associated vegetation and the soil beneath the trees.[19]

- In many regions, urban forests are the most extensive, functional, and visible form of green infrastructure in cities.

- Functions of urban forests include:

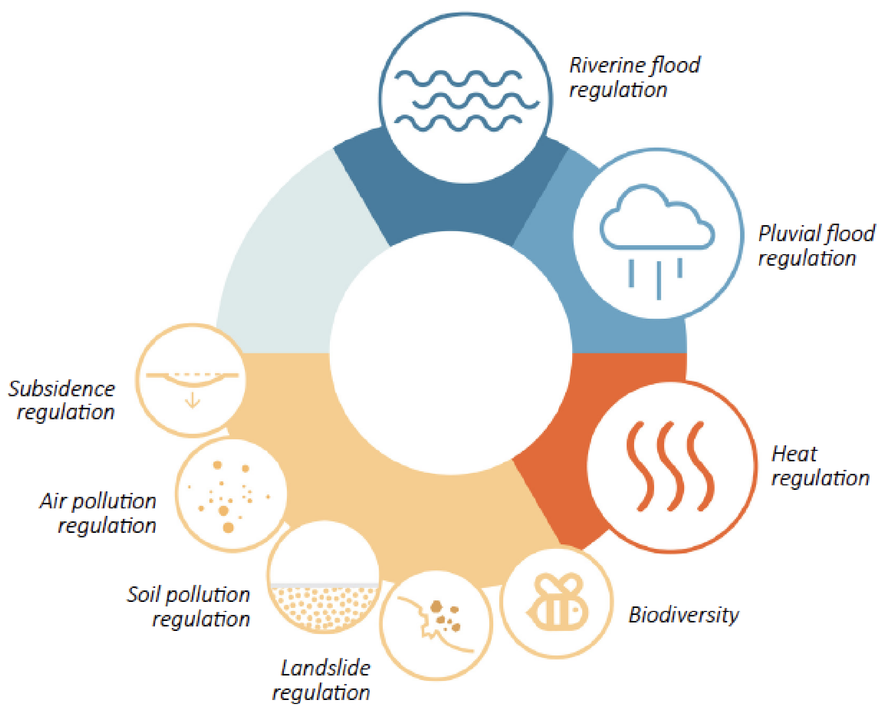


Figure 10: Functions of Urban Forests

- Green infrastructure is the natural and semi-natural infrastructure within a city that provides ecosystem services like stormwater management or air pollution abatement.[20]

[18] Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). Urban forests and pollution mitigation: analyzing ecosystem services and disservices. Environmental Pollution (Barking, Essex: 1987), 159(8–9), 2078–2087.

[19] https://cities4forests.com/lg-urban-forests/what-is-an-urban-forest/

[20] Lafortezza, R., Pauleit, S., Hansen, R., Sanesi, G., & Davies, C. (2017). Strategic Green Infrastructure Planning and Urban Forestry. In Francesco Ferrini, Cecil C. Konijnendijk van den Bosch, & Alessio Fini (Eds.). Routledge Handbook of Urban Forestry. (pp. 179-193). London, UK and New York, NY.

- Urban reforestation slows run-off and stabilise soil, thus protecting infrastructure and buildings from flooding, undermining and siltation. For example, planting climate-resilient and soil stabilising tree species and multi-use plants along roads— Flooding and soil erosion resulting from extreme rainfall and increasingly frequent and severe storms.

- Urban forests have a great potential to mitigate the urban heat island effect and air pollution, and to retain stormwater.

- Urban forests protect rivers by intercepting rainfall, increasing infiltration, and reducing flooding.

- Urban forests clean soils, sequester carbon, and regulate water cycles through retention, infiltration and evapotranspiration; improve air and water quality; provide critical habitat for a variety of species.

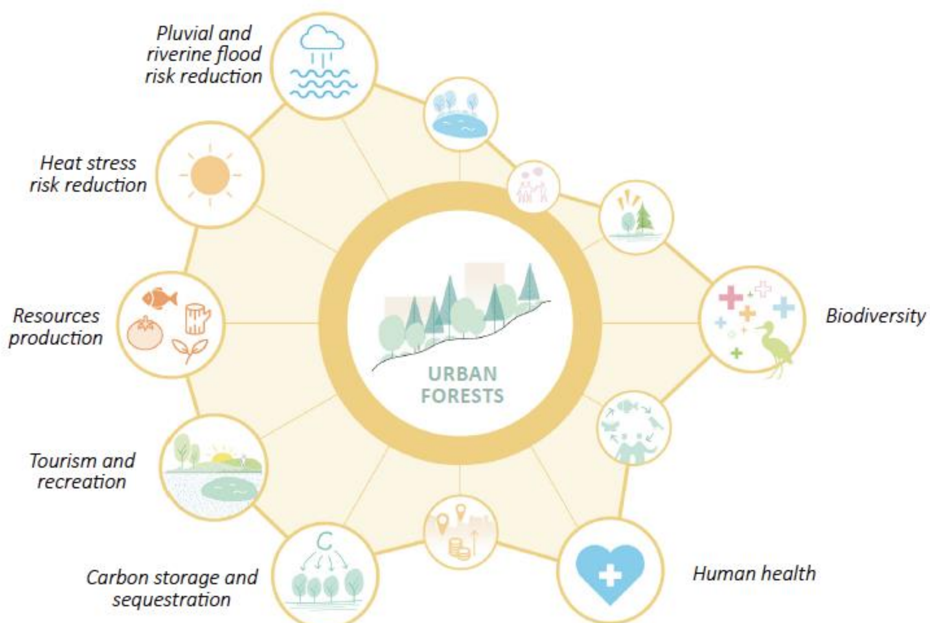


Figure 11: Importance of Urban Forests to People and Society in General

- Functions, roles and importance of urban forestry at tree, street and city levels:

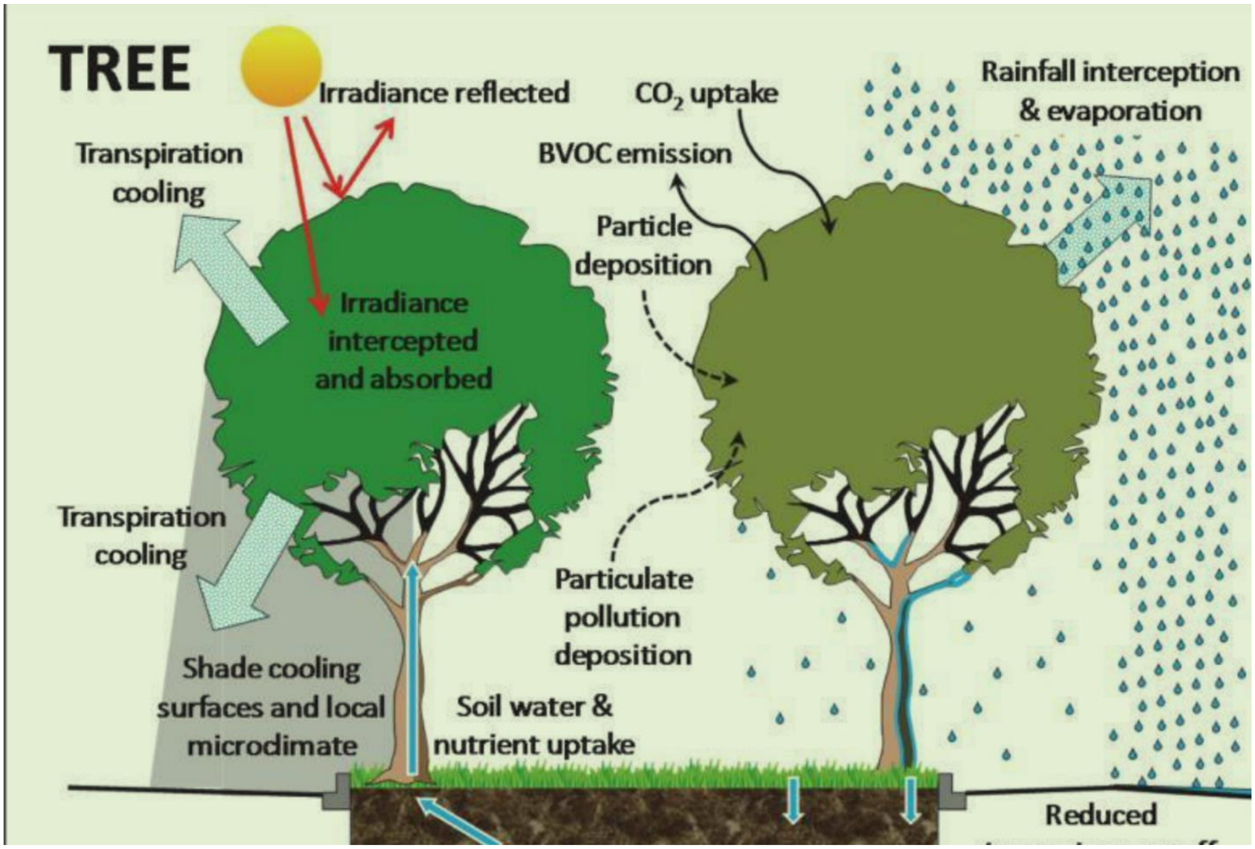


Figure 13 The role and importance of trees in urban areas

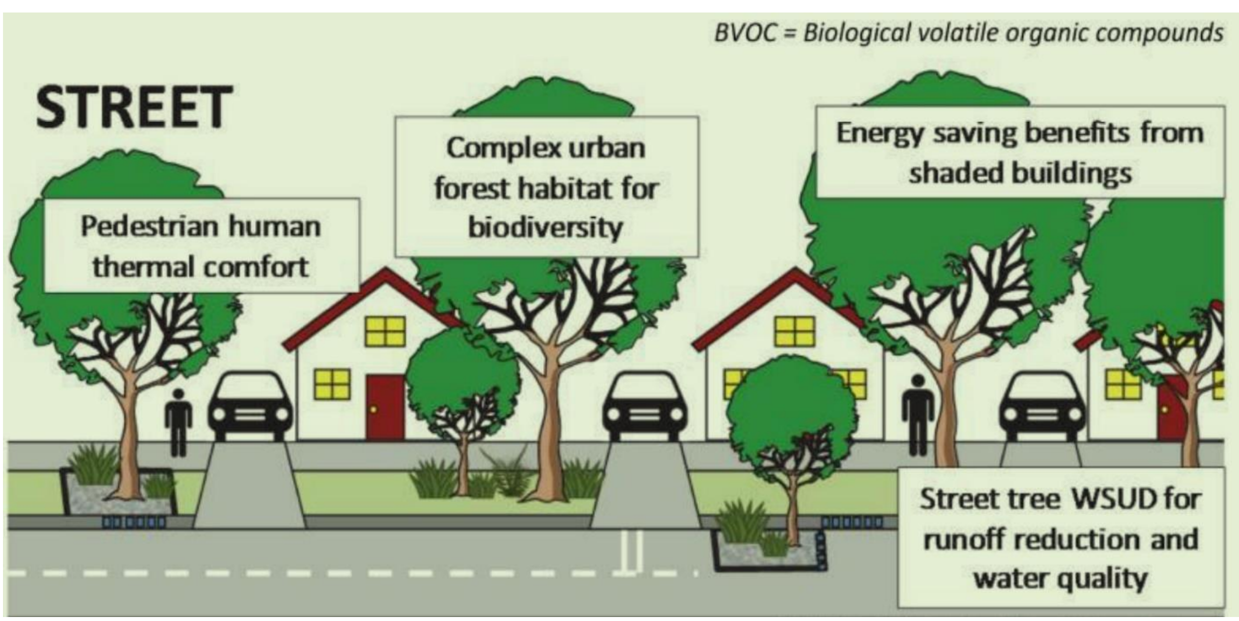


Figure 12:The role and imparlance of trees - street level

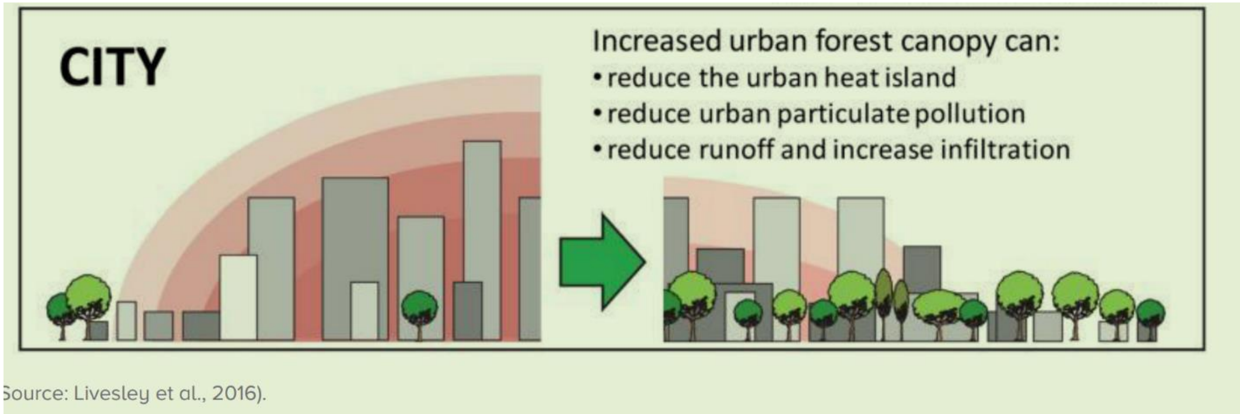


Figure 14: The role and importance of trees – at the city level

- Processes supported by urban forests are:

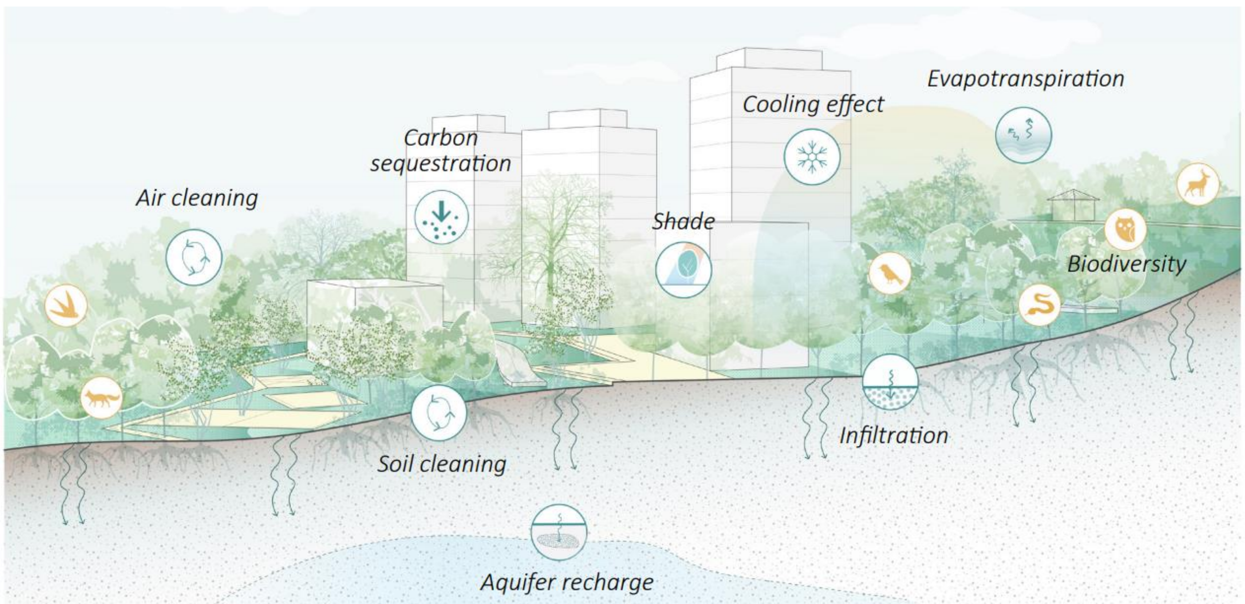


Figure 15: Benefits of Urban Forests

- Cost considerations for urban forests are related to land access, construction, implementation and maintenance as follows:

Land	Construction and Implementation	Maintenance
Access and ownership of land is need for urban forests	Urban forest implementation costs include tree inventory, securing necessary government permits, site preparation (for example, draining, cleaning, weeding and invasive species removal), and reforestation (tree purchase, planting, watering, and pruning as required	The cost of forest maintenance can vary widely depending on the location of the urban forest, forest condition, and its age (newly planted versus conserved mature forests) and species composition of trees
Land for urban forests can be public or private		Urban forests maintenance costs include: • Training and capacity building • Monitoring and additional inventory • Replanting depending on tree mortality • Pruning • Tree disposal when needed • Tree litter management
Land required for urban forests may be small to large. Larger urban forest areas may require engagement and cooperation with multiple landowners and stakeholders and can raise transaction costs (similar to the process for the expansion of roads and highways)		
Example of land related costs include:		

Land	Construction and Implementation	Maintenance
• Acquisition costs • Land use costs (e.g. payments to landowners) • Community resettlement costs		

Tabletop Discussion/Group Exercise

- How and where can urban forests be applied to urban and peri-urban areas in the Jamaican context?

Case Studies – Urban Forests

Photo by World Bank

Project #1: *Freetown the Tree Town Campaign, 2020–23*
Location: *Freetown, Sierra Leone*
Description: *Within and surrounding the urban space around the capital, Freetown, trees have given way to buildings, a bleak testament to ongoing deforestation and environmental degradation in Sierra Leone. The Freetown Municipality began a one million tree-planting campaign in 2020. In addition to diverse native tree species with extended canopies and strong roots, private compound and community-based trees include mango trees to provide additional fruit harvesting community benefits. Educational workshops, community-based stewardship, planting and growing models establish ownership and value in the campaign at the community level. "This isn't just about planting trees. It's about growing trees, and it's about ensuring that each one of us is part of the process," says Yvonne Aki-Sawyerr, Mayor of Freetown. "A million trees is our city's small contribution to increasing the much-needed global carbon sink."*

Benefits

Education, Health, Biodiversity, Employment.

Source

Freetown City Council
https://www.betterplace.org/en/projects/82290-tree-planting-campaign-in-sierra-leone

Photo by Matthew Henry on Unsplash

Equitable distribution

Increase awareness

Promote environmental stewardship

Project #3: *Toronto Strategic Forest Management Plan, 2012–22*
Location: *Toronto, Canada*
Description: *The City of Toronto recognizes the value of urban forests and aims to increase its tree canopy cover to 40 percent. The City's focus is on maximizing the potential ecological, social, and economic benefits of urban trees. The Urban Forestry branch of the Parks, Forestry and Recreation division maintains over four million trees on public property and works with local groups and residents to expand and improve the urban forest throughout the city. Since 2013, the city has been planting approximately 100,000 trees on public lands—parks, streets, ravines—per year, with ambitions to increase that to 300,000 trees per year through new private–public partnerships with private landowners.*

Benefits
Governance, Health, Biodiversity.
Source
City of Toronto, Urban Forestry
https://www.toronto.ca/data/parks/pdf/trees/sustaining-expanding-urban-forest-management-plan.pdf

Urban Farming

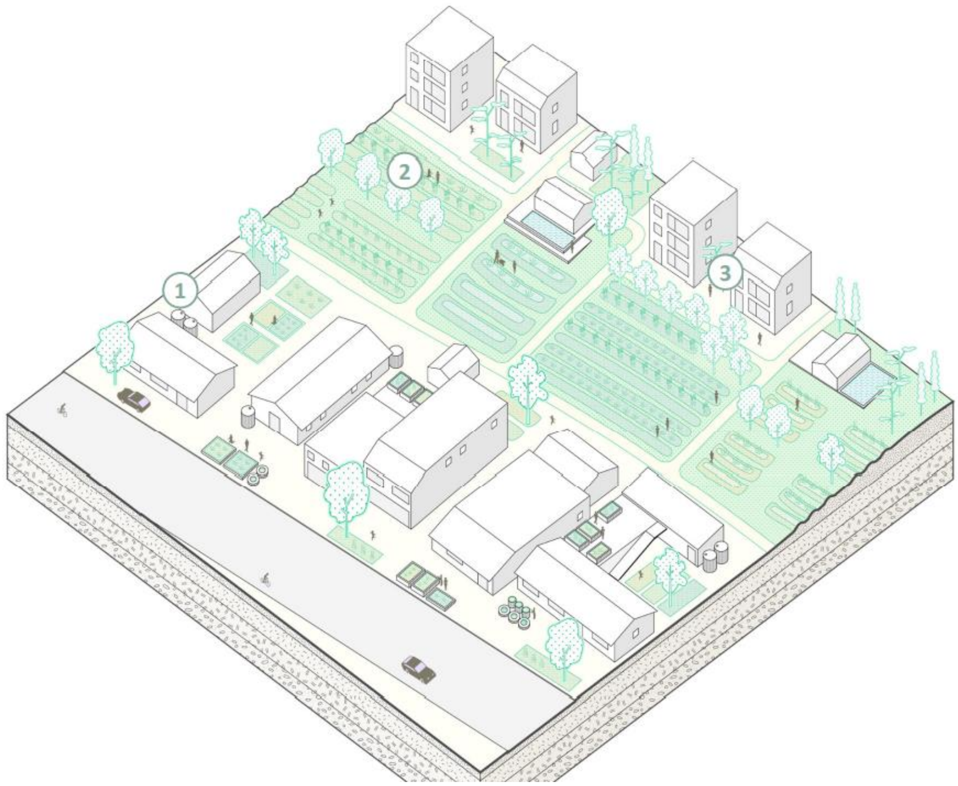


Figure 16: Visualizations of urban farming

- Urban farming is a way for people to grow crops for personal consumption or to sell locally and beyond. Urban agriculture can be defined as the growing of plants or animals within and around cities and associated activities such as producing and delivering inputs as well as processing and marketing of agricultural products (FAO 2011). The most important incentive for urban farming is to increase food security for urban livelihoods.

- Functions of Urban Farming include:
    - Outdoor urban farms increase the amount of pervious surface, and can capture, store, and infiltrate rainwater, reducing runoff (Aerts et al. 2016).
    - Farming soils often have high levels of organic content and a structure that allows water to percolate deeper into the ground. Adding more organic content can increase their water retention and storage capacity, allowing the soils to act as natural sponges.
    - Farms can also include ponds and rain collectors to store additional water. Heat regulation:

- Urban agricultural areas, especially orchards (fruit trees), reduce urban heat by creating shade and have an ameliorating effect on the immediate local climate.
- Urban farms clean air, water, and soil, and offset drought by storing water.
- In areas where development is not possible, such as steep slopes, floodplains, and areas with no bedrock and unstable soils, farming can be used to stabilize soils and prevent mudslides (Smit et al. 1996).
- Compost can be produced from farms and used to foster organic agriculture and created a sub-industry. This also reduces waste to landfill (Olson and Gulliver 2011).
- Urban farms may increase biodiversity in the surrounding areas.

Benefits of Urban Farming include:

- Urban farming changes the ratio between paved and unpaved surface in the city reducing the amount of stormwater runoff that ends up in storm drains. During heavy storms, that means protecting urban rivers from untreated runoff.
- Open-soil farming stores and infiltrates rainwater, as its rich organic soils act as sponges, soaking up rainwater (Aerts et al. 2016).
- Producing and providing food, in particular vegetable crops, fruit, spices, and poultry,
- Carbon sequestration - the carbon sequestration potential of urban agriculture is largely dependent on the degree to which trees are combined within the agricultural landscape.
- Stimulation of local economies and job creation and new job opportunities such as the participation of hotels and restaurants in urban farming and the creation of niche markets such as farm-to-table concepts in restaurants and hotels.
- Contribute to food security and create job opportunities (Agbonlahor et al. 2007). Human health as farming can improve social wellbeing and nutritional health (Hallett et al. 2016)
- Urban agriculture creates a better understanding of the value and the meaning of food, which provides opportunities to educate children. Participation in farming helps children learn and gain better understanding of the natural environment, while adults can gain new skills, such as learning about nutritional values of crops they grow (Smit 1996). Urban agriculture could also promote greater participation in 4H clubs.

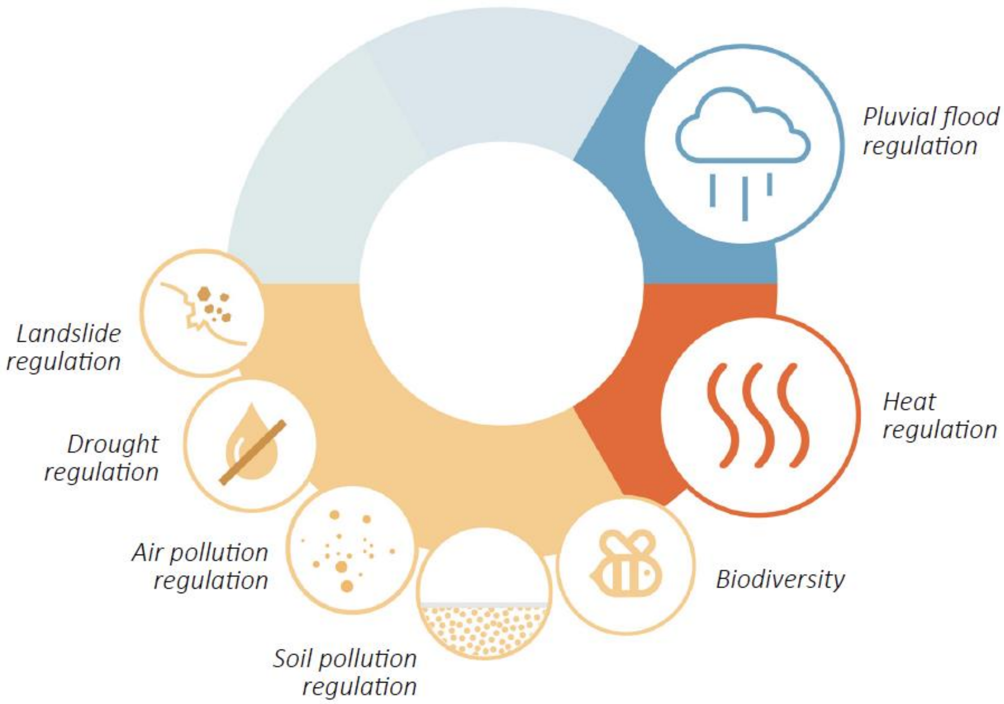


Figure 17: Benefits of Urban Farming

- Urban farming techniques and their characteristics include:

Technique	Characteristics and Benefits
Raised beds	Raised bed farming is a low-cost technique in urban areas where soil pollution can be a threat. Raised beds can be built to any size, using any noncorrosive material, as long as the structure provides good drainage. Raised beds have many advantages: in temperate regions with cold winters, the beds warm up quicker than the barren ground in the spring, thereby extending the growing season. In areas with limited sun, beds can be tilted to maximize the exposure for plant growth. In cold months beds can be covered or converted into greenhouses
Shipping container farms	Useful in colder climates with higher temperature amplitudes. Containers can fit in almost everywhere, even just in an unused corner of a parking lot and can be powered by renewable energy sources (RES). Special systems can be installed to create an optimal growing environment.
Backyard gardens	Involves growing food on one's property. Backyard gardens are a great example of community building practice with the produce

Technique	Characteristics and Benefits
	being often shared among friends, family, neighbours, or co-workers.
Rooftop gardens	Some densely populated cities already have an extremely limited space. This is where rooftop space comes in. Their advantage is that this form of farming can help in reducing urban heat island and improving the air quality. Rooftop gardens can also be used to beautify common urban spaces.
Vertical Farming	Vertical farming involves growing plants in layers that are deployed vertically i.e. on shelving, or on specially modified pallets against fences or walls. Vertical farms can be housed in abandoned constructions, inside buildings still used, or in above mentioned shipping containers. They are usually combined with other innovative techniques like aquaponics or hydroponics.
Hydroponics	A system for cultivating plants without soil. Instead, nutrients are added to water in which plants are immersed with materials used to support plants’ growth. Hydroponic systems can use organic matter like manure to promote healthy produce. Since water in hydroponics systems is recycled and reused, it can save on water usage – while a traditional farm uses about 400 litters of water to grow a kilogram of tomatoes, a hydroponic system can grow the same amount using only 70 litters of water.
Amphibious farming	Inspired by the ancient Aztec way of farming called chinampas, amphibious farming uses artificial islands built in water. The islands are secured in place by driving wooden stakes into a lakebed and establishing a perimeter with woven reed fences. Amphibious farming areas create a grid, with large enough canals between the island crop beds for a small boat to move through. Planting beds use compost produced in situ as the growing medium
Aquaponics	A practice of bringing up aquaculture and animals like fish or shrimp with vegetables or herbs. It involves the use of a system that captures rain and stormwater from within the city which can then create a self-sustaining, recirculating system. Aquaponics is a highly elaborated technique, but it can be one of the most efficient ways for vegetables, crops, and a protein alternatives cultivation.

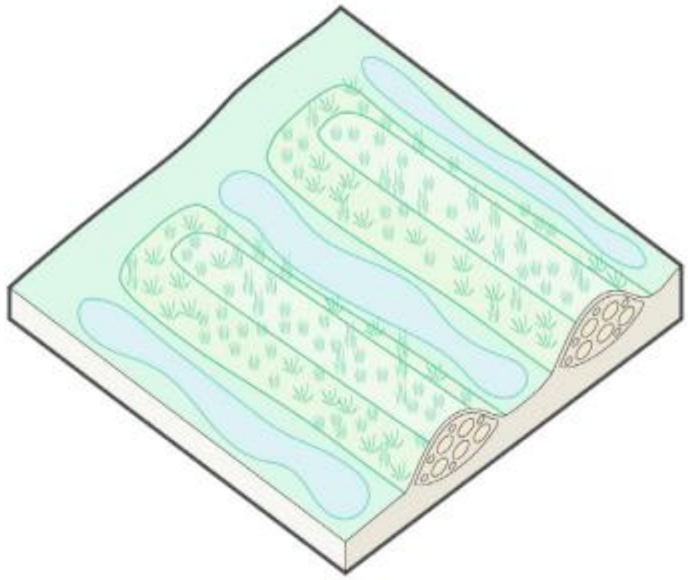


Figure 18: Visualization of a raised bed

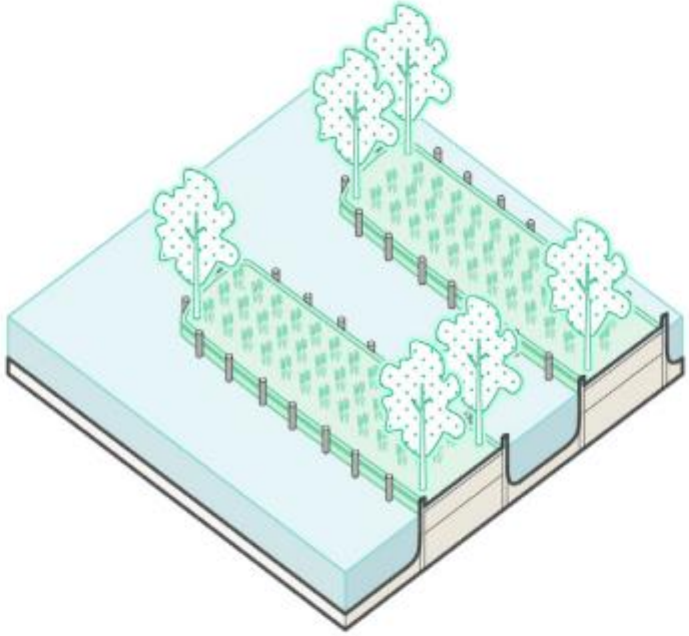


Figure 19: Visualization of amphibious farming

- Cost considerations in urban farming include:

Land	Construction and Implementation	Maintenance
Access to or ownership of land is required for urban farming. Land on which urban farms may be located may be public or private. Land area required for urban farms may range from small areas for community gardens to larger agricultural operations either within or adjacent to urban areas.	Urban farming costs in the U.S. is estimated at US$46.71/m2 /year (US$467,100/ha/ year), including personnel, location plans, environmental assessment, site preparation	Maintenance costs of urban farming include traditional farming activities over a growing season, including weeding, fertilizing, watering, and harvesting.

Tabletop Discussion/Group Exercise

- How and where can urban farming be applied to urban and peri-urban areas in the Jamaican context?

Case Studies – Urban Farming

Photo by Hernán García Crespo on Flickr

Preservation of cultural knowledge and agricultural heritage | Local community empowerment | Boost of local economies and tourism

Project #1: *Floating farms, ongoing*
Location: *Xochimilco, Mexico City*
Description: *Waterborne chinampa farming system—sometimes called floating gardens—is a form of ancient raised bed agriculture that continues to be successfully used by small farmers today. Chinampas are long and narrow floating garden beds separated by canals. The garden lot is built of layers of woven wetland reed mats, stacked on top of each other while alternating directions of a weave, and interlaced with mud and thick mats of decaying vegetation. The layered bed accumulates additional highly fertile fluvial sediment and makes for an exceptionally productive growth medium. The benefit of a chinampa system is that the water in the canals provides a consistent passive source of irrigation that allows for efficient and reliable agricultural practice.*

Benefits
History and Identity, Education, Economy.
Source
Mexico City, FAO, Authority of the world natural and cultural heritage zone in Xochimilco, Tlahuac, and Milpa Alta
https://www.fao.org/3/I9159EN/i9159en.pdf
https://www.fao.org/giahs/giahsaroundtheworld/designated-sites/latin-america-and-the-caribbean/chinampa-system-mexico/en/

Photo by Ninara on Flickr

Households largely involved in urban farming | Collaboration of local community in research surveys | Woman empowerment.

Project #3: *Kibera's vertical farms, 1980s to date*
Location: *Kibera, Nairobi, Kenya*
Description: *Urban agriculture in Nairobi is practiced in backyard farms, on open spaces under power lines, along roadsides, railway lines and riverbanks as well as on institutional land. In the mid 1980s, when the urban population reached one million mark, 20% of Nairobi households were growing crops and 17% kept livestock within the city limits. It is estimated that 30% of households in Nairobi are involved in urban farming. Social value is created by the promotion of value-chain development and direct producer–consumer marketing. Family time and labor spent on urban agriculture depends on the size of land, intensity of the practice, and number of livestock. In the peri-urban transition areas, most labor for vegetable production is provided by women.*

Benefits
Economy, Gender Empowerment, Education.
Source
African Studies Centre, Leiden, Netherlands
http://documents1.worldbank.org/curated/en/434431468331834592/pdf/807590NWP0UDS00Box0379817B00PUBLIC0.pdf

Open Green Spaces

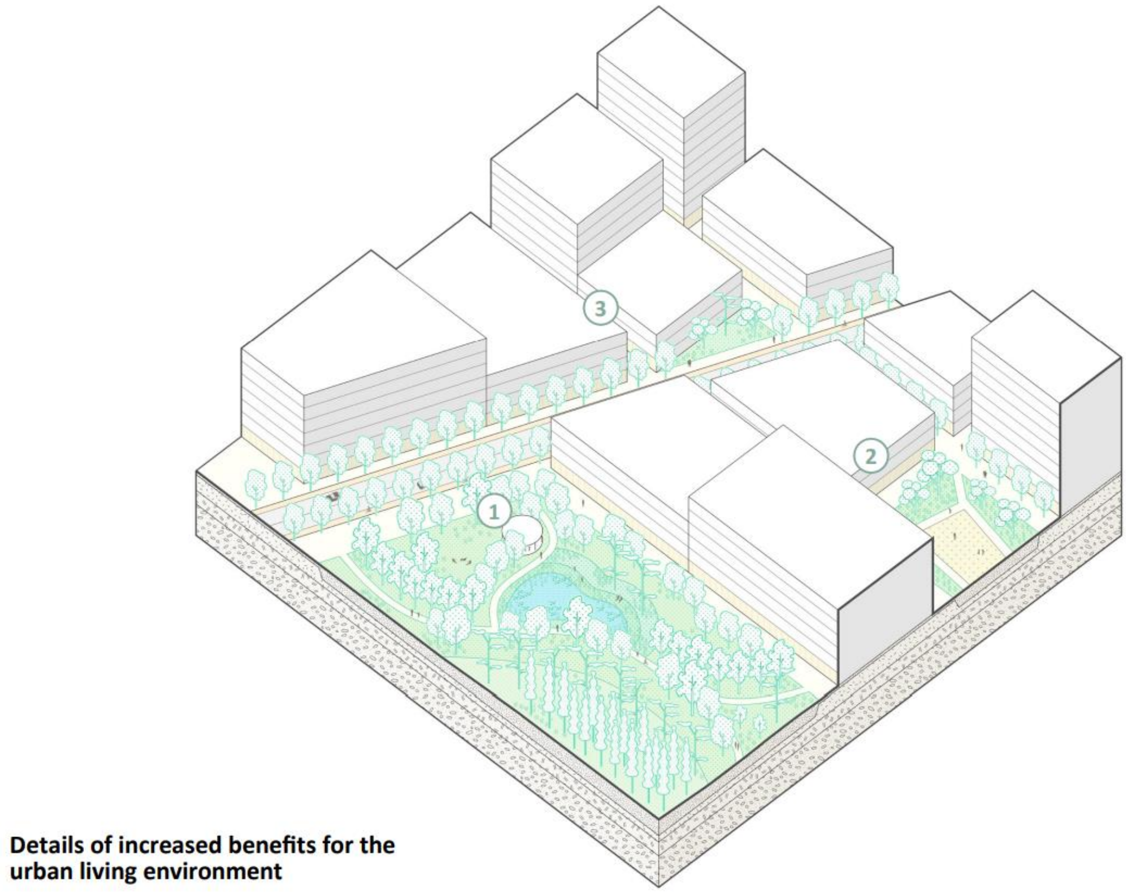


Figure 20: Visualization of open green spaces in the urban context

- Open green spaces cool cities and counter their 'heat island' effect. Increased temperatures and more frequent and intense heat waves are especially harmful for cities, which are on average 3–8°C warmer than surrounding rural areas. This so-called urban heat island effect is mainly caused by the heat emitted by buildings, industry, and transport, as well as by a lack of the shading and cooling effect of vegetation. The solution is, therefore, green.

- Tree canopy cover and well-irrigated grassed areas can lower surface temperature by around 15°C, green walls and roofs cool adjacent rooms by about 2°C, and green areas lower the urban heat island effect by 1°C, on average. This phenomenon is known as the 'park cool island effect'. Urban trees are perhaps the most effective and least costly approach to urban heat island mitigation and adaptation (Norton et al., 2015; Solecki et al., 2005)

- There is growing recognition of the importance of developing green urban areas and linking fragments of green space with ecological corridors to improve biodiversity and animal species dispersal within the urban landscape.

- Urban areas can have positive effect for human health and climate change adaptation. The capacity of vegetation to retain water is an important flood prevention feature that can reduce peak discharges.

- In cities, green spaces can also provide cooling through shading and enhanced evapotranspiration, thereby reducing the heat island effect that occurs in many cities. The expansion of city structures threatens green areas which have fragmented natural areas with the creation of small patches of green spaces amongst buildings and roads.

- Preservation and creation of green spaces help in augmentation and sequestration of carbon. Healthy vegetation and green spaces in the city vicinity influence the quantity of water availability locally.

- The creation of green areas and corridors can be applicable in most urban areas.

- There is a wide array of available techniques which allows for the application of green spaces in areas with various characteristics and even where space is limited. Some of the techniques include green roofs and walls which use vegetation on the roofs and facades of buildings to provide cooling in summer and thermal insulation in winter.

- Functions of open green spaces include:
    - Helping to manage stormwater and mitigate floods. Trees, gardens, and lawns intercept and absorb rainwater through soil infiltration and evapotranspiration, also helping to recharge aquifers. The capacity of green spaces to reduce flooding depends on the extent of the park relative to the catchment area, the topography, type and density of vegetation, and soil characteristics.
    - Urban green spaces reduce heat by providing shade and evaporative cooling (Gehrels et al. 2016). By some estimates, large park areas of more than 10 hectares can reduce temperatures by 1°C or 2°C (33.8 or 35.6°F) within 350 meters of the park boundary (Aram et al. 2019). Small parks can maintain air temperatures lower than the surrounding built areas by as much as 3°C (37.4°F) (Singerland 2012).

    - Open green spaces reduce subsidence, build resistance against drought, remove pollutants from air, water, and soil, and support biodiversity by providing nourishment and habitat for flora and fauna (Eisenberg and Polcher 2020)

- Some types of open green spaces include:
    - Pocket parks – these are relatively small open spaces distributed throughout the urban fabric. Pocket parks serve the immediate population of a neighbourhood and provide a wide variety of small-lscale recreation possibilities, such as playgrounds, dog parks, workout stations, water fountains, vegetable and flower planters, and other props for neighbourhood recreation. Pocket parks can also appear on vacant lots throughout communities

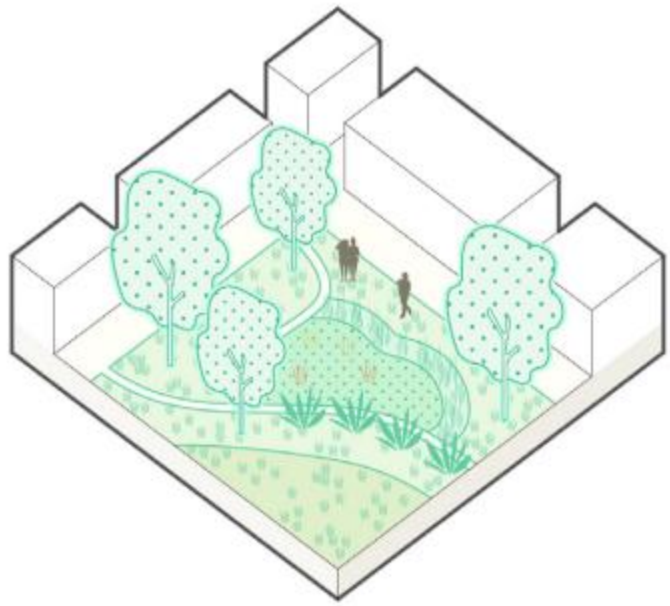


Figure 21: Visualization of a pocket park

Natural playgrounds include trees, flowers, rocks, and water features and can help children develop their sensory skills, tactile perceptions, creativity, and appreciation for nature (Kahn and Kellert 2002). Playgrounds encourage social and physical activity for all ages. Ponds and other blue–green infrastructure in playgrounds can provide educational opportunities to children, green retreats of recreation, and enjoyment to others, while contributing to stormwater management.

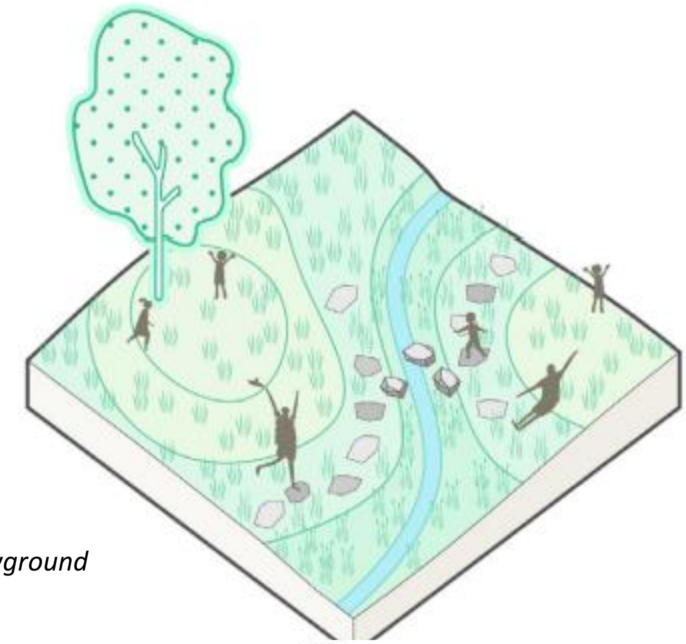


Figure 22: Visualization of a natural playground

Climate-proof Residential Gardens – These gardens can help with stormwater reduction. Where there are several residential gardens in urban areas, they can have a large cumulative impact in stormwater reduction if they are integrated into larger green infrastructure networks. Each garden manages storm water from buildings, roofs, and courtyards, capturing and recycling stormwater. The vegetation also helps mitigate heat, while trees, bushes, and other vegetation provide habitat. Residents can also use gardens for growing vegetables and recreational uses – using similar techniques as in urban farming.

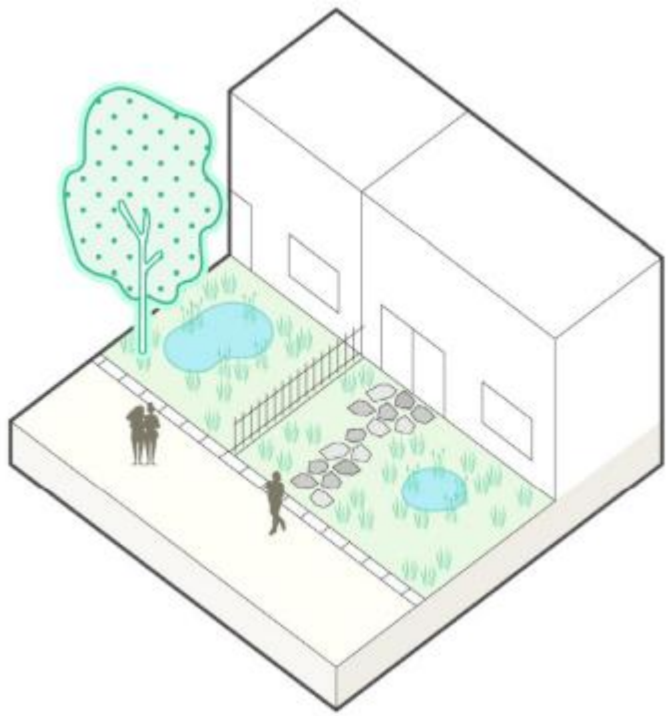


Figure 23: Visualization of a residential garden

Tabletop Discussion/Group Exercise

- How and where can open green spaces be applied to urban and peri-urban areas in the Jamaican context?

Case Studies – Open Green Spaces

Photo by Saúl Ortega on Flickr

Private donation from local stakeholders | *Equity promotion through playing and learning* | *Linked to cultural amenities, offering interdisciplinary activities*

Project #1: *Julio Mario Santo Domingo Library Park, Completed 2010*
Location: *Bogotá, Colombia*
Description: *The Santo Domingo Library and gardens, set in 55,000 m^2 space, offer extraordinary benefits to the population of the northern districts of Bogotá—Usaquen and Suba. The restoration in 2010 involved conserving many existing plants while adding new ones. The gardens create an excellent education space and contain many rediscovered indigenous plants that are endangered, reviving a process of ecological restoration. The project demonstrates how important a healthy, green space can be to the mental wellbeing and physical health of urban dwellers*

Benefits
Education, Biodiversity, Health.
Source
Diana Wiesner and Daniel Bermúdez.
http://landezine.com/index.php/2013/06/julio-mario-santo-domingo-library-park-by-diana-wiesner-arquitectura-y-paisaje/

https://www.researchgate.net/publication/307751026_Julio_Mario_Santodomingo_Library's_Public_Space

Photo by Google Earth

Renewal of common residential areas and building trust through design | *Community involvement in project design and execution* | *Active space between private and public properties*

Project #4: *Common-Unity, Completed 2016*
Location: *San Pablo Xalpa, Azcapotzalco, Mexico City*
Description: *Common-Unity is a public space rehabilitation project for San Pablo Xalpa Housing Unit in Azcapotzalco, Mexico City. The unit was previously divided into sectors. Walls, fences, and barriers led to a fragmentation of spaces that did not allow the community to benefit from public spaces. The project transformed such a divided space into a neighborhood space. The recovered public space became an extension of each apartment. The strategy was a big success: people contributed to the design and an increasing number of people decided to remove their fences*

Benefits
Heat Stress Risk Reduction, Social Interaction, Health and wellbeing.
Source
Rozana Montiel, Estudio de Arquitectura
https://www.archdaily.com/892388/common-unity-rozana-montiel-estudio-de-arquitectura

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Green Corridors or Linear Natural Infrastructure

- Green corridors, are also known as linear natural infrastructure

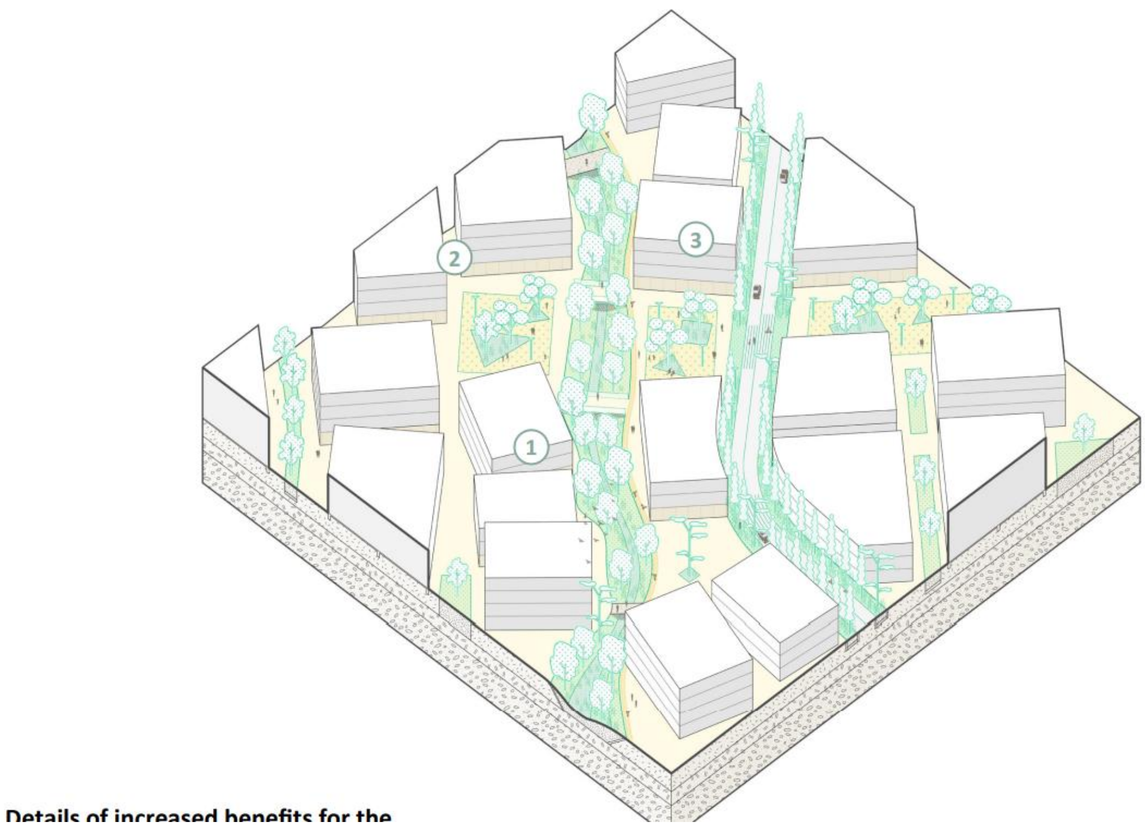


Figure 24: Visualization of green corridors in the urban setting

- Green corridors are strips of trees, plants, or vegetation can be found at a range of scales, and typically connect green spaces in a city, creating a green urban infrastructure network.

- Green corridors complement green spaces in a city, protect natural habitat, and typically contain the most valuable animal species urban habitat.

- The corridors allow biota to move, survive, and propagate.

- Adequately designed green corridors can improve urban ventilation, allowing for cooler air from outside to penetrate the more densely built areas, and reducing the urban heat island effect.

- Together with architecture, street trees and green corridors enhance urban identity and raise the prestige of different areas.
- Techniques for Incorporating Green Corridors in Urban Areas include:
  - Street tree canopies which are streets lined with large tree canopies which on one hand enhance the image of a city, increase its competitiveness, deliver economic and environmental benefits. Some cities are famous for a particular type of tree and attract seasonal tourism based on the tree-blooming schedule. On the other hand, tree canopies offer a wide range of ecosystem services as they circulate rainwater, create a local microclimate, absorb pollution, provide shade, and attenuate heat. Heat reduction translates into lower cooling bills for buildings. Cooler streets with large tree canopies promote walking and social interaction.

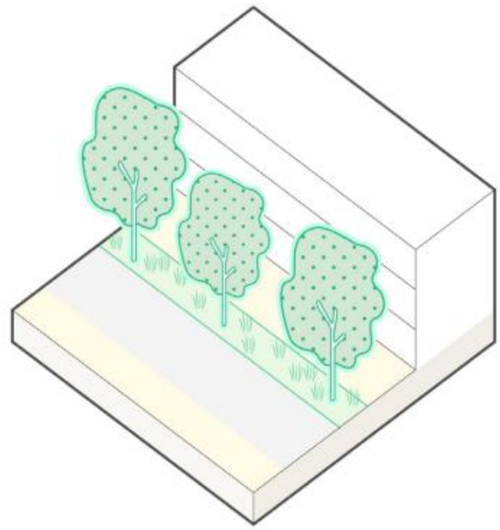


Figure 25: Street tree canopies

  - Green avenues and boulevards are among the most attractive urban typologies, historically proven to improve business, increase property taxes and enhance the prestige and desirability of cities. Functioning as environmental corridors from the start, they are instrumental in climate adaptation. An unpaved, vegetated medium can be integrated into the green infrastructure network for climate adaptation and help prevent floods. Continuous tree canopy efficiently mitigates urban heat, provides shade and shelter for small species, and promotes walking and healthy living.

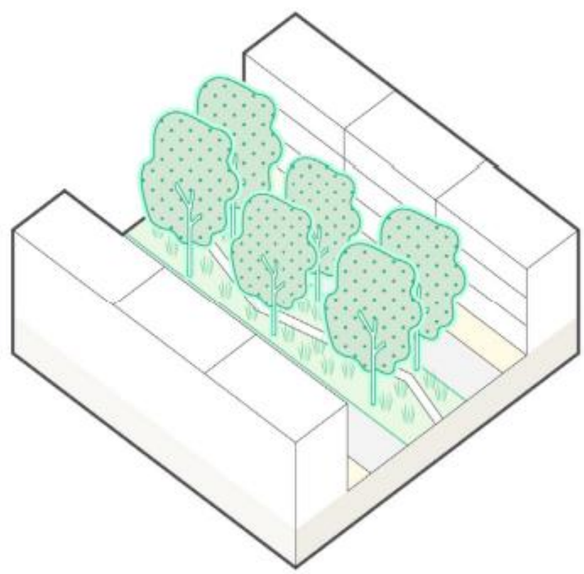


Figure 26:Green avenues

- Urban green corridors involve placing trees along streets, open train tracks, and other transportation and infrastructure corridors, in open and derelict spaces. Green corridors should be designed for multiple functions such as new bike paths, walking, and jogging routes, in addition to water management areas. Green corridors can help establish better landscape connectivity across the city and improve ecosystem functions (NWC 2016). the most efficient way to create a green corridor is to plant deciduous trees as large canopies.

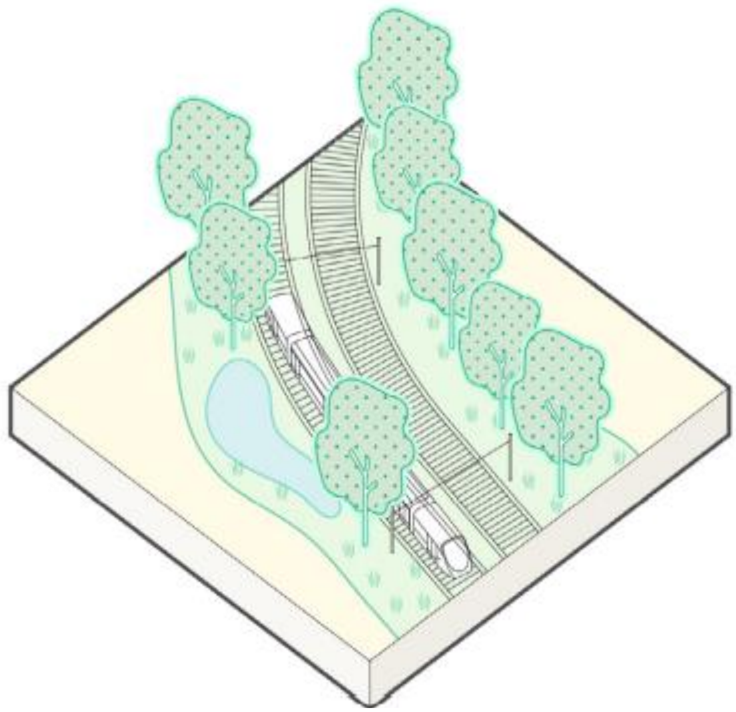


Figure 27: Urban green corridor

- Benefits of open green corridors include:
  - Reducing temperatures and heat in urban areas as trees in green corridors by creating shade and through evapotranspiration. This reduces the amount of heat reflected off buildings and pavements. A continuous tree corridor will have a greater cumulative heat mitigation effect than a set of individual trees (DDOE 2012). The shade reduces the amount of harmful UV radiation reaching pedestrians; it reduces wind speeds and air pollution.
  - Reducing the incidence of flooding in urban areas as the trees in green corridors increase the interception of rainwater in urban environments, reducing risks of local floods and peak loads of stormwater in the sewerage system.
  - Enhancing the tourism product and increasing opportunities for recreation, allowing both tourists and resident to experience the urban area in new ways.

- to the outdoors (Sullivan et al. 2004). Carbon storage and sequestration: Linear green corridors, such as street trees store and sequester carbon. For example, an empirical study of Beijing street trees found very high heterogeneity carbon density rates between different corridors (Tang et al. 2016). This study estimated the average aboveground carbon density of urban street trees at 13.9 ± 0.7 tons CO2 per ha. The contribution of green corridors to carbon sequestration will vary significantly based on the habitat structure and growth rates of plants associated with the corridor. Where dominated by grassy areas, rates are likely to be in the region of 0.5 to 5 tons CO2 per ha per year whereas this could increase to well above 5 tons CO2 per ha per year for forest-dominated corridors; and found an average sequestration rate of 0.5 ± 0.3 tons CO2 per ha per year (Bernal et al. 2018). Human health:
- Green corridors work as buffers and shield people from the noise and pollution of large-scale infrastructure.

- The spatial arrangement of street trees and green corridors define levels of biodiversity in cities. Green corridors sustain biodiversity by connecting different patches of green within the city. Street trees provide habitat for birds, and other smaller species of animals.

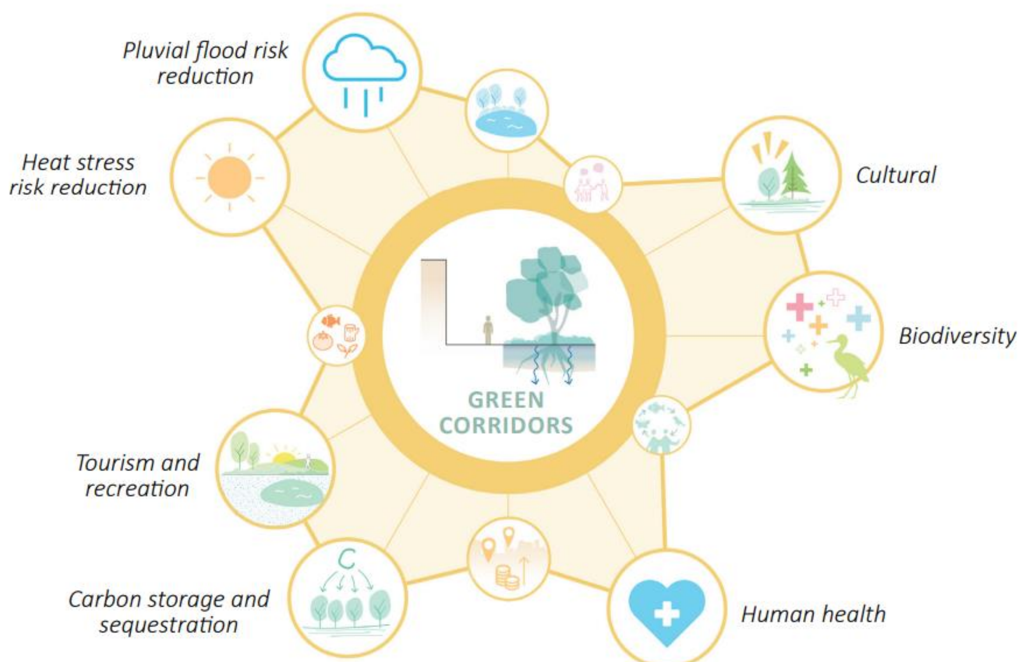


Figure 28: Benefits of green corridors

CASE STUDY: Green Corridors, Medellin, Colombia

Project Description: Like many cities, Medellín is affected by rising urban temperatures and the intensification of the urban heat island effect because of climate change. The Medellín Green Corridors project addresses this issue by creating green corridors, which span a total of 65 hectares, in urban spaces where they are needed the most, such as in abandoned or isolated areas. These corridors both connect existing green spaces and create new green spaces for an increase in habitat connectivity and overall urban biodiversity. To create parks, 8,300 trees and 350,000 shrubs have been planted, as well as borders along 18 roads and 12 waterways to provide shade and improve air quality to these congested areas. A 2-3°C drop in surface temperature has already been achieved, with a noticeable impact on the well-being of citizens. Additionally, the creation of green space allows for greater carbon sequestration. As plants continue to grow and the project evolves, these benefits are only expected to increase.

Ecosystem services restored or conserved: Urban green spaces created to reduce urban heat island effect and for carbon sequestration.

Conventional engineering approach: Streets, curbs, and sidewalks

What makes this a good green-gray example? Many abandoned spaces, once troubled by crime and drug use, have now been transformed into gardens, that are taken care of by community members from disadvantaged backgrounds who previously did not have access to work. With the emphasis on community improvement and involvement, this project yields a deep sense of community ownership.

Tabletop Discussion/Group Exercise

- How and where can green corridors be applied to urban and peri-urban areas in the Jamaican context?

Case Studies – Green Corridors

Photo by Google Earth

Showcase for coexistence of infrastructure and social interaction | *Design oriented: Launched as an international idea competition* | *Active participatory process with neighbors*

Project #3: *Cuernavaca Ferrocarril Linear Park, 2016–20 (Phase 1)*
Location: *Mexico City, Mexico*
Description: *Located at the heart of Mexico City, the project consists of an active urban forest of 4.5 km in length, which crosses 22 districts and buildings. This green corridor is an active, programmed, and sustainable connector of spaces. It created spaces that contribute to the spirit of community and it has promoted a sense of ownership of public space by people. It also achieves high social value by strengthening identity and memory of the history of the place, by creating a sustainable and high quality environment for people to linger and use at their own leisure.*

Benefits
Education, Culture, Biodiversity, Health, Community.
Source
Gaeta Springall Architects
https://mooool.com/en/linear-park-ferrocarril-de-cuernavaca-by-gaeta-springall-arquitectos.html

Photo by Thomas Timlen on Flickr

Symbol for sustainable development of public space | *Long term vision, framework and design strategies to guide progressive implementation* | *Launched as an international competition for masterplan development*

Project #4: *The Rail Corridor Project, 2015–21*
Location: *Singapore*
Description: *The closure of Keratapi Tanah Melayu (KTM) railway in 2011, bisecting Singapore released 24 km of continuous land spanning the entire nation. In the face of population growth and urbanization, Singapore made the bold decision to transform the 100-hectare site into public space to provide benefit to its people and the environment.*
The design included the creation of 8 themed stretches and 10 activity nodes, dedicated to different sports or leisure activities.
The project reinvented hidden space within Singapore to inspire movement and new ways of experiencing the environment. It allows people to enjoy the interactions between city, nature, land, water, community and art, as well as enjoy heritage sites. The Rail Corridor has become a green, vibrant and healthy space to engage residents and visitors with Singapore's natural and built heritage.

Benefits
Education, Historic Value, Health and Sports, Heat Stress Risk Reduction.
Source
Tan See Nin, Urban Redevelopment Authority
https://www.csc.gov.sg/articles/co-creating-the-rail-corridor's-future

Building Solutions

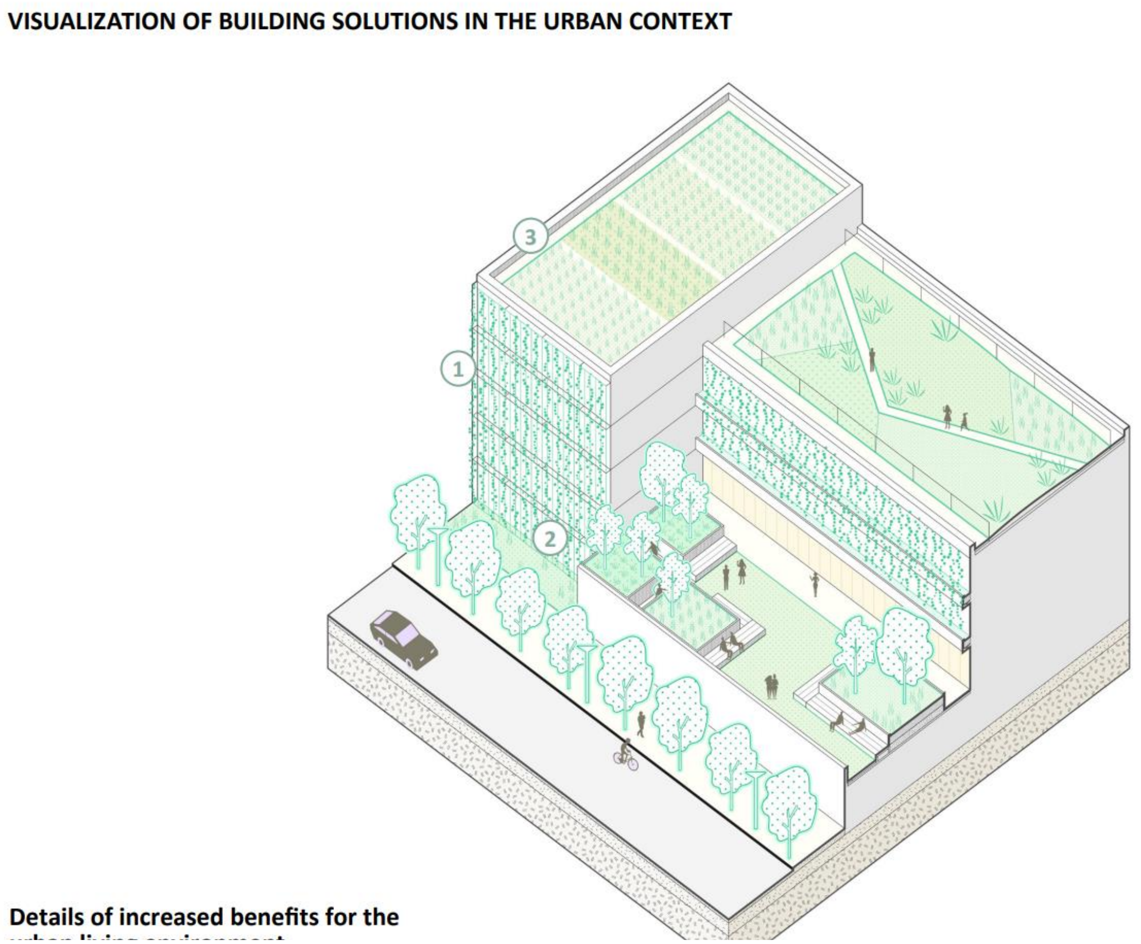


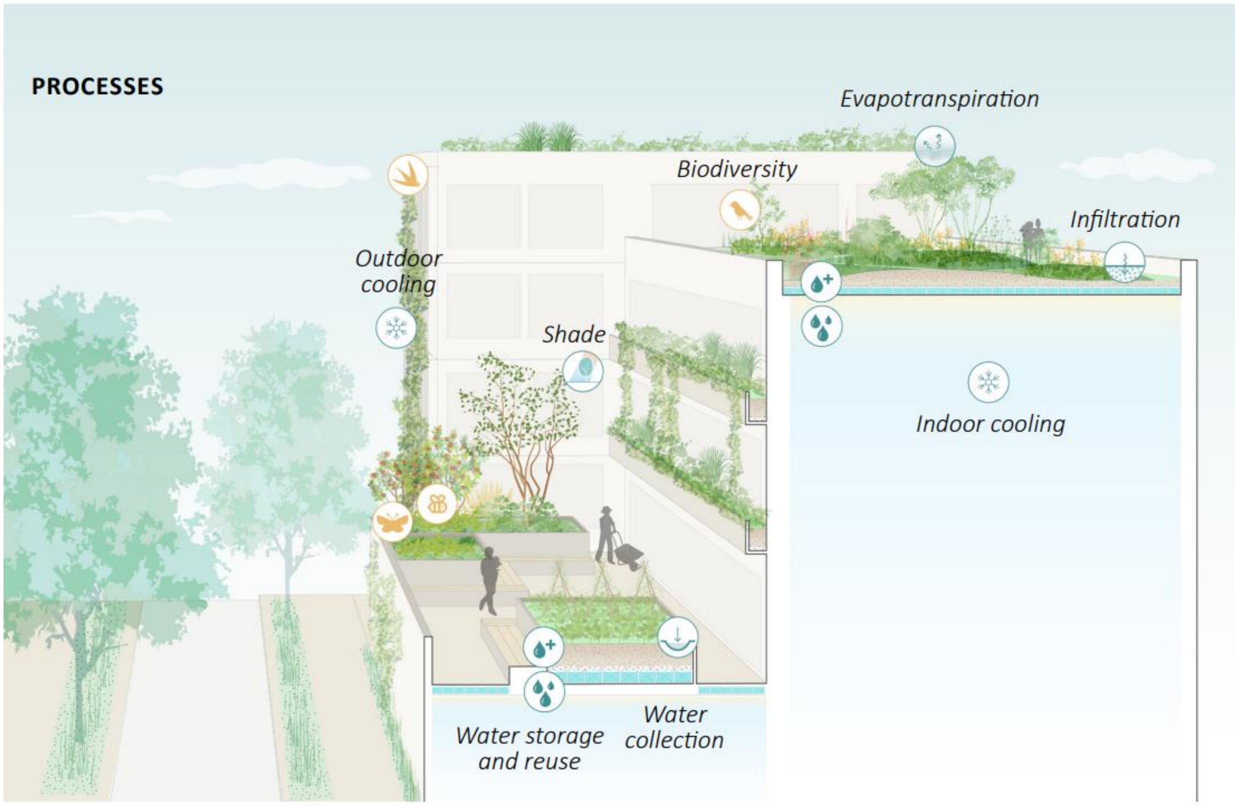
Figure 29: Visualization of Building Solutions

- Building solutions include adding green surfaces to building roofs and facades, creating opportunities to capture, store, and reuse stormwater, improve air quality, and reduce temperatures. It involves construction of new green roofs and green facades on new buildings or existing buildings (through renovation).

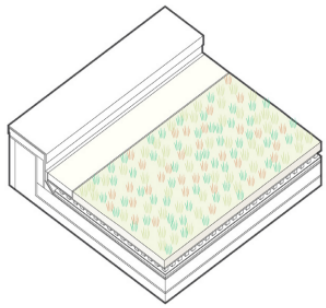
- Building solutions provide urban flooding and heat reduction benefits, and at the same time they can reduce costs by enhancing efficiency of climate control systems in buildings.

- Green roofs and facades are examples of building solutions and may also improve property values and marketability of a building, especially in urban areas with little green space, and accommodate additional space for human use and urban functions associated with food production.

- Processes and benefits of building solutions

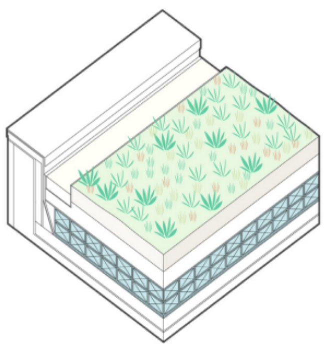


SPECIAL TECHNIQUES FOR GREEN ROOFS AND GREEN FACADES



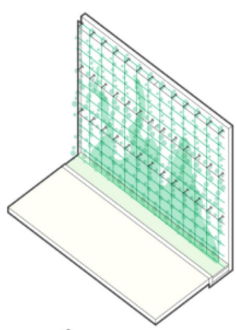
Extensive green roofs

Extensive green roofs consist of several horizontal layers—bioengineered growth medium; membranes to support and control plant roots; buffers to collect, filter, store, reuse, or discharge water, as well as structural and insulation layers. Performance criteria based on desired plant typology and the quantity of water determine the thickness and the composition of the layered structure. The roofs are normally not accessible to the public and have drought resistant plants that can withstand variations in temperature and sun exposure (Eisenberg and Polcher 2020).



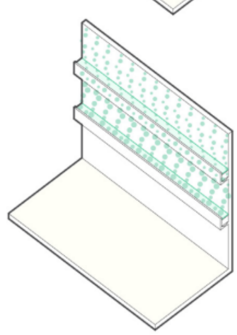
Intensive green roofs

The structure of intensive green roofs has a thicker substrate layer supporting higher variety of vegetation. In addition to water management and cooling, they provide amenities to building residents—opportunities for gardening, exercise, sunbathing, relaxation, and socializing. Intensive green roofs have good returns on investment of lowering building energy bills. They provide habitats for attractive species, birds, bees, and other pollinators. Installation and maintenance come with a higher price tag than extensive green roofs (Eisenberg and Polcher 2020). Rooftop gardens are a special type of intensive green roofs, which serve as a productive garden for urban farming. Rooftop gardens require higher investments and a robust structural capacity of the roof to support the higher installation and, maintenance, but offer higher use and accessibility to people. A special type of smart green roofs is constructed with a system of crates located under the vegetation layer that stores rainwater. The crate system can be dynamically controlled and drained at a later preferred time. In return, the stored rainwater can be used for irrigation (Dakdoctors.com).



Ground-based green facades

Ground-based green facades are a type of green wall with climbing plants rooted in ground planters. The climbing or self-clinging plants, with adhesive pads as part of their anatomy, can grow directly on the wall or on a special frame connected to the wall. The plants extract water and nutrients from soil at ground level and can grow very tall, and adjust to climate fluctuations and different lighting conditions. Many flowering and evergreen species can add aesthetic experience to exterior walls, cool, and freshen the air (Eisenberg and Polcher 2020).



Facade-bounded greening

Facade-bounded greening is a type of green wall using technology for irrigation and special substrates for reducing the weight of green facades (Eisenberg and Polcher 2020). They are more expensive than ground-based greening and require higher use of resources in construction and maintenance. Facade-bounded greening allows for a combination of 10–15 plant species, most often mosses and perennials, and grows fast and uniform. The thin layer of soil inhibits their suitability in cold, temperate regions (Iwaszuk et al. 2019).

Figure 30: Techniques for Developing Green Roofs and Green Facades

- Cost considerations for building solutions are:

Land	Construction and Implementation	Maintenance
Access to or ownership of land is required, potentially through collaboration and engagement with building owners	The cost of green roof installation varies widely depending on the types of building solutions, the complexity of the installation roof, and material and labor costs at the site location.	Maintenance costs on green roofs or facades will be a function of the type of roof as well as of the local climate and weather. Frequent inspection of green roofs and facades is necessary to conduct necessary maintenance, such as clearing dead plants, weeding, pruning, and fertilizing. Intensive green roofs are generally more expensive than extensive green roofs.

Tabletop Discussion/Group Exercise

- How and where can building solutions be applied to urban and peri-urban areas in the Jamaican context?

Case Studies – Building Solutions

Photo by Doaa211 on Wikimedia Commons

Government initiative in collaboration with local stakeholders

Scope for education and promotion of healthy lifestyle

Women empowerment and knowledge transmission

Project #1: *Greening Cairo's roofs, 2001–03*
Location: *Cairo, Egypt*
Description: *The objective of the Cairo and Alexandria Green Roof program was to offer low-income suburban families a possibility of growing their own food and to create income-generating opportunities. The program was wholeheartedly embraced by local women, who began to produce fresh vegetables and use the roofs for social gatherings in a safe, semiprivate setting. FAO initially trained 48 families in the use of hydroponics systems and green techniques, eliminating use of pesticides. Since then the project has become an urban and peri-urban horticulture model.*

Benefits
Environmental, Climate, Micro-economy, Gender Empowerment.
Source
FAO Regional Office for Near East and North Africa
https://www.researchgate.net/publication/269873380_Green_Roofs_in_Cairo_A_Holistic_Approach_for_Healthy_Productive_Cities

Photo by Alejandro Arango / El Equipo Mazzanti

Integrated with park and neighborhood renewal plan

Scope for equity, publicness, social connection, and crime reduction

Design oriented: Launched as idea competition

Project #3: *Bicentenario Park, 2007–16*
Location: *Bogotá, Colombia*
Description: *Bicentenario Park was conceived as a revitalization project in downtown Bogotá and inaugurated in 2016. It is a reinforced concrete bridge that adapts to the topography of the terrain and meets a vast number of urban technicisms and norms of the city. In order to transform this bridge into a green public space of 4,600 m^2, a series of extensive and intensive green roofs were designed, resulting in eight small vegetated squares. A wide variety of native and adapted plants were selected by the Botanical Garden of Bogotá. The new Parque Bicentenario restoration has become a healing factor in the division between the south and north sectors of Bogotá.*

Benefits
Heat Stress Reduction, Equity, Recreation, Social Interaction.
Source
Bogotá city, El Equipo Mazzanti
https://www.greenroofs.com/projects/parque-bicentenario-bogota/

https://www.archdaily.co/co/898371/parque-bicentenario-un-proyecto-que-ayuda-a-coser-una-herida-urbana-en-bogota

Natural Inland Wetlands

- Natural inland wetlands are highly biodiverse, productive ecosystems that form an interface of land and water and deliver valuable ecosystem services.
- Processes supported by natural inland wetlands include:

- Functions of natural inland wetlands include:
    - Pluvial and riverine flood regulation: Certain inland wetlands attenuate stormwater flow by spreading it evenly across their flat and wide terrain, instead of confining it to a narrow channel. This way they can hold back considerably more stormwater, while infiltrating and removing the sediment and pollution and stabilizing the water table (Ozment et al. 2019). The potential for flood attenuation varies across wetlands and is based on their size, vegetation and soil type, shape and capacity of the basin, and other factors.
    - Heat regulation: In highly humid conditions, the rate of wetland evapotranspiration significantly impacts local and regional climate (Roggeri 2013). Studies suggest that wetlands may have cooling effect. For example, a study conducted in Mexico City measured the effect of wetlands on temperature and recorded an incremental rise of about 2°C (35.6°F) every 35 meters as the distance from the body of water increased (Wetlands International 2020). Heat reduction can be further increased in areas with large, dense canopy trees or if the airflow can pass unobstructed across the open water areas.
    - In urban environments wetlands extract pollutants from the surface water, lessen stream erosion, recharge groundwater, store stormwater, and release it during dry periods (Wood and van Halsema 2008).
    - Natural inland wetlands mitigate the loss of biodiversity in urban environments and provide key habitats for l ocal and migratory species.

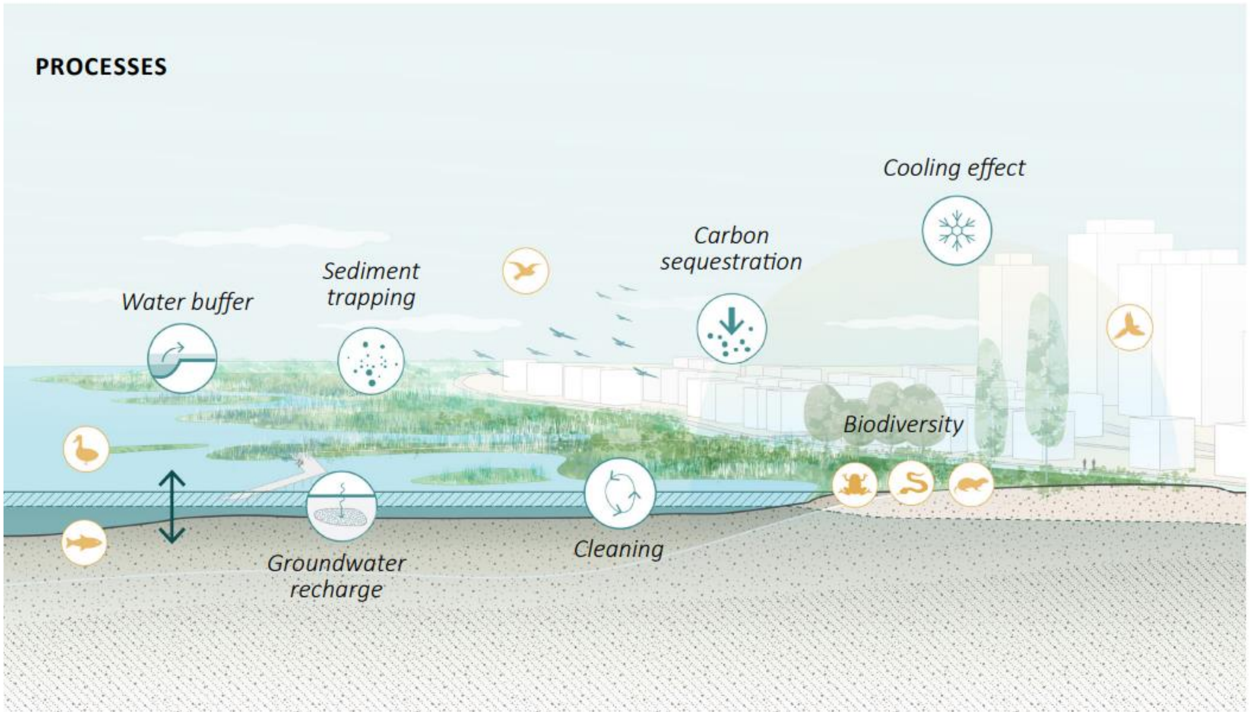


Figure 31: Processes supported by natural inland wetlands

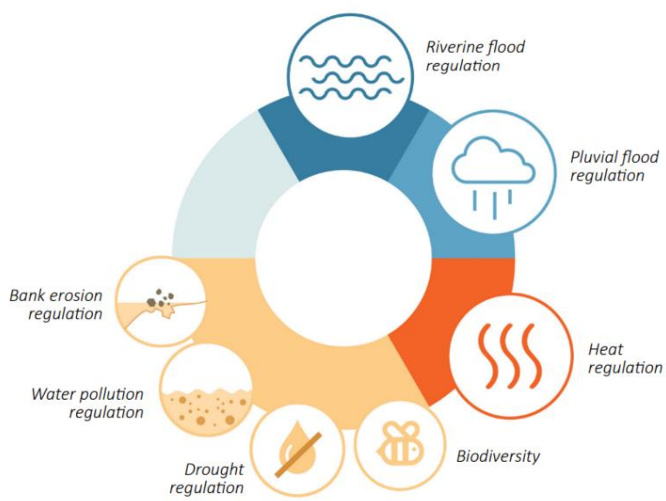


Figure 32: Functions of natural inland wetlands

- Benefits of inland wetlands include:
    - Mitigating floods in urban environments and protecting urban rivers by capturing, buffering, and storing stormwater (Wood and van Halsema 2008), reducing the velocity and the amount of peak stormwater flow, and preventing large quantities of untreated water from entering the water bodies (Maltby 1986).
    - Treating wastewater and improving water quality in urban environments by purifying and enhancing the retention of many compounds and facilitating processes such as denitrification, ammonification, and the formation of insoluble phosphorous metal complexes (Bastian and Benforado 1988).
    - Acting as natural sediment traps with the slow flow of water through wetland vegetation promoting sediment deposition.
    - Important carbon sinks, as they are able to store vast amounts of carbon and thereby helping to mitigate climate change. Sequestration rates increase with vegetation cover (Valach et al. 2021) and are likely to be higher for woody than herbaceous systems. Drained or damaged wetlands on the other hand, are a major source of greenhouse gas emissions since human disturbance, particularly drainage, releases carbon in CO_2, leading in years to the loss of carbon that accumulated over centuries or millennia. The wise use and restoration of natural inland wetlands is therefore essential to protect stored carbon and reduce avoidable carbon emissions (The Ramsar Convention Secretariat, 2018).
    - Stimulate local economies and job creation: As wetlands have a significant tourism potential, and food and materials they can stimulate the local economy, by supporting several jobs and livelihoods
    - Being important sources of food and building materials. These uses need to be carefully managed so as not to undermine other ecological functions, which require balancing agricultural uses and needs of biodiversity (Wood and van Halsema 2008).
    - Support of wildlife populations

Figure 33: Benefits of inland wetlands

- Natural inland wetlands also provide tourism and recreation services and are some of the last remaining pieces of natural habitat in cities. Tourism and recreation activities supported by inland wetlands include fishing, hiking, nature observation and photography, bird watching, canoeing, and boating (Wood and van Halsema 2008).

- Wetlands are also one of the most productive habitats with greater species diversity, nutrient recycling, and niche specialization than most other ecosystems. Almost all the world's waterbirds and migratory birds use wetlands as feeding, migratory way stations and breeding grounds (CBD 2015).

Case Studies – Natural Inland Wetlands

Photo by Bing maps

Wetland protection approach. Conservation and Management Act

City largely depends on wetlands resources

Community sensitivity and local heroes for conservancy

Project #1: *East Kolkata Wetlands, 2006 to date*
Location: *Kolkata, India*
Description: *Spread over 12,500 hectares on the eastern side of the city of Kolkata, this natural wetland is a Ramsar site and one of the largest wastewater-fed aquaculture systems in the world. It provides fishing opportunities for locals and supports paddy and vegetable cultivation in small plots in and around the wetland system. The wetlands serve two functions that may seem contradictory at a first glance: they are the city's free sewerage works and they are also a fertile aquatic market garden. Wastewater is used in paddy fields and vegetables are grown on the verdant banks and on a long, low hill created by Kolkata's organic waste. Wetlands are also a habitat for fish. Not only do these wetlands provide affordable food and vegetables for the city, they also provide livelihood for about 1.1 million people.*

Benefits

Heritage, Economy, Water quality, Flood and Heat Stress Risk Reduction.

Source

East Kolkata Wetlands Management Authority (EKWMA)
http://ekwma.in/ek/
https://www.theguardian.com/cities/2016/mar/09/kolkata-wetlands-india-miracle-environmentalist-flood-defence

Photo by Kongjian Yu / Turenscape

Restoration approach for existing wetlands

Creation of a new urban park and recreation amenities

Showcase for water urbanism approach

Project #3: *Qunli National Urban Wetland, 2006–21*
Location: *Qunli New Town, China*
Description: *Qunli New Town is a new district on the outskirts of Haerbin City in North China. It was built to accommodate 350,000 new residents in over 32 million m² of buildings in 2010. 16.4% of the land to develop was zoned as permeable green space. The rest of the former flat plain was covered in impervious concrete. A 34.2-hectare park was designed on a former wetland area to mitigate flooding. Stormwater from the newly developed urban area is collected in a pipe around the circumference of the wetland. The water is filtrated in the ponds and then deposited into the wetland. Native wetland grasses and meadow grow in the ponds at various depths and following the natural evolution process. A recreational area was integrated into the park for sports and leisure activities.*

Benefits
Biodiversity, Health, Social, Flood and Heat Stress Risk Reduction.
Source
Haerbin City Municipality and Turenscape
http://landezine.com/index.php/2014/01/qunli-national-urban-wetland-by-turenscape/

Photo by Alphart Lungu on Flickr

Large-scale partnership for restoration efforts

Considered the lifeline of region economy

Community involvement in maintenance and job generation

Project #4: *Zambia Wetland Restoration Efforts, 2011–33*
Location: *Kafue Flats, Zambia*
Description: *WWF Zambia has worked to protect and restore wetlands and freshwater ecosystems for more than 50 years. It then engaged organizational and private sector stakeholders in a water stewardship approach in a 30-year project to restore the Kafue Flats floodplain grasslands while simultaneously enhancing their productivity divided in a short-term implementation (2003-2005), medium term (2006-2010) and long term (2011-2033). The project has undertaken a highly intensive eradication of the mimosa tree. The project has generated employment opportunities for at least 150 people from local communities.*

Benefits
Employment, Wildlife, Ecotourism, Food.
Source
WWF Zambia, Government of Zambia
https://www.wwfzm.panda.org/climate___energy_footer/?27825/Wetlands-for-Sustainable-Cities

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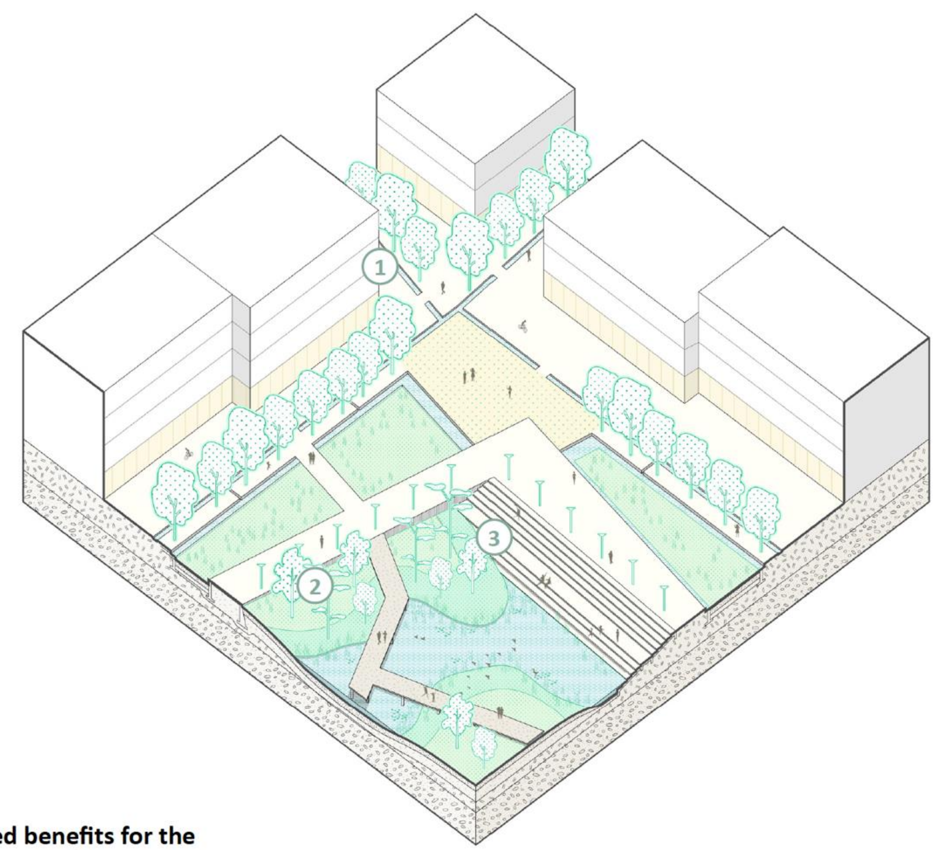
Constructed Inland Wetlands

- Constructed inland wetlands reduce the amount of stormwater runoff by collecting and storing water during flood events. Attenuation capacity of constructed wetlands is determined almost entirely by the size and shape of the basin and the controls used to manage outflow during flood events (Ozment et al. 2019).

- Open water surfaces of constructed inland wetlands have the capacity to absorb heat and help regulate the rate of air temperature change. Open water and wetlands reflect solar radiation and influence humidity and microclimates through natural processes.

- Constructed inland wetlands are typically designed to address water quality risks by removing various pollutants (Kennen and Kirkwood 2015). They can clean stormwater, wastewater, and groundwater by removing and—partially or completely—degrading organic contaminants and nitrogen, while filtering out and storing other inorganic contaminants in the soil (Kennen and Kirkwood 2015).

VISUALIZATION OF CONSTRUCTED INLAND WETLANDS IN THE URBAN CONTEXT



Details of increased benefits for the urban living environment

The Technology of Constructed Wetlands (CW)

- Natural wetlands are rarely used for the polishing of light-contaminated effluents in some areas, but generally their use for wastewater treatment purposes is mostly avoided around the world, since this could cause irreversible damage to ecosystems.

- The basic concept of CW systems is to replicate the various naturally occurring processes under controlled conditions for a beneficial purpose, e.g., treatment of wastewater. This means that CWs are designed in such a way as to mimic and enhance the functions of natural wetlands.

- Although CWs cover in general the same values and functions with natural wetlands, they provide a wider range of ecosystem services; it has been shown that CWs possess a higher value in terms of flood and stormwater control, water quality improvement and biodiversity restoration.

- Their main design characteristics make them more easily adopted and integrated into the built environment by urban planners, engineers, and landscape architects. CWs represent a very interesting and effective development in the field of ecological engineering.

- According to their function and purpose, they can be classified in three main application areas:
    - Constructed wetlands for habitat creation: these systems aim at providing a new wildlife habitat. The main goal is to exploit the ecological benefits of CWs and not only their function as a treatment facility. The main characteristics of CWs (i.e., presence of water and vegetation) make them suitable for the creation of a new ecological habitat or for the restoration of a degraded ecosystem, by attracting wildlife species, especially birds, and establishing a green area. These systems can also be utilized as a source of food and fiber, and as public recreation and education sites
    - Constructed wetlands for flood control: these systems receive the runoff during flood events. Their implementation increases stormwater storage capacity and infiltration volumes, while reducing the volume of water reaching the sewer system and eventually the treatment plants. Within the urban hydrologic cycle, these CWs may significantly contribute to the integrated urban water management and also provide the ability to recycle the stored water volume.
    - Constructed wetlands for wastewater treatment: these are engineered systems designed to receive and purify wastewater from various sources, exploiting the

naturally occurring treatment processes. This is the most widely used application of CWs internationally.

Tabletop Discussion/Group Exercise

- How and where can constructed inland wetlands be applied to urban and peri-urban areas in the Jamaican context?

Case Studies – Constructed Inland Wetlands

Photo by Cord Rodefeld on Flickr

Climate awareness and identity | *Public space renewal program* | *Participatory process with local communities*

Project #1: *Tanner Springs Park, 2009–12*
Location: *Portland, USA*
Description: *Located in Portland, Oregon, the celebrated Tanner Springs Park is centered around a bioengineered wetland. The project captures and filters stormwater from every roof and paved surface in the surrounding area, reduces flooding during extreme precipitation events, improves water and air quality. This high performance constructed wetland of one acre boasts a great deal of biodiversity and offers a pleasant, accessible social hangout for the neighborhood and delivers significant social benefits for the community. The park also features a boardwalk, an art installation, and a recreational path running through its central area. Park programming emerged through a series of participatory charrettes with the community, which built a strong sense of pride and ownership among the participants.*

Benefits
Health, Education, Heat Stress Risk Reduction.
Source
Atelier Dreiseitl
https://sustainability.asu.edu/urbanresilience/2018/11/portland-oregon-tanner-springs-park/

Photo by Landprocess / Panoramic studio

Urban icon

Design oriented: Launched as an international idea competition

Integrated in educational and cultural institution

Project #2: *Chulalongkorn Centenary Park, 2012–17*
Location: *Bangkok, Thailand*
Description: *The Chulalongkorn University Centenary Park is the critical first part of Bangkok's green infrastructure designed to mitigate environmental degradation and add much-needed outdoor public space to the gray city. The park water treatment system is built around constructed wetlands with detention lawns and retention ponds. The constructed wetlands follow the slope of an inclined plane, and steps down through a series of weirs and ponds. Water passes through a weir, cascades down, flows through a plant- filled pond below, passes through another weir, and flows through another pond. Water is cleaned every time it passes through plants until reaching the retention pond, where children and adults can safely play and enjoy the water.*

Benefits
Pollutants Reduction, Biodiversity, Tourism, Social Interaction.
Source
LandProcess, Kotchakorn Voraakhom
www.nparks.gov.sg/-/media/cuge/ebook/citygreen/cg16/cg16_05.pdf

https://worldlandscapearchitect.com/chulalongkorn-centenary-park-green-infrastructure-for-the-city-of-bangkok/#.YWV7s_lBxPY

Mangrove Forests/Blue Forests

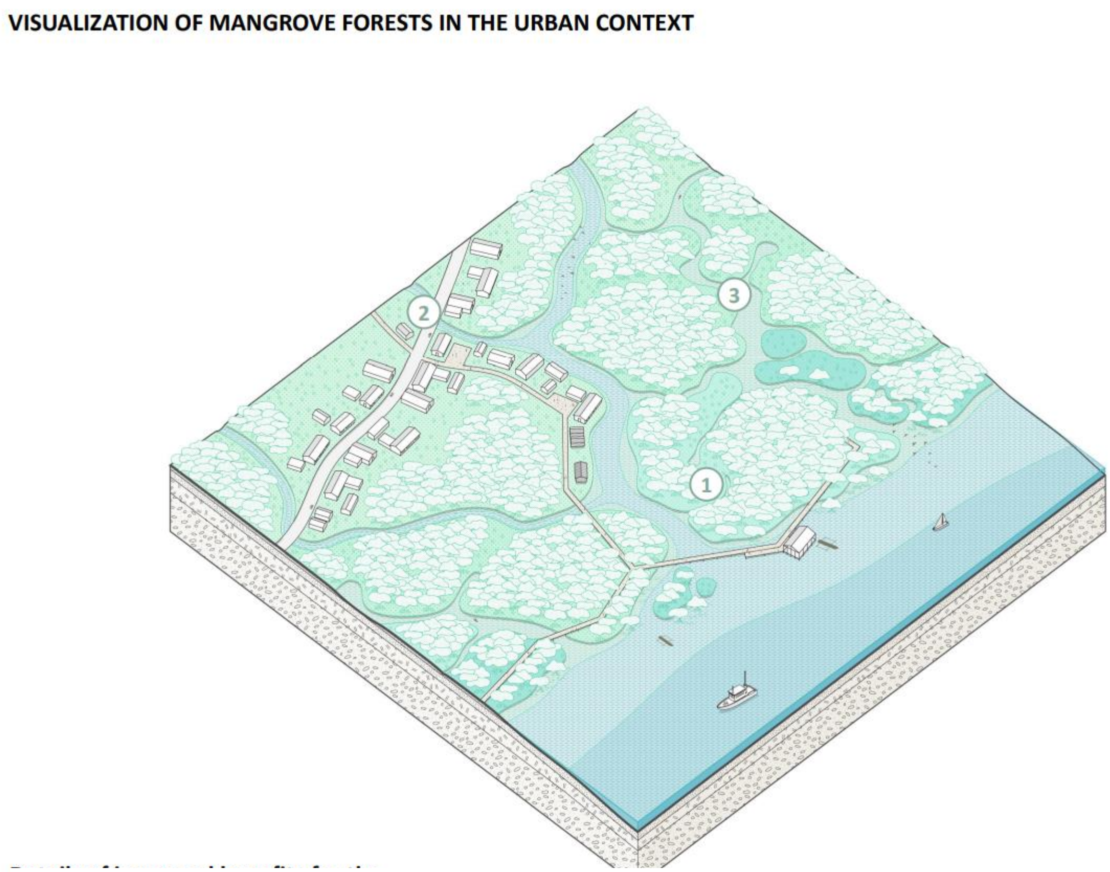


Figure 34: Visualization of mangrove forests in the urban context

- Mangroves are also referred to as the blue forest, are a unique coastal ecosystem of halophytes — salt tolerant trees and shrubs that live in the coastal intertidal zone.

- About 80 different species of mangrove trees—red, white, and black mangroves—are found in many coastlines across tropical and subtropical latitudes near the Equator.

- Mangroves are often located close to urban environments and provide an important protective buffer from coastal hazards. Their flood protection benefits have been estimated more than $US65 billion per year globally (Menendez et al. 2020).

- Mangrove forests also help stabilize the coastline because they reduce erosion from storm surges, currents, waves, and tides.

- Mangrove forests also provide multiple economic and social benefits to coastal communities. Mangroves act as filters for nutrients and sediment, reduce erosion, maintain water quality, and offer feeding and breeding habitats for fish, birds, and crustaceans, critically contributing to the livelihoods of many fishing communities (Zu Ermgassen et al. 2020).

- Mangroves are among the most carbon-rich forests in the tropics and one of the coastal ecosystems globally with the greatest potential to capture and store blue carbon (Taillardat et al. 2018).

- Major causes of destruction to mangrove ecosystems include deforestation, aquaculture expansion in coastal areas for shrimp farming, and aquaculture ponds (Barbier and Cox 2003), to freshwater diversion and land reclamation (Valiela et al. 2001) and other forms of unsustainable use of coastal resources and development.

- It has been estimated that 62% of global losses between 2000 and 2016 resulted from land use change, primarily through conversion to aquaculture and agriculture.

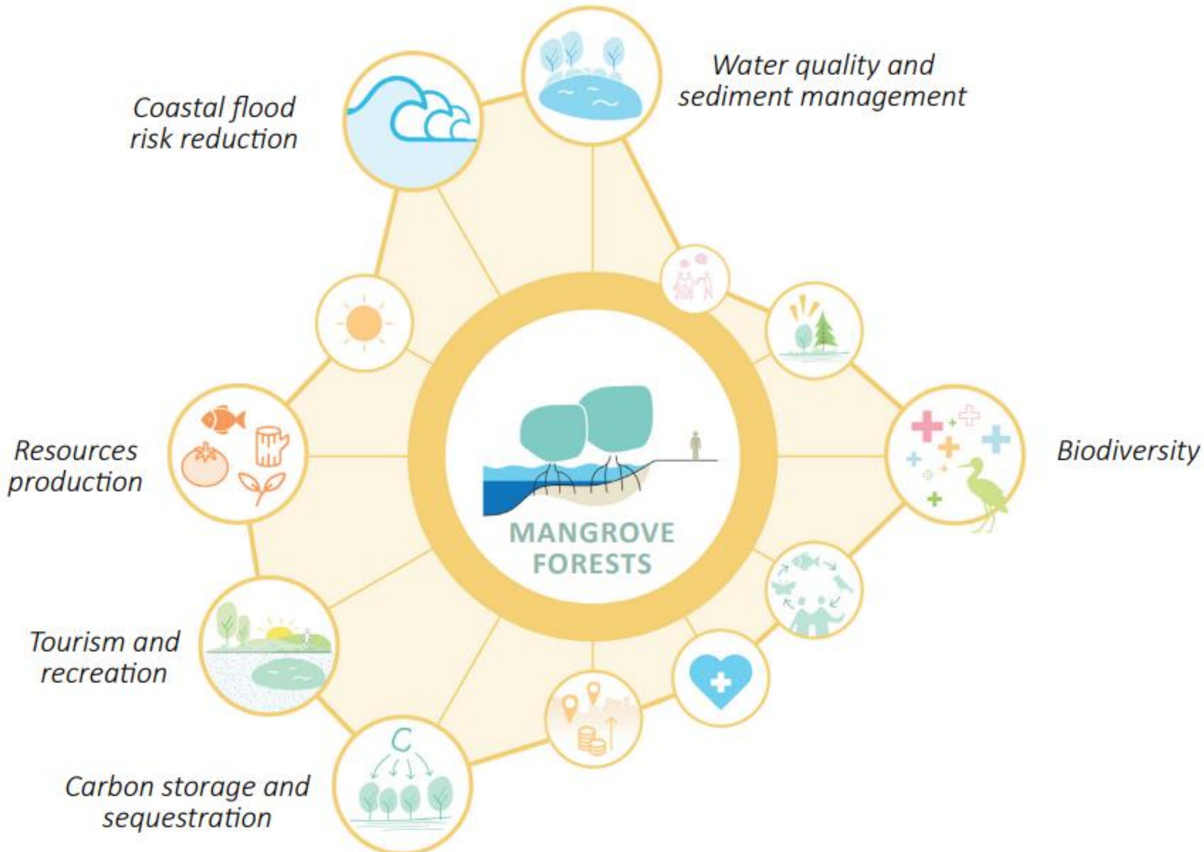
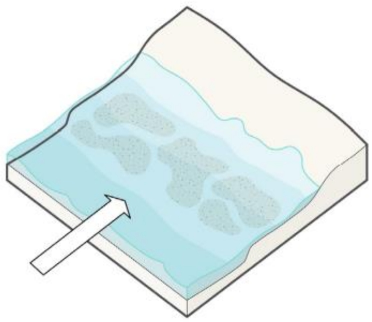


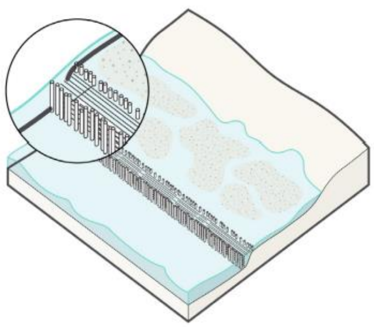
Figure 35: Benefits of mangrove forests to urban areas

Techniques for restoring degraded mangrove forests include:



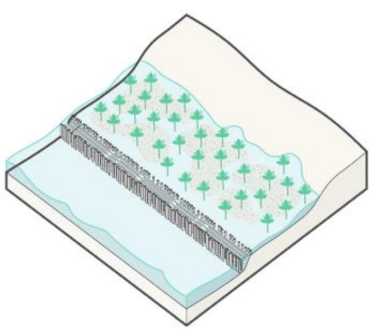
Restore hydrology

Mangrove forests rely on the tides for their growth and expansion. The strategic removal of certain water control devices will recover tidal influence and recreate the conditions for mangrove development, especially in areas were human activities previously restricted tidal environments.



Permeable structures

Permeable structures help mangrove forest restoration by capturing sediment and providing substrate for mangroves to grow naturally. The permeable structures are placed as a grid system facing the direction of the tidal current to maximize the sediment capture and dampen erosive waves. The construction can be done by local communities with structures made of local materials such as bamboo, twigs, and other brushwood (Deltares n.d.).



Planting or sowing

Planting or sowing mangroves requires previous study of the area to ensure that biophysical conditions are appropriate for mangrove recovery. The purpose of the planting is to assist or enrich the natural regeneration process when natural supplies of seeds and propagules are limited due to lack of nearby parent trees or lack of hydrological connection to these trees. This is often the case along coastlines that suffer widespread mangrove degradation (Deltares n.d.).

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Topic 2: Introduction to Cost Benefit Analysis for EbA

- Guiding decision makers in the selection of adaptation options is critical for implementing the most efficient adaptation approaches for every specific context. Cost-benefit analysis is useful for comparing adaptation options such as infrastructure and EbA.

- Economic analysis of climate change adaptation options is an input to decision making, but it should not be the only ranking process. Economic analysis does not provide information on the political, legal, social, environmental or cultural acceptability of the options. CBA does provide information on the contribution of an adaptation project to society's overall welfare, but not all impacts can be reduced to monetary terms. While CBA for climate change adaptation projects is, in principle, no different than the economic analysis of any development project, it should be acknowledged that the uncertainty surrounding climate change projections does suggest that additional sensitivity analysis and inputs from various stakeholders may be needed, to accommodate the non-economic aspects of decision-making.

- Cost-benefit analysis (CBA) is a systematic, quantitative method of assessing the life cycle costs and benefits of competing alternative approaches. This includes determining which one of the alternatives is best. Cost-benefit analysis compares benefits and costs to society of policies, programmes, or actions to protect or restore ecosystems. Cost-benefit analysis measures the net gain or loss to society from a policy or action.

- The basic CBA rule is that an investment is to be judged potentially worthwhile if its benefits exceed its costs, where benefits and costs are defined to include any welfare gains and losses which occur because of the investment. The CBA also presents a comparison between cases "with" or without" a given alternative. This implies that comparing the net cost and net benefits of a project with the existing situation or baseline is required:

Net Benefits of Alternative A (NB) = [Ba – Ca] – [Bb – Cb]

Where:

A denotes alternative A
B denotes the baseline

- The term 'costs' include capital investments, operations and maintenance and the opportunity cost of capital, i.e. the revenues which would have accrued if the capital in question was used for the next best alternative. Benefits can be straightforward revenue from an investment or the findings of economic valuation studies when non-marketed environmental goods are concerned.

- As a decision support tool, CBA provides a format for enumerating the range of benefits and costs surrounding a decision, aggregating the affects over time using an approach called discounting, and arriving at a dollar-denominated "present value" that, in concept, is comparable with other governmental uses for scarce financial resources, including leaving them in the hands of taxpayers. In other words, CBA can be defined as a procedure for:
    - Measuring the costs and benefits to all individuals, that is society, using money as the measuring rod of those cost and benefits
    - Aggregating the money valuations of the costs and benefits of individuals and expressing them as a net social cost or benefit

- In its simple form, cost/benefit analysis is carried out using only financial costs and financial benefits. For example, a simple cost/benefit analysis of a road scheme would measure the cost of building the road and subtract this from the economic benefit of improving transport links. It would not measure either the cost of environmental damage or the benefit of quicker and easier travel to work.

- A more sophisticated approach to cost/benefit analysis is to try to put a financial value on these intangible costs and benefits. This can be highly subjective - is, for example, a historic water meadow worth $25,000, or is it worth $500,000 because of its environmental importance? What is the value of stress-free travel to work in the morning?

Objectives of Cost Benefit Analysis

- Facilitating choice among projects

- Allocation of resources

- The objective of cost-benefit analysis is to determine whether society, as a whole, will be better off if the policy or action is implemented. This requires enumerating and evaluating all of the measurable benefits and costs and comparing them. In this manner, a single policy or action may be evaluated to determine whether it provides net economic benefits to society. Alternatively, several policies or programmes may be compared to determine which provides the greatest net economic benefits.

The Time Dimension of Cost-Benefit Analysis

- Once estimated cost and benefit values are determined, adjustments to these values become necessary as incremental costs and benefits from a given policy initiative are not realized immediately. Instead, they accrue over a number of years. While some policy costs are incurred immediately, others accrue at various points in time in the future. Also, the benefits are not realized in a single period. These time differences affect the results of the CBA, and without considering the time-oriented differences, the cost benefit analysis would yield biased result and any policy decision based on them would be misguided.

- The two considerations that must be taken into account are:

- Present value determination or opportunity cost of money - costs and benefits to be realized in some future period are not valued as highly as those to be achieved immediately – future costs and benefits have be to adjusted downward to be comparable to those incurred in the present

- Inflation correction- to adjust for changes in the general price level - need to account for expected changes in the price level over time – the value of costs and benefits measured in today's dollars will be much higher in future dollars during periods of inflation

- Only when the cost and benefit estimates are adjusted for time differences, should they be compared to one another.

Discounting

- Discounting is applied to benefits received and costs incurred in the future for two reasons. First, people generally prefer to receive benefits sooner rather than later, and to pay costs later rather than sooner. Second, money that is available now can be invested and earn a return. Thus, money available now is worth more to people than money received in the future.

- For example, if $1 is invested at a 10% interest rate, it will be worth $1.10 after one year, $1.21 after two years, and so on. Discounting reverses this process, by calculating the value, in today's dollars, of a given amount received in the future. For example, if a person is promised $1.10 at the end of a year, and their discount rate is 10%, they would be equally happy with $1.00 today.

- Thus, the discounted present value of a benefit received in the future is calculated as: Bt/(1+r)t, where Bt is the benefit to be received in year t, and r is the discount rate. Costs would be similarly discounted. So, a benefit of $1.21 received in two years, where the discount rate is 10%, is worth $1.21/(1.1)2 = $1.21/1.21 = $1 today. Thus, $1 is the discounted present value of $1.21 received in two years, for a 10% discount rate.

- For decisions related to natural resources, the appropriate discount rate is the rate that reflects society's preferences for allocating natural resource use over time. However, determining the social discount rate is controversial, and the choice of discount rate can have a large effect on the results of a benefit-cost analysis. A larger discount rate gives more weight to the present in relation to the future, and thus benefits to the current generation are given more weight than benefits to future generations. Many have argued for a social discount rate for environmental projects that is lower than the market rate, in order to leave more opportunities for future generations.

Steps in Conducting a Cost-Benefit Analysis

1. Defining Objectives and Project Scope
   Every policy/project must have an objective (or objectives). Decision-makers in the bureaucracy often specify the objective. However, to facilitate the process of the CBA this objective (or objectives) should be clear and unambiguous.

2. Identifying and Screening the Alternatives
   At this stage of the process, all possible options for achieving the objective(s) must be listed. One of the options must be the status quo, which is the "do nothing" option. It must be borne in mind that the "do nothing" option is not without costs. In this particular example, doing nothing about wastewater treatment will result in social costs. Therefore, the avoidance of these costs must be counted among the benefits of the project. The other options could include different technologies for meeting the standard. However, in some cases, there could be just two options: "do nothing" versus a given treatment process.

3. Identifying the Benefits and Costs
   Cost and benefits of each alternative must be identified. Once these costs and benefits have been identified, they must be valued in order to allow comparison between alternatives. The basic assumption here is that prices reflect value or opportunity costs, or can be adjusted to do so. In an environmental CBA, the prices of inputs (and outputs), which do not reflect their true value to the society, are adjusted. This process is referred to as **shadow pricing,** and involves adjusting the market prices by given discount factors. In addition, many environmental costs and benefits do not have market prices and as such, non-market valuation methods must be used to estimate their values.

4. **Calculating Discounted Cash Flows and Project Performance Criteria**

Once the costs and benefits with and without the project have been identified and valued (in monetary terms), the analyst is now ready to compare the costs and benefits in order to make a decision as to which alternative(s) to accept or reject.

Project performance criteria (or project selection criteria) provide a means by which different alternatives that last several years into the future and which have different streams of costs and benefits could be compared. Calculating these measures involves using the technique of discounting. We often use expressions like "time is money," and "a bird in hand is worth two in the bush," and so on. These expressions imply that money has a time value. In particular, present values are better preferred than future values. By discounting, we "reduce" future streams of benefits and costs to their "present values" to enable comparisons to be made between competing alternatives. (Discounting is explained in more detail below.)

Other project performance criteria are the internal rate of return (IRR) and the benefit-cost ratio (BCR). The IRR is the maximum interest rate at which a given project could recover the investment and operating costs and still break even. The BCR is the ratio of the present value of project benefits to the present value of costs.

5. **Ranking the Alternatives in Order of Preference**

If there is just one other option in addition to the "do nothing" option, the decision rule is to accept a project or policy when NPV= O. If there are several options, they are then ranked using the size of the NPV.

6. **Conducting Sensitivity Analysis**

Sensitivity analysis is used to assess the possible impact of uncertainty by posing "what if" questions. These questions pertain to what would happen to the project's viability if some or all of the key parameter values happen to be different from the original values. A sensitivity analysis highlights the critical factors affecting the project's viability. This allows the decision-makers or project manager to pay attention to these factors during the implementation stage. Parameters subjected to sensitivity analysis include:

- The discount rate;
- Length of the project planning horizon;
- Different timing of the project's operation;
- Changes in the capital outlays;
- Changes in the price of market goods; and,
- Changes in social and environmental benefits and costs.

The sensitivity analysis is normally carried out by recalculating the project performance criteria, using a range of values for the uncertain parameter (or parameters). The results of the sensitivity analysis may be in the form of two-way and three-way tables. A sensitivity analysis helps the project analyst to identify the range of parameter values within which a project can remain economically viable. It helps to identify critical variables and, in so doing, provides information that could be used to redesign a particular option. Sensitivity analysis may also point to the need to acquire additional information to ensure that the assumptions are more realistic.

7. Make a final recommendation
   Cost-benefit analysis provides much useful information to the political process, but should not be used as a one-dimensional test of desirability. Other decision-making concerns include sustainability, equity, and other social values.

Topic 3: Cost-Benefit of EbA

- It is suggested that EbA can be more cost-effective, provide both the desired adaptation benefits and multiple co-benefits, and be more sustainable than engineered adaptation measures in the long term.

- EbA projects around the world are confirming some economic advantages of EbA, in particular that EbA can be more cost-effective.

Benefit-to-cost ratio for each scenario of adaptation options, with assumed percentage of damage avoidance

Scenario	Benefit-to-cost ratio (FJD)	Assumed damage avoidance
Ecosystem-based options	$19.50	10-25%
Emphasis on ecosystem-based options	$ 15.00	25%
Emphasis on engineering options	$ 8.00	25%
Engineering options	$ 9.00	25-50%

Costing EBA – A Case Example

A study in Lami Town, Fiji has indicated that while a hybrid approach with an emphasis on ecosystems-based measures is comparable to engineered infrastructure with regards to the assumed damage avoidance, the benefit-to-cost ratio nearly doubles.

An Economic Analysis of Ecosystem-based Adaptation and Engineering Options in Lami Town, Republic of the Fiji Islands

A study conducted in Lami Town, Fiji by UNEP calculated the benefit-to-cost ratio of adaptation measures using a suite of estimated costs of implementation, avoided damages, and estimates of ecosystem service benefits. The calculations were applied to four different scenarios: 1. 100% ecosystem-based measures, 2. Emphasis on ecosystem-based measures (75% ecosystem-based, 25% engineering options), 3. Emphasis on engineering options (25% ecosystem-based, 75% engineering options) and 4. 100% engineering options. Ecosystem-based measures identified included replanting mangroves, replanting stream buffers, reducing coral extraction and reducing upland logging; engineering options included building sea walls, re-enforcing rivers and increasing drainage. The results are displayed in the figure below, indicating significantly greater economic advantages of adopting ecosystem-based measures.

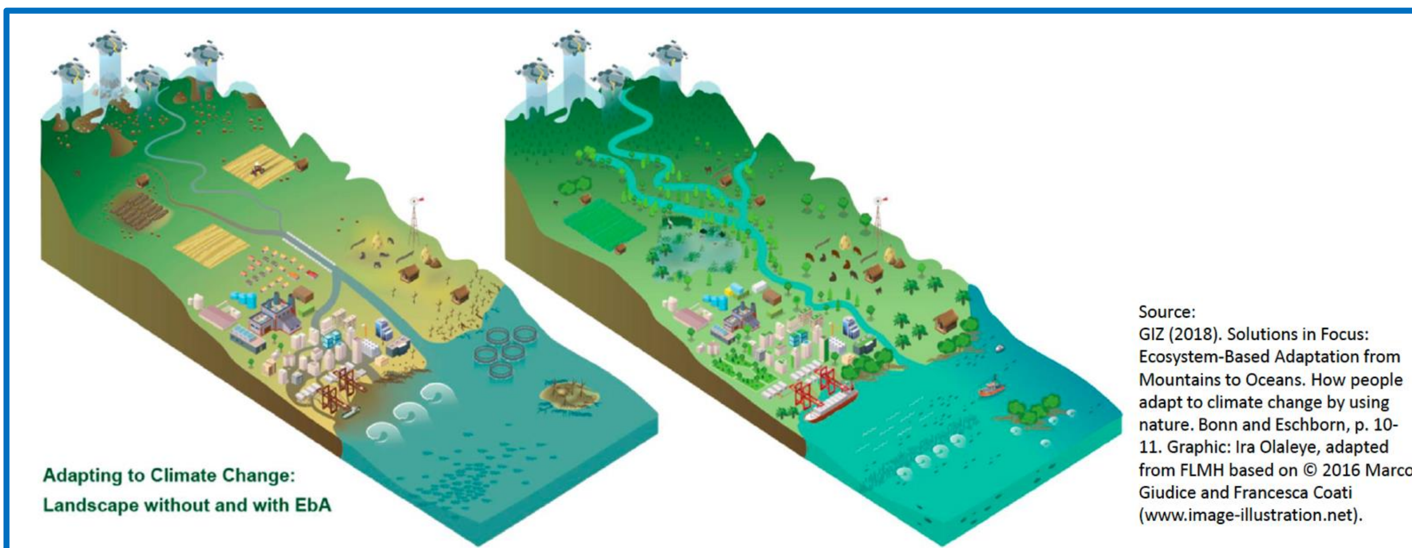
Adapting to Climate Change with and without Urban EbA in Kingston (interventions in urban and peri-urban areas)

- We have learnt that urban development is a key factor in how climate risks, such as floods, affect a city. As urban populations have expanded, so have cities onto wetlands and other flood-prone areas. The costs of not controlling urban expansion onto land vulnerable to climate hazards as well as not taking bold climate adaptation action will be dire. The effort required to improve urban planning and climate adaptation integration has become increasingly easier; sustainable urban planning policies can mitigate climate risks over the long term once there are put in place.

- EbA is a powerful instrument for effective climate change adaptation and a holistic development approach.

Tabletop Discussion

- Discuss the cost benefit of EbA within the context of urban and peri-urban areas in Jamaica, making reference to named urban and peri-urban areas of each type below:
    - Urban Forests
    - Urban Farming
    - Open Green Spaces
    - Building Solutions
    - Green Corridors
    - Natural Inland Wetlands
    - Mangrove Forests



Module 4: Creating the Enabling Environment for the Use of EbA

Overview of Module 4:

Module 4 is structured around 4 topics as follows:

- Topic 1: Mainstreaming and Integrating EbA in National Policy Development Processes and Project Design
- Topic 2: Mainstreaming Gender in EbA
- Topic 3: The Inclusion of Ecosystem-based Adaptation in Countries' National Adaptation Plans (Climate Change)
- Topic 4: Financing EbA

At the end of this module, participants should be able to:

Understand	**The concept of mainstreaming EbA**
Know	**The components of mainstreaming EbA**
Examine	**The key entry points for mainstreaming EbA**
Know	**How to mainstream EbA in development planning at the national and local levels**
Understand	**How to include EbA in National Adaptation Plans**
Understand	**How to mainstream gender in EbA**

Topic 1: Mainstreaming and Integrating EbA in National Policy Development Processes and Project Design

- To better harness the potential of EbA it needs to be fully mainstreamed into development policy and practice

- Mainstreaming EbA refers to the process of integrating ecosystem-based approaches into planning and decision-making processes at different governance levels. The ultimate goal of mainstreaming is to enhance the effectiveness, efficiency and longevity of climate change adaptation (CCA) by embedding its principles and practices into local, municipal and national policies, planning, financing, training and awareness campaigns, among other policy tools.38 Mainstreaming is addressed here as a crucial addition to integrating EbA into the NAP documentation, as EbA should be incorporated into all planning processes and institutional changes may be needed to facilitate that. The opportunities and challenges of mainstreaming also elucidate some of the issues that need to be addressed in integrating EbA into the NAP formulation, implementation and review (chapters 3–5).

- Mainstreaming EbA is important, as it helps to enhance long-term sustainability and opens possibilities for funding, which are external to climate-specific funding sources. Mainstreaming is challenging, however, because it involves a paradigm shift in the culture and practices of institutions. Hence, it requires strengthening institutions and capacities.

- To effectively mainstream EbA into planning processes and strategies, adaptation practitioners must be prepared to deal with the existing barriers, such as fragmented national policies and the prevailing "silo effect" of sector agencies. A whole new approach is needed to foster communication and coordination horizontally and vertically, across sectors and ministries or departments, as well as from national to local levels, and with effective participation of civil society (Tye 2020).

- The framework of mainstreaming EbA into development planning consists of three major components:
    - Finding the entry points and making the case
    - Mainstreaming EbA in policy and planning processes
    - Strengthen EbA implementation

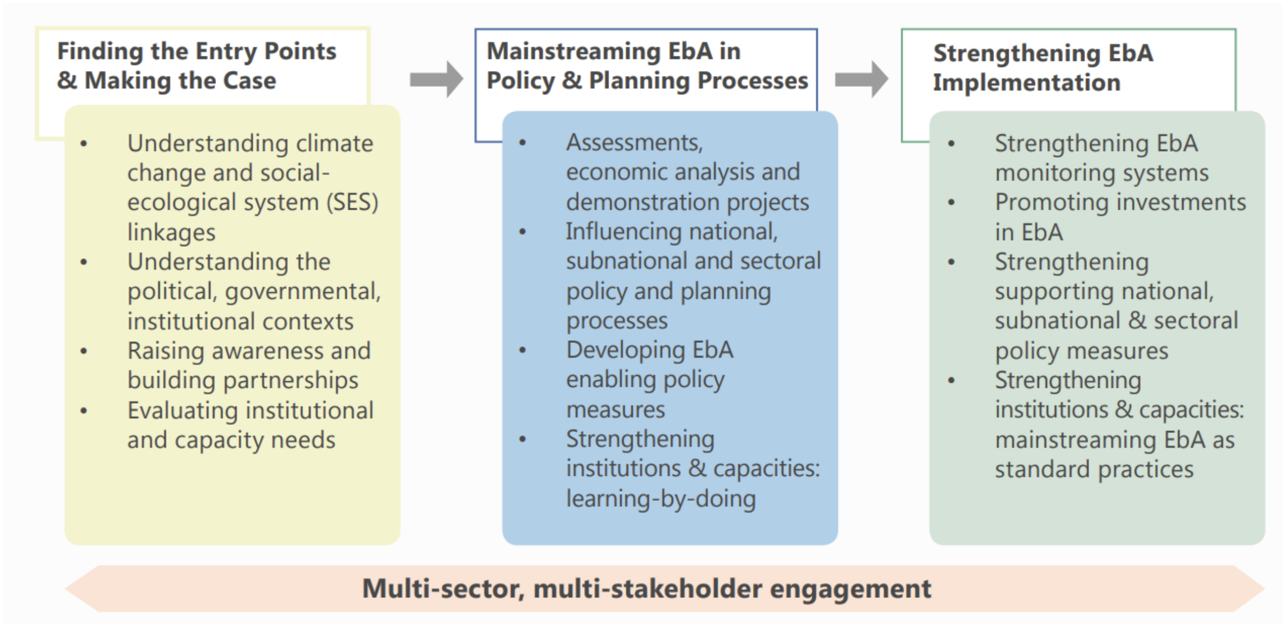


Figure 37: The Components of Mainstreaming EbA into Development Planning

- The whole process – from inception through policy formulation, implementation, and monitoring – requires participation and cooperation of different stakeholders including government policy makers, implementing agencies, development partners, the private sector, and communities. Regulations and standards need to be revised, for example such as employing building codes to reflect climate risks in terms of infrastructure, the mandatory consideration of nature-based solutions in all planning levels and investment projects, or the consideration of resilience needs of ecosystems. Coherent adaptation strategies draw on a wide range of potentials – they include natural assets, technical skills and financial resources.

- The mainstreaming of EbA can occur at key strategic points both at the national and sectoral levels. See Figure below.

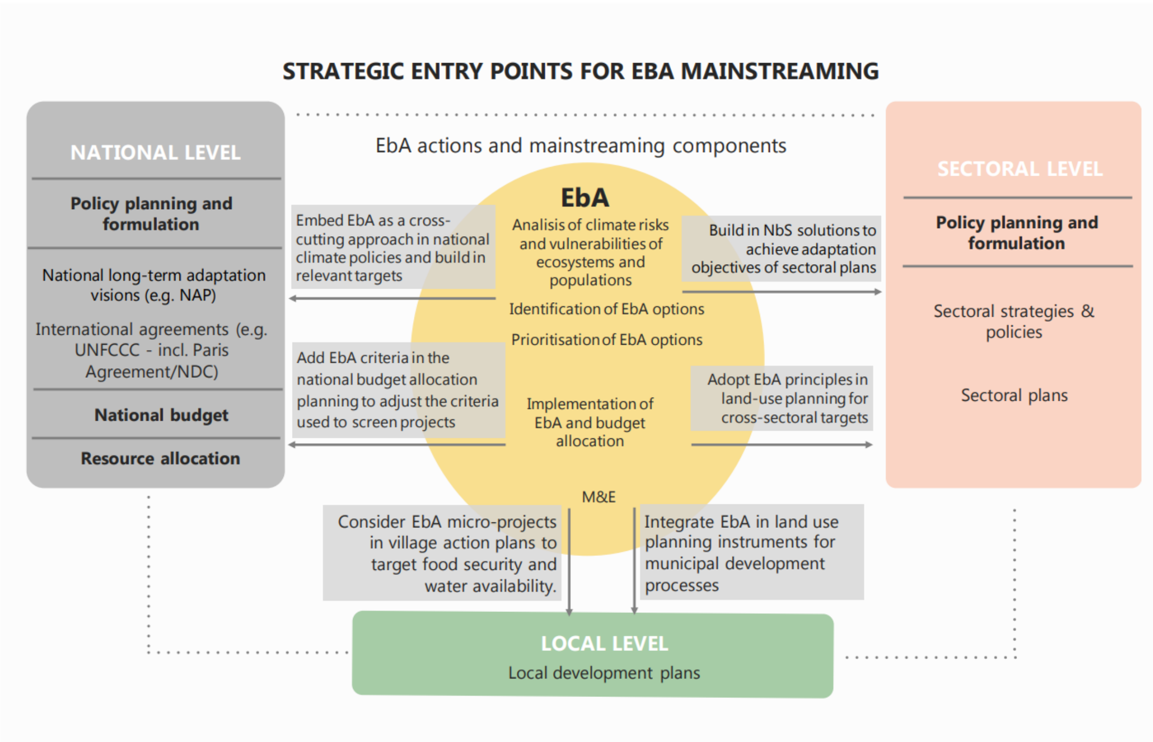


Figure 7 - Key entry points for EbA mainstreaming at different governance levels Source: GIZ, 2019 adapted from L.Ilieva, 2018

Figure 38: Key Entry Points for EbA Mainstreaming at Different Governance Levels

- Effective mainstreaming into policies, plans and practice involves the integration of Nature-based Solutions into climate- and disaster-risk planning and decision-making processes at different governance levels and spatial scales, from local to landscape.

- Development planning needs to consider anticipated climate risks and impacts - particularly on the livelihoods, resilience, and health of the population, but also on ecosystem functions and services, and whether future service delivery might be at risk.

- The integration of EbA into the policy agenda is uneven. While there is significant (and growing) attention being paid to EbA in the international policy arena and a growing number of countries are integrating EbA into national-level commitments (e.g. NAPs and NDCs), progress varies across countries. In addition, the extent to which this national support for EbA is being effectively translated into local policies, plans and strategies is not yet clear, as there are only a handful of studies that have examined the mainstreaming of

EbA into local policy frameworks. However, the existing studies suggest EbA is still often only a fringe component of local policies and plans, rather than a central element (Reid et al. 2019; OECD 2021).

Mainstreaming EbA in Development Planning

- Mainstreaming climate change is the iterative process of integrating considerations of climate change adaptation into policy making, budgeting, and implementation and monitoring processes at national, sectoral, and subnational levels as well as the different key sectors in the development field.

- Mainstreaming EbA has as its goal to achieve that 'natural capital' and ecosystem services are taken into account in development strategies, policies and actions in coherent ways. That includes considering relevant aspects across all sectors in the sector-specific planning and implementation tools, the instruments and methods, as well as in monitoring, building in specific indicators and observing the impacts.

- Mainstreaming can focus on different levels — from national policies to local plans or individual business practices; from cross-cutting development plans such as poverty reduction strategies to sectoral policies such as agricultural growth and development strategies.

- Mainstreaming proposals include:
    - National planning and development processes - Risk reduction / resilience and adaptation targets based on strategies for adaptive ecosystem management must be integrated into medium and long-term national development planning frameworks and budgeting processes.
    - Local and community planning processes - Based on a thorough understanding of local development aspirations, needs, priorities and capacities, nature-based solutions are encouraged as they create various social, environmental and economic benefits, foster adaptive management and increase local ownership over natural resource management.
    - Sectoral policy, incentives and disincentives - Synergies among sectoral development priorities, climate change adaptation, risk reduction and biodiversity conservation need to be identified - this includes the removal of perverse subsidies and the provision of incentives for land and resource use that aim to sustainably manage and/or restore ecosystems.
    - Land-use plans - In the context of land-use and spatial planning, all resource use practices (including land and sea) must be informed about climate risks and

vulnerabilities andappropriately situated to optimize adaptation and ecosystem management / restoration.

- Finance and decision-making - Nature-based principles and criteria must be included in all spheres of public expenditure planning, the funding decisions of the international donor community (ODA), as well as the private sector.

Examples of Mainstreaming EbA at the International Level

- At the international level, EbA has been gaining traction due in part to its ability to deliver on global policy goals related to climate change as well as other global policy goals associated climate change mitigation, biodiversity conservation and sustainable development.

- Within the United Nations Framework Convention on Climate Change (UNFCCC) EbA has been elevated in several areas including the Cancun Adaptation Framework, the Nairobi Work Programme, the AF, REDD+ planning National Adaptation Plan (NAPs) and Nationally determined contributions (NDCs).

- NbS were also prominently featured at UNFCCC COP 26 with several announcements and commitments related to the use of ecosystem restoration and conservation to help society adapt to climate change.

- There is also increasing political interest and commitment to investing in ecosystem conservation, restoration and management to achieve the goals of the Sendai Framework for Disaster Risk Reduction the Global Mangrove Alliance, the 2030 Agenda for Sustainable Development, the Ramsar Convention on Wetlands, the New Urban Agenda, the United Nations Convention to Combat Desertification (UNCCD). the Bonn Challenge, the UN Decade on Ecosystem Restoration and related international agreements and initiatives (Epple et al. 2016; Seddon et al. 2021; Sudmeier-Rieux et al. 2021).

- An increasing number of high-level policy reports, declarations and initiatives have highlighted the importance of EbA and other NbS for addressing global challenges. Some key examples include:
  - NbS (including EbA) were included as one of the nine action tracks of the 2019 United Nations Climate Action Summit, convened by the United Nations Secretary-General.
  - The Nature-based Solutions for Climate Manifesto, which was launched at the 2019 United Nations Climate Action Summit, calls for countries to mainstream NbS within national governance, climate action and climate policies and scale up the

conservation and restoration of forests and other terrestrial ecosystems, freshwater systems, marine and coastal systems in support of climate change adaptation and mitigation. This manifesto was signed by 32 countries, the European Commission, 21 civil society organizations and 8 private sector groups (Seddon et al. 2021).

- The Least Developed Countries 2050 Vision (LDC 2050 Vision) highlights the importance of ecosystems for climate resilience. One of the three overarching goals of the LDC 2050 Vision is that "climate-resilient landscapes and ecosystems are sustainably managed, less vulnerable to shocks and stresses, and use NbS" (LDC Initiative for Effective Adaptation and Resilience 2019).
- At the UNFCCC COP26 in November 2021, leaders from more than 130 countries (representing nearly 90 per cent of the world's forests) signed the Glasgow Leaders' Declaration on Forests and Land Use in which they pledged to halt and reverse forest loss and land degradation by 2030 and promote more sustainable use of ecosystems in support of climate adaptation and mitigation goals (Butler 2021).
- The Glasgow Climate Pact recognizes "the critical role of protecting, conserving and restoring nature and ecosystems in delivering benefits for climate adaptation and mitigation" (UNFCCC 2021a).

Examples of Mainstreaming EbA at the National Level

- At the national level, EbA has been gaining traction evidence by its incorporation in national and regional polices. As part of the Paris Agreement, Countries who are party to the UNFCCC are required submit NDCs which outline the actions they will take to reduce their national emissions and adapt to the impacts of climate change. A recent analysis of the NDC submissions found that 133 governments (the equivalent of 66 per cent of all nations that have signed the Paris Agreement) have committed to restoring or protecting ecosystems in their climate targets (Seddon et al. 2020b). This includes 104 governments that have included EbA or conservation action in the adaptation components of their NDCs, 77 countries that have included them both in their adaptation and mitigation components and 27 governments that have included them in their mitigation targets (Seddon et al. 2020b).

- The NAPs of individual countries also demonstrate the national-level uptake of EbA. The NAPs are a strategic means of identifying medium-and long-term adaptation needs and developing and implementing strategies and programmes to address those needs (Hammill, Dekens and Dazé 2020; UNEP 2021c). The NAP Global Network72 tracks how EbA is being integrated into NAPs (Terton and Greenwalt 2020). As at March 2020, all 19 of the NAPs that had been submitted to the UNFCCC included some consideration of ecosystems and the services they provide, and most had specifically included EbA measures in their plans, especially in forests, freshwater, and coastal ecosystems (Terton and Greenwalt 2020).

- A study of the NAPs and national adaptation strategies being used by 13 of the G20 countries also points to the increased attention being paid to EbA (Prabhakar, Scheyvens and Takahashi 2019). The study found that almost all the countries are promoting ecosystem protection and conservation to foster adaptation, and several key countries (such as Brazil, Italy, Mexico and the USA) used ecosystem-based approaches as a guiding principle for adaptation efforts (Prabhakar, Scheyvens and Takahashi 2019).

- There are also examples of regional policies supporting EbA approaches, especially within the European Union. Multiple European Union policies place a strong emphasis on the use of EbA, including the recently updated EU Climate Adaptation Strategy (European Commission 2021)73, the EU Green Infrastructure Strategy (European Commission 2013)74 and the EU Biodiversity strategy for 203075 (European Commission 2020) among others (World Business Council for Sustainable Development [WBSCD]

Examples of Mainstreaming EbA at the Municipal Level

- At the local level, evidence on the integration of EbA into subnational or municipal policies, regulations and plans is sparse, scattered and hard to find. The handful of case studies that have examined the mainstreaming of EbA in local action have tended to highlight the fact that EbA has not yet been successful mainstreamed into local adaptation plans.

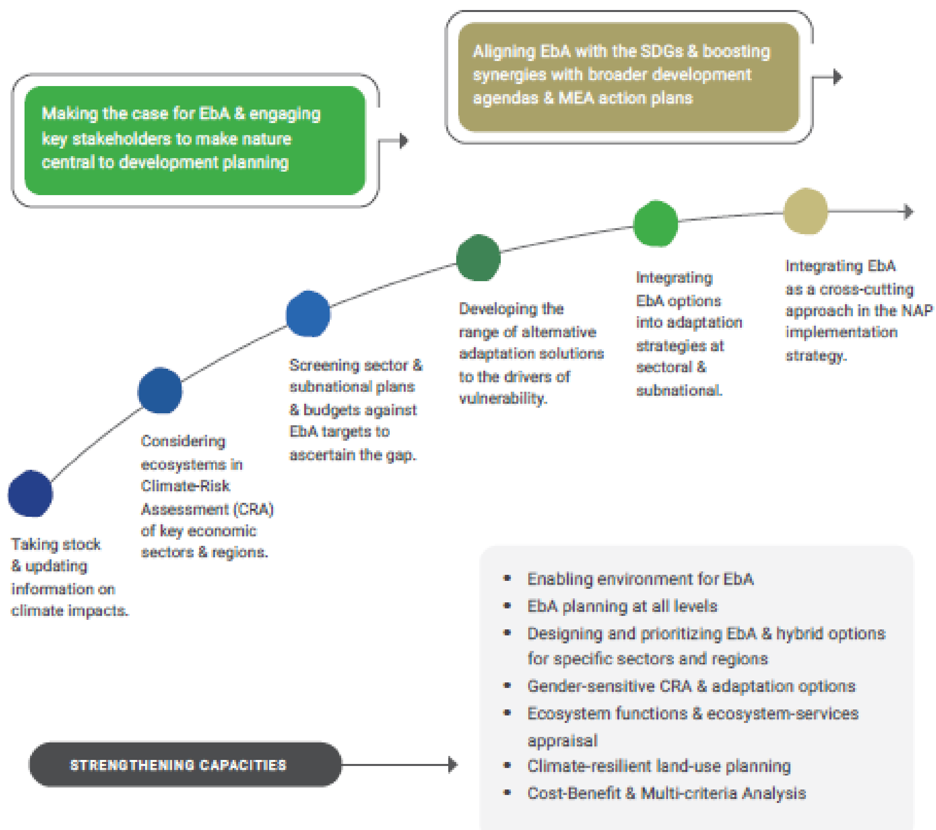
Topic 2: Mainstreaming Gender in EbA

- Applying an ecosystem and gender equality and social inclusion (GESI) lens to analyze the adaptation context
- Assessing the gender-differentiated vulnerability and risks before deciding on the most effective EbA option
- Demonstrating how the ecosystem services protected provide benefits to women and girls, disadvantaged and vulnerable groups and persons with disabilities
- Designing a GESI action plan to be included as an integral part of the EbA project design
- Ensuring that the GESI action plan is adequately resourced in the project financing
- Combining EbA and GESI indicators in the monitoring and reporting system

Topic 3: The Inclusion of Ecosystem-based Adaptation in Countries' National Adaptation Plans (Climate Change)

- A growing number of countries are implementing EbA and integrating it into their emerging climate change policy responses (Seddon 2018; Seddon et al. 2019). For example, of the 141 countries with adaptation plans in their intended nationally determined contributions (INDCs), 49 per cent refer to EbA actions.

- Incorporating EbA in the formulation stage of the NAP



Tabletop Discussion/Group Exercise

- How has Jamaica's INDC incorporated EbA? Reviewing the most recent INDC.
- Are there any gaps?
- Were there any missed opportunities that you have identified for the inclusion of EbA? Describe.

Topic 4: Financing EbA

- EbA is currently being funded by a small number of key bilateral donors, multilateral donors and climate and environment funds, with public finance for EbA in 2018 estimated to be between US$3.8 billion and US$8.7 billion in 2018 (Swann et al. 2021).

- Tracking the investment in EBA reveals that finance for EbA has come from different sources including international public sources (such as multilateral climate and environmental funds, multilateral development funds, bilateral financial cooperation), domestic public sources (such as national funds and budgets) and private sources (including non-profit organizations, market debt and business investments; Hunzai et al. 2018).

- However, it is difficult to estimate the total finance that is being allocated to EbA due to the lack of centralized data on EbA projects, the large number and diversity of actors involved, the lack of a standard way of tagging and reporting finance and funding sources, and the fact that EbA activities are often blended or integrated with other adaptation activities.

- A study led by the WRI and the GCA estimated the amount of public international funding flowing towards NbSA (Swann et al. 2021). Using publicly available data from the OECD, the authors estimated that US$ 3.8 billion to US$ 8.7 billion were provided to EbA in 2018, up from an estimated US$ 2.1 billion to US$ 4.1 billion in 2012 (Swann et al. 2021). This funding represents approximately 0.6 to 1.4 per cent of total climate finance flows and 1.5–3.4 per cent of public finance flows in this area (Swann et al. 2021). Most of this funding was provided by a handful of bilateral donors (Germany, Japan, Sweden, the UK and the USA) and by multilateral donors, the biggest of which were the Asian Development Bank, the European Union, the GCF, IFAD, the GEF and the AF (Swann et al. 2021). Most of this funding was provided in the form of grants, which accounted for as much as 85 per cent of funds deployed to developing countries (Swann et al. 2021). Funding for EbA was mainly directed towards activities in countries in sub-Saharan Africa and South and Central Asia, which together have received approximately 50 per cent of total public EbA funding.

- The United Nations Adaptation Gap Report 2020 (United Nations 2021a) reviewed the investments of four institutions that support climate and NbS action, including the GEF, the GCF, the AF, and the IKI of the German Government. Combined, these organizations have invested US$ 18.8 billion in climate mitigation and adaptation over the last 30 years. Of this climate funding, projects that included NbS for adaptation (or EbA) accounted for only 13 per cent of these funds. The amount of funding and percentage of climate funds dedicated to NbS was variable across funds: the GEF spent US$ 8.61 billion on NbS funding from 1991–2020, representing an estimated 13 per cent of their total climate financing; the GCF invested US$ 2.02 billion from 2015–2020, which represented 9 per cent of their climate funds; the AF dedicated US$ 0.504 billion to NbS (or 68 per cent of its climate funds), while IKI invested US$ 0.92 billion (or 26 per cent) of their climate funds (United Nations 2021a). According to the report, funding for EbA remains inadequate.

Module 5: Natural Resource Valuation for EbA

Overview of Module 5:

Module 5 is structured around 5 topics as follows:

- Topic 1: The Importance of Valuing Ecosystems – An Introduction to Natural Resource Valuation
- Topic 2: Linking NRV and EbA – The Importance
- Topic 2: A Review of Environmental Valuation Methods
- Topic 3: Introduction to Undertaking Total Economic Value (TEV) as a means of Assessing the Health of Ecosystem
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- Topic 5: Introduction to Environmental Valuation Methods

At the end of this module, participants should be able to:

Understand	**The linkages betweeen EbA and natural resources valuation**
Define	**Ecosystem values**
Examine	**The importance of placing economic values on ecosystems**
Know	**The various NRV tools and how to apply them in ecosystem valuations and in EbA**
Be	**Able to undertake a TEV of a named ecosystem**

Topic 1: The Importance of Valuing Ecosystems – An Introduction to Natural Resource Valuation

- To the extent that the goods and services contribute to human welfare and well-being, they are said to be sources of economic values.
- An economic valuation provides a means for measuring and comparing the various benefits of environmental resources and their ecosystems and can be a powerful tool to aid and improve their use and management.
- Natural resource valuation, or environmental valuation, is a series of techniques that economists use to assess the economic value of market and non-market goods, namely natural resources and resource services.
- Economic valuation provides a means for measuring and comparing the various benefits of ecosystems, and can be a powerful tool in environmental management.

- Economic valuation consists of a series of techniques that are used to assign quantitative values to the goods and services provided by environmental resources and ecosystems, whether or not market prices are available for these goods and services.
- The economic values of ecosystem benefits are useful for:
    - Generating values for ecosystems to support policymaking processes which can then determine how to allocate public spending on conservation, preservation, or restoration initiatives.
    - Making better land use decisions for conservation or other uses
    - Being able to set priorities for biodiversity and natural resource conservation (within a limited budget/tight fiscal space)
    - Assessing environmental impacts of non-environmental investments
    - Revising the national economic/income accounts
    - Counteracting the widespread mismanagement of environmental resources which occurs because the market system cannot accurately reflect the social and economic values of ecosystems (especially regulatory services which are not bought and sold in markets)
    - Comparing the benefits and costs of different projects or programmes or uses of the environment
    - Assessing the overall contribution of ecosystems to social and economic well-being
    - Assessing the relative impact of alternative actions
    - Providing a base for prioritizing conservation or restoration projects
    - Maximizing the environmental benefits per dollar spent
    - Determining user fees for various environmental goods and services
    - Designing the most effective tools, policy and regulations for managing the natural environment
    - Choosing economic instruments for protecting and conserving natural resources (e.g. taxes, subsidies).
    - Calculating damages for compensation

- Economic valuation assesses a resource in terms of its value to humans. The commonly used Total Economic Value (TEV) framework divides the value of ecosystem goods and services into use and non-use values. The total economic value of the environment is made of different types of economic values, each corresponding to the different use that is made of the environment.
- Natural resources valuation is one tool of environmental management.
- Natural Resource Valuation has the ability to complement and strengthen traditional environmental management tools and is invaluable in environment decision-making. *Share some other tools of environmental management.*
- NRV can play a role in: influencing decision making and policies around economic, social and environmental issues; calculating damages for compensation; and identifying extractable revenues for environmental management.

- In the case of compensation, NRV could bring consensus about compensation among conflicting partners: Where there is debate among those involved in an environmental dispute, economic valuation tools can be used to resolve legal differences.

Tabletop Discussion

- Do you think that NRV can strengthen the existing EIA process?
- What are some of the uses to decisionmakers of NRV?
- How do you think NRV and EbA are related?

Topic 2: Linking NRV and EbA – The Importance

- When undertaking EbA, decisionmakers should be aware of the current economic value of the ecosystem and also the value to be gained by society of restoring and conserving these ecosystems for adapting to climate change pressures (e.g. coral reefs restoration for storm protection),
- Valuing ecosystems also will provide the basis for justifying restoring the resilience, the ecological/economic productivity and the capability of the ecosystems to regenerate and adapt to changes and shocks due to climate shocks.
- By investing in EbA and knowing the level of investment needed based on the value of the ecosystem, decisionmakers that invest in conserving and increasing the value of natural capital, may also realize several (present and future) other additional positive impacts, beyond climate change adaptation.

Topic 3: Introduction to Undertaking Total Economic Value (TEV) as a means of Assessing the Health of Ecosystem

- Economic valuation assesses a resource in terms of its value to humans. The Total Economic Value (TEV) framework divides the value of ecosystem goods and services into use and non-use values.
    - The total economic value of the environment is made of different types of economic values, each corresponding to the different use that is made of the environment.
    - The notion of total economic value (TEV) provides an all-encompassing measure of the economic value of any environmental asset. The net sum of all the relevant Willingness to Pay (WTPs) and Willingness to Accept (WTAs) for the outcome of a project or change in policy defines the total economic value of any change in well-being due to a project or policy. It decomposes into use and non-use (or passive use) values, where further sub-classifications can be used if required.[21]

Total Economic Value				
Use Values			**Non-Use Values**	
Direct Use	**Indirect Use**	**Option Value**	**Bequest Value**	**Existence Value**
Outputs directly consumable Direct benefits from use of the primary goods	Functional Benefits	Future direct and indirect values	Use and non-use value of environmental legacy Value for future generations	Value of knowledge of continued existence – value for existence without use
Provisioning Services: ▪ Food ▪ Biomass ▪ Wood products (timber and fuel wood) ▪ Bioprospecting: medicines, biochemicals Cultural Services: ▪ Recreation ▪ Tourism ▪ Education/science	Provisioning Services: ▪ Fresh water Regulatory services: ▪ Flood control ▪ Storm protection ▪ Nutrient cycles ▪ Carbon storage ▪ Erosion control Supporting Services: ▪ Soil Quality ▪ Tourism resources	▪ Both direct and indirect use values	Provisioning Services: ▪ Freshwater Regulating Services: ▪ Carbon storage ▪ Air quality Cultural Services: ▪ Scenery ▪ Landscape ▪ Recreation ▪ Science/education Supporting Services: ▪ Soil Quality	▪ Habitats and biodiversity ▪ Wildlife ▪ Species ▪ Genetic resources ▪ Ecosystems ▪ Cultural identity

[21] https://www.oecd-ilibrary.org/environment/cost-benefit-analysis-and-the-environment_9789264010055-en

Some Definitions and Concepts related to TEV

- Use values relate to the actual use of the good or service produced by the environment. This actual use (such as a visit to a beach, or the extraction of forest products, or the transportation of goods by via sea) may be current or may remain a possibility in the future.

- Possible use may become important as people may be willing to pay to maintain a good in existence to preserve the option of using it in the future. As such, Option Value is considered as a use value.

- Use values are sub-divided into 3 categories:
    - Direct use values – examples include harvesting of fish or collection of fuel/wood and may include both commercial and non-commercial activities that may be carried out by local communities. Direct use values are further sub-divided into consumptive direct use value and non-consumptive direct use value.
    - Consumptive direct use value is perhaps the most intuitive of all values. It refers to the economic value of those goods and services produced by the environment which are actually extracted for the purpose of consumption. Examples of consumptive direct use include harvesting of fish either for commercial or recreational purposes; extracting of timber or non-timber forest products; harvesting of fruits from fruit trees; abstracting surface water or groundwater for domestic, agricultural, or industrial purposes. These activities generate economic values which are then referred to as the consumptive direct use value of the environment.
    - Non-consumptive direct use value refers to the economic value of those goods and services produced by the environment without actual extraction or abstraction taking place. Examples of non-consumptive direct use, among numerous others, include Using surface waters for transportation such as shipping; recreational swimming; bird watching in a protected area; hydropower production
    - Indirect use values - result from the use of services provided by the environment and ecosystems – many of which are part of the regulatory functions of the natural environment. Examples of indirect use (use of services), include water purification services provided by wetlands; carbon sequestration services provided by forests; storm and flooding protection services provided by mangrove swamps; watershed protection services provided by forests etc.

    - Option values refer to the benefit of potentially using a resource at a later point in the future. For example, protected areas may be set aside for conservation purposes not only for the direct and indirect values they may currently generate, but also for keeping the option possible (in the future) to conduct these or other activities.

- Non-use values is also called existence value, i.e., the value humans place on the knowledge that a resource exists, even if they never visit it or use it. Non-use values refer to the satisfaction placed by society simply from knowing that the existing flow of goods and services produced by the environment is maintained as it currently even if there is no current or potential use of these goods and services by themselves (existence value) or is maintained to keep the option opened for use by future generations (bequest value).

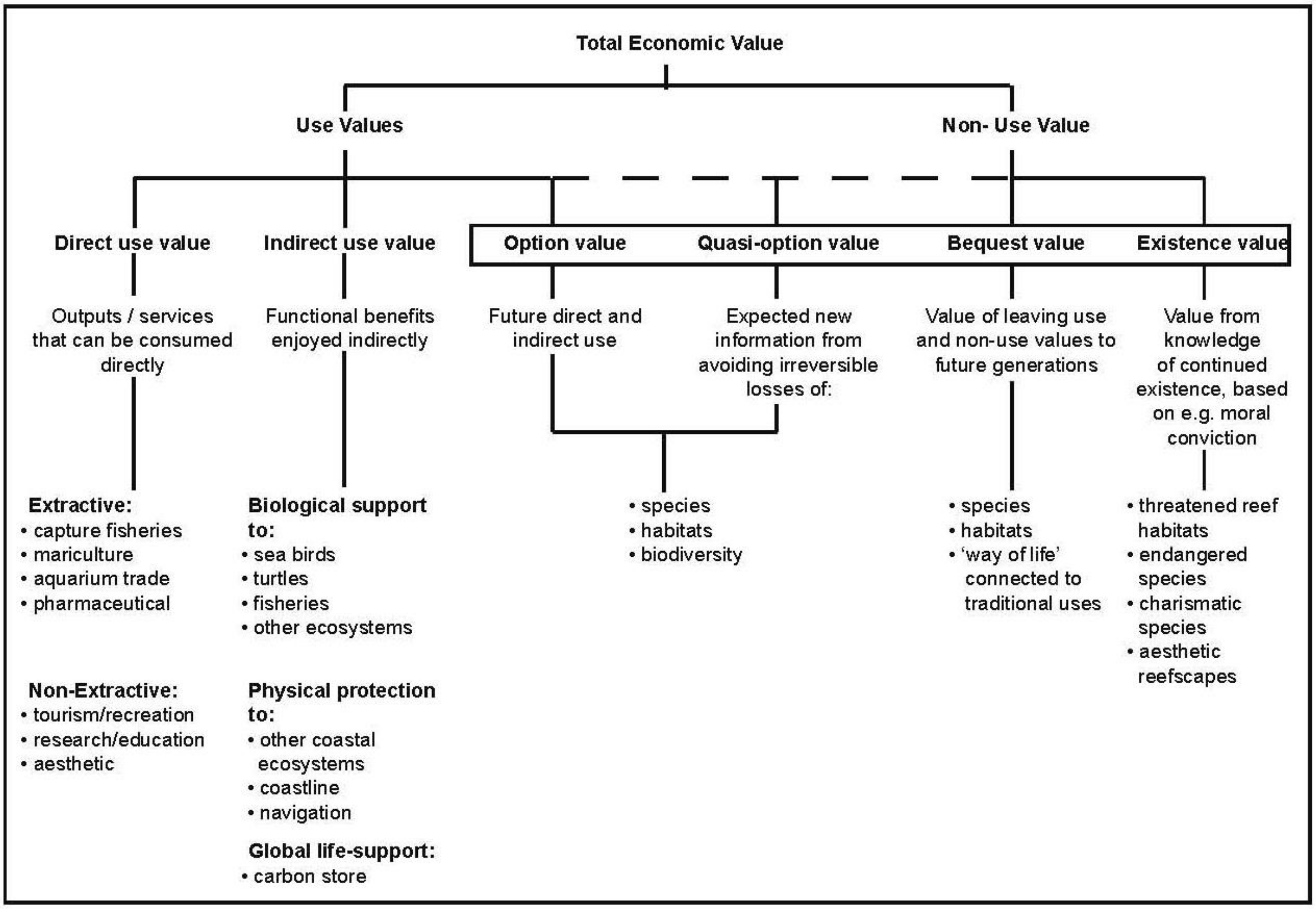
- The classification for non-use values generally includes existence value, altruistic value and bequest value. Existence value refers to the WTP to keep a good in existence in a context where the individual expressing the value has no actual or planned use for his/herself or for anyone else. Consideration may also be given to a feeling of concern for the asset or stewardship. A bequest value is similar, but the concern is related to the next and future generation having the option to make use of the good.

- Non-use and option values are frequently the most controversial elements of TEV; they are the most difficult to quantitatively measure, and have the greatest uncertainty attached to them.

- Ecosystems such as coral reefs, watersheds, forests mangroves have both direct use and indirect use values.

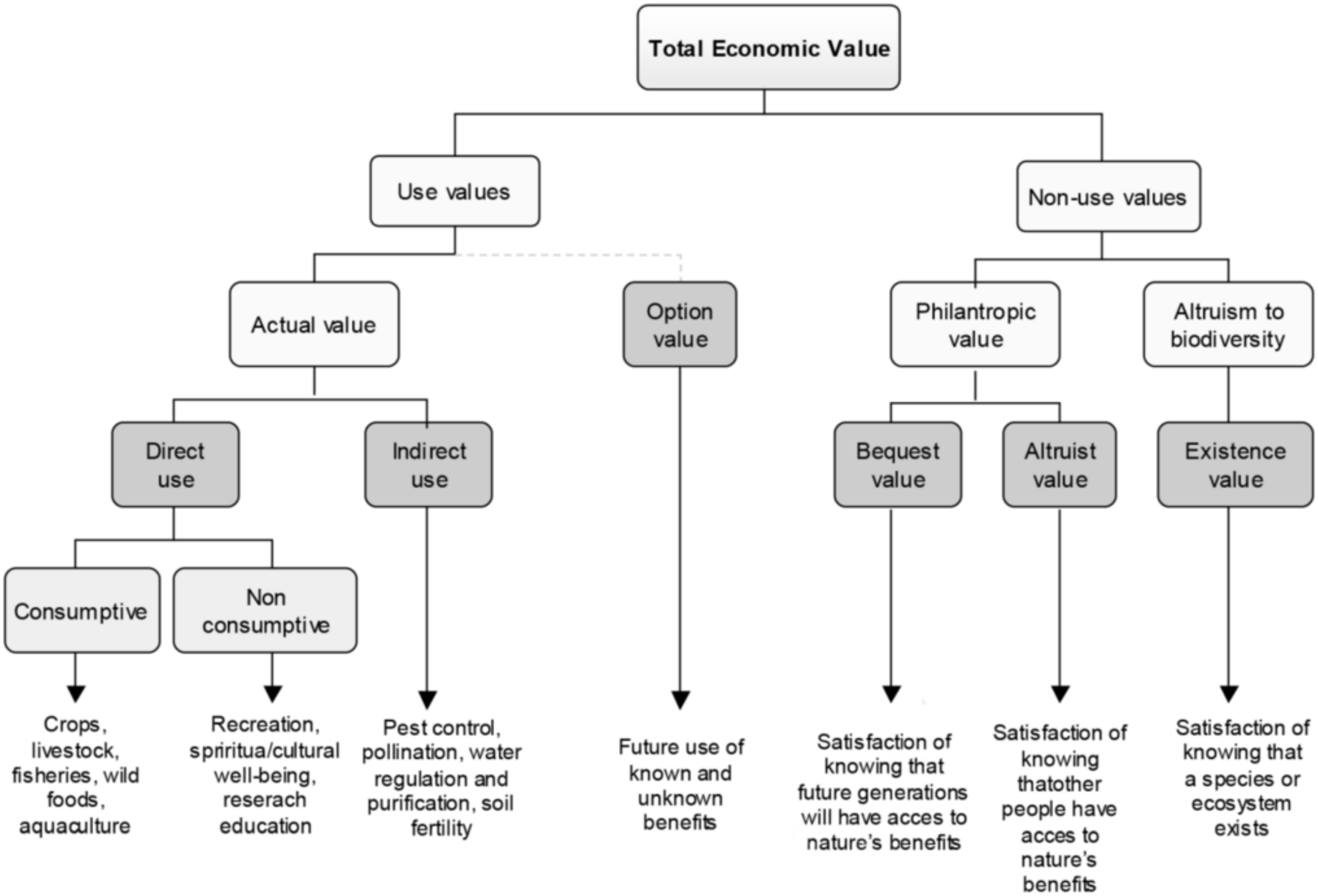
Topic 4: Undertaking the TEV of Forests, Watersheds, Coastal Resources, Mangrove Forests, Coral Reefs, etc.

Example of the TEV of a Coral Reef



Source: Barton (1994).

Example of the TEV of a Freshwater Wetland



Topic 5: Introduction to Environmental Valuation Methods

The table below provides information on several tools used in natural resource valuation. NRV methods are divided into three main categories: direct market price, revealed preference methods and stated preference methods.

NRV Valuation Method/Tool	Application
Direct Price Method This method should be used when markets for environmental goods and services exist. By observing how much of an environmental good is bought and sold at different prices, it is possible to infer directly how people value that good. The benefits of an increase in the quantity of an environmental good or service should be estimated using data on these market transactions. Unfortunately, direct markets for environmental goods and services do not often exist. In this case, alternative methodologies for valuing environmental resources should be used.	
Market Prices	This method estimates the economic value of ecosystem products or services that are bought and sold in markets. For those resources for which markets exist, economists determine individuals' values by observing their preferences and willingness to pay (WTP) for the goods and services at the prices offered in the market. The market price method can be used to value changes in either the quantity or quality of a good or service. Main Strength: Market/shadow prices are usually the best estimate of WTP; market prices reflect individuals' decision-making reality (they are the prices faced when making a decision Main Limitation: Market and policy failure mean that shadow prices need calculating to find WTP; prices underestimate true value since they do not include consumer surplus; Prices vary by season, so averages mislead.
Revealed Preference Methods These methods are based on actual consumer or producer behaviour and identify the ways in which a non-marketed good influences actual markets for some other good. Preferences and values are 'revealed' in complementary or surrogate markets. RP methods use data on actual choices made by individuals or firms in related markets. Revealed preference methods include: • Replacement cost • Damage cost avoided • Mitigating expenditure	

NRV Valuation Method/Tool	Application
• Net factor income • Production function method • Hedonic pricing method • Travel cost method	
Replacement Cost	The replacement cost method estimates the value of ecosystem services as the cost of replacing them with alternative man-made goods and services. For example, the value of a wetland that acts as a natural reservoir can be estimated as the cost of constructing and operating an artificial reservoir of a similar capacity. The replacement cost technique assumes that the costs incurred in replacing lost environmental assets with man-made alternatives can be interpreted as an estimate of the value of the goods and services received from the environmental asset. Basically, it is assumed that the amount of money society spends to replace an environmental asset is roughly equivalent to the lost benefits that asset provides to society. The replacement cost method is particularly useful for valuing ecosystem services that have direct man-made or artificial equivalents, such as water storage or wastewater processing. The method is also relatively simple and inexpensive to apply. It does not require the use of detailed surveys or complex analysis. The replacement cost method does not, however, produce a strictly correct measure of economic value, as it is not based on people's preferences for the goods and services being valued. Instead, this method assumes that if people pay to replace a lost ecosystem service, then that service must be worth at least the cost of replacement. Therefore, this method is most appropriately applied in cases where replacement expenditures have been, or will be, made. Identifying technically feasible but economically or socially unviable replacement options may result in high over-estimates of ecosystem values. A key weakness of this technique is that it is often difficult to find exact replacements for ecosystem goods and services that provide an equivalent level of benefits. If the

NRV Valuation Method/Tool	Application
	man-made infrastructure provides a lower (higher) level of service, the value of the ecosystem may be under (over) estimated. The replacement cost method is a useful valuation tool for valuing ecosystem services such as water storage and purification, and coastal protection in a straightforward way. Main Strength: Relatively easy to calculate and useful as a second-best estimate. Main Limitation: Difficult to establish if net benefits of prevention or replacement would be same as the "with project intervention"
Damage Cost Avoided	Ecosystems frequently provide protection for other economically valuable assets. The damage cost avoided method uses either the value of property and assets protected, or the cost of actions taken to avoid damages, as a measure of the benefits provided by an ecosystem. For example, if a coral reef provides protection to coastal areas from storm damage, the value of the coastal protection function of the reef may be estimated as the damages avoided or by the avoided expenditures by coastal residents to protect their properties. The damage cost avoided method is particularly useful for valuing ecosystems that provide some form of natural protection. A potential weakness of the method is that in most cases estimates of damages avoided remain hypothetical. They are based on predicting what might occur under a situation where ecosystem services decline or are lost. Even when valuation is based on real data from situations where such events and damages have occurred, it is often difficult to relate these damages to changes in ecosystem status, or to be sure that identical impacts would occur if particular ecosystem services declined. The damage cost avoided method provides a relatively straightforward approach to estimate the value of natural protection services.
Net Income Factor	The net factor income method estimates the value of ecosystem services as an input in the production of a marketed good. It estimates the value of an ecosystem input as the total

NRV Valuation Method/Tool	Application
	surplus between revenues and the cost of other inputs in production. For example, the value of a coral reef in supporting reef-based dive recreation should be calculated as the revenue received from selling diving trips to the reef, minus the labour, equipment and other costs of providing the service. This method is likely to be useful for valuing many ecosystem services such as the support of tourism, fisheries, and other similar industries. It is a relatively simple method to apply and uses generally available data.
Production Function	The production function method estimates the value of a non-marketed ecosystem product or service by assessing its contribution as an input into the production process of a commercially marketed good. This method is different from the net factor income method in that it estimates a functional relationship between inputs and output, i.e. shows how output changes with changes in input. The net factor income method, on the other hand, takes the quantities of outputs and inputs as given. A production function describes the relationship between inputs and outputs in production. For example, the production of fruits and nuts from a forest may be described as a function of hours spent harvesting (labour) and the area and quality of the forest. A change in the availability of an ecosystem input may result in both a change in total output and a change in the use of other inputs. For example, a reduction in the area of forest may result in either a decrease in the harvest of fruit or an increase in the number of hours spent harvesting a given quantity. Either way the harvester suffers an economic loss. By calculating the change in the value of production (the surplus between revenues and the cost of production) given a change in ecosystem input, you will be able to observe the value of that input. The production function valuation method can be applied either to the activities of firms or to households and individuals. The production function valuation method is technically difficult to apply and has substantial data requirements. In valuing changes in inputs/outputs, it is essential to distinguish between changes in quantity that are sufficient in

NRV Valuation Method/Tool	Application
	scale to result in changes in price, and those that do not result in price changes. If the change in output or resource input is small relative to their respective total market shares, then you should assume that prices will remain constant after the change in output. If the change in output is large relative to the total market, this may induce changes in the price of the affected good/service, and you must establish the change in price likely to result. This requires us to consider the underlying supply and demand of the affected good/service.
Hedonic Pricing	The hedonic pricing method should be used to estimate economic values of ecosystem services that directly affect the price of marketed goods. The basic premise of the hedonic pricing method is that the price of a good is related to its characteristics, including its environmental characteristics. The hedonic pricing method is often used to value environmental amenities that affect the price of residential properties (hedonic property value studies). For example, a house that is close to an aesthetically pleasing natural area may be worth more than a similar house that is further away. Such differences in house characteristics and prices may be used to identify the value of natural amenities using statistical methods. Hedonic property value studies assume that individuals perceive housing units as bundles of attributes and derive different levels of utility from different combinations of these attributes. When transaction decisions are made, individuals make tradeoffs between money and attributes. These tradeoffs reveal the marginal values of these attributes and are central to hedonic property value studies. Hedonic property value studies use statistical regression methods and data from real estate markets to examine the increments in property values associated with different attributes. Structural attributes (e.g., number of bedrooms and age of house), neighbourhood attributes (e.g., population demographics, crime, and school quality), and environmental attributes (e.g., air quality and proximity to hazardous waste sites) may influence property values.

NRV Valuation Method/Tool	Application
	When assessing an environmental improvement, it is essential to separate the effect of the relevant environmental attribute on the price of a housing unit from the effects of other attributes. The hedonic property pricing technique is very difficult, if not impossible to use if the property market is not well developed or related property price data over time are not available.
Travel Cost	The travel cost method is used to estimate the value of ecosystems or sites that are used for recreation. The premise behind this method is that the travel expenses that people incur to visit a site represent the "price" of access to the site. Travel expenses include the actual travel costs (e.g. price of using public transport, petrol and maintenance for travel by private car, aeroplane etc.), time costs, and admittance fees. With this information, peoples' willingness to pay to visit a site should be estimated based on the number of trips that they make at different travel costs. For example, for a forest that is used for recreation, information on the number of people that visit the site and the time and cost they spend travelling to reach it can be used to estimate the economic value of the recreational service that is provided. The travel cost method is frequently used to value site-specific levels of environmental resource provision and, to a lesser extent, quality. Basically, information on visitors' total expenditure to visit a site is used to estimate the demand for the services provided by the site. This demand information is then used to measure the average benefits to visitors, which is subsequently aggregated over the affected population to derive a measure of total benefit. It can also be used to measure the benefits/costs resulting from changes in the services (quantity and/or quality) provided by the site. The method can be used to estimate the economic benefits or costs resulting from: • Changes in access costs for a recreational site • Elimination of an existing recreational site • Addition of a new recreational site • Changes in environmental quality at a recreational site

NRV Valuation Method/Tool	Application
	The travel cost method is dependent on a relatively large data set. Data are usually collected through visitor interviews and questionnaires, which require sampling to cover different seasons or times of the year, and to ensure that various types of visitors from different locations are represented. The locations of origin of visitors to a site are often grouped into zones of increasing distance from the site. Complex statistical analysis and modelling are required in order to construct information on visitor demand. Travel cost surveys are typically expensive and time-consuming to carry out. An additional source of complication is that several factors make it difficult to isolate the value of a particular ecosystem in relation to travel costs, and these must be taken into account in order to avoid overestimating ecosystem values. Visitors frequently have several motives or destinations on a single trip, some of which are unrelated to the ecosystem being studied. They also usually enjoy multiple aspects and attributes of a single ecosystem. Because travel cost models are concerned with active participation, they measure only the use value associated with any recreation site. This technique is now well established for valuing the non-market benefits of outdoor recreation sources. It is useful because it is based on actual observed behaviour. Main Strength: Useful for recreational facilities and eco-tourism; more useful when travel distances are short. Main Limitation: Estimated parameters and benefits highly sensitive to opportunity cost of time estimates; data intensive, complex and costly.
Stated Preference Techniques Many ecosystem services are not traded in markets and are not closely related to any marketed goods. Thus, people cannot "reveal" what they are willing to pay for them through their market purchases or actions. In these cases, surveys can be used to ask people directly what they are willing to pay based on a hypothetical scenario. Alternatively, people can be asked to make tradeoffs among different alternatives, from which their willingness to pay can be estimated. In	

NRV Valuation Method/Tool	Application
addition, **these techniques are the only way to estimate non-use values attached to environmental resources.**	
Contingent Valuation	In contingent valuation (CV) studies, people are asked directly to state or reveal what they are willing The contingent valuation method is a stated preference method and involves directly asking people, in a survey, how much they would be willing to pay for specific environmental services. The contingent valuation method can be used to estimate economic values for all types of ecosystem services. The term "contingent" denotes that valuation is based on a specific hypothetical scenario and description of the environmental service. For example, in the case that a wetland provides habitat for a popular species of animal, respondents to a survey might be asked to state how much additional tax they are willing to pay to preserve the wetland in order to avoid a decline in the population of that species. In some cases, people are asked for the amount of compensation they would be willing to accept to give up a specific environmental service rather than their WTP to avoid its loss. The idea is that a hypothetical, yet realistic, market for buying or selling the use and/or preservation of a good or service can be described in detail to an individual, who then participates in the hypothetical market by responding to a series of questions. These questions relate to a proposed change in the quality or provision of the good or service. The responses to these questions are then analyzed to estimate the average value the respondents associate with the proposed change. This value can subsequently be aggregated over the affected population to derive a measure of total benefit (or cost). Most contingent valuation studies are conducted via face-to-face interviews or postal surveys with individuals, but sometimes interviews are conducted with groups. A variety of question formats are used in order to elicit respondents' statement or bids of their WTP/WTA for particular changes in the provision of ecosystem goods or services. to pay for a benefit or to avoid a cost, or what they are willing to accept to forego a benefit or tolerate a cost. In some cases, people are asked for the amount of compensation

NRV Valuation Method/Tool	Application
	they would be willing to accept to give up specific environmental services. It is called “contingent” valuation because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service.
Benefits Transfer	Value transfer involves borrowing an estimate of WTP from one site (the study site) and applying it to another (the policy site). What is borrowed is a mean value that is unadjusted or a mean value that has been modified to ‘suit’ the new site. The attraction of value transfer is that it avoids the cost and time involved in conducting primary valuation studies. The value transfer approach to environmental valuation was developed for situations in which the time and/or money costs of primary data collection for original direct and indirect studies are prohibitive. With value transfer, environmental benefit estimates from existing case studies (i.e., the study sites) are transferred to a new, policy case study (i.e., the policy site). Given the limited resources that may be available for conducting valuation studies on small islands, under certain circumstances (see below) value transfer can provide a fast and affordable process to estimate values for environmental services. There are a number of conditions that need to be satisfied in order for value transfer to provide valid estimates. First, the ‘primary’ value from the study site must be theoretically and methodologically valid. Second, the populations in the study and policy sites must be similar. Third, the difference between pre-policy and post-policy quality (or quantity) levels must be similar across study and policy sites. Fourth, the study and policy sites must be similar in terms of environmental characteristics. Fifth, the distribution of property rights and other institutions must be similar across sites. The accuracy of value transfer will become questionable if any of these conditions are violated. There are two general sources of error in the values estimated using value transfer: (1) errors associated with estimating the original measures of value at the study site(s); and (2) errors

NRV Valuation Method/Tool	Application
	arising from the transfer of these study site values to the policy site. As with all types of information, transfer studies are most useful to the end-user when sources of uncertainty are identified and, where possible, quantified.

Valuation Method	Approach	Application	Examples	Limitations
Market prices	Observe prices directly in markets	Environmental goods and services that are traded directly in markets	Timber and fuel wood from forests, clean water from wetlands	Market prices can be distorted e.g. by subsidies. Environmental services are often not traded in markets
Replacement cost	Estimate cost of replacing environmental service with man-made service	Ecosystem services that have a man-made equivalent that could be used and provides similar benefits to the environmental service	Coastal protection by mangroves; water filtration by wetlands	Over-estimates value if society is not prepared to pay for man-made replacement. Under-estimates value id man-made replacement does not provide all the benefits of the environmental service
Damage cost avoided	Estimate damage avoided due to ecosystem service	Ecosystems that provide protection to houses, communities or other assets	Coastal protection by mangroves/reefs; river flow control by wetlands	Difficult to relate damage levels to ecosystem quality
Net factor income	Revenue from sales of environment-related goods minus cost of other inputs	Ecosystems that provide an input in the production of a marketed good	Filtration of water by wetland; commercial fisheries supported by coral reef	Over-estimates ecosystem values
Production function	Estimate value of ecosystem service as input in	Ecosystems that provide an input in the production of a marketed good	Filtration of water by wetlands; commercial fisheries	Technically difficult; high data requirements

Valuation Method	Approach	Application	Examples	Limitations
	production of marketed good		supported by coral reef	
Hedonic pricing	Estimate influence of environmental on price of marketed goods	Environmental characteristics that vary across goods (usually houses)	National parks, air pollution, proximity to landfills	Technically difficult; high data requirements
Travel cost	Travel costs to access a resource indicate its value	Recreation sites	National parks, marine protected areas	Technically difficult; high data requirements
Contingent valuation	Ask survey respondents directly for WTP for environmental service	Any environmental good or service	Species loss, natural areas, air pollution	Expensive to implement
Choice modelling	Ask survey respondents to trade-off environmental and other goods to elicit WTP	Any environmental good or service	Species loss, natural areas, air pollution	Expensive to implement; technically difficult
Value transfer	Uses values estimated at other location	Any environmental good or service	Species loss, natural areas, air pollution	Possible transfer errors.

Ecosystem Service	Valuation Method
Food, timber, fuel wood	Market prices
Water filtration	Replacement cost, net factor income, production function
Water storage	Replacement cost, net factor income, production function
River flow control	Replacement cost, damage cost avoided, production function, net factor income
Coastal protection	Replacement cost, damage cost avoided, production function, net factor income
Support to fisheries	Net factor income, production function
Recreation site	Market prices, contingent valuation, travel cost, hedonic pricing, choice modelling
Visual aesthetics	Contingent valuation, hedonic pricing, choice modelling
Biodiversity	Contingent valuation, choice modelling
Non-use/existence values	Contingent valuation, choice modelling

Tabletop Discussion/Group Exercise

- Define the Total Economic Value (TEV) of a forest, watershed, or coral reef, making reference to both use and non-use values.
- Having identified the TEV, describe the valuation techniques you would use to obtain values for the elements included in the TEV.
- What is the value of conserving the ecosystem?
- To whom does the value accrue?
- How does degradation and loss of natural resources lead to costs to different segments of society?
- Who gains and who loses when a natural resource is conserved or degraded?
- Discuss how NRV should be mainstreamed in policy, planning and decision making – and the potential impacts it can have to achieving SDGs 13, 14, 15 and 1

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