City Adapt

RECONNECTING CITIES WITH NATURE

LATINAMERICA AND THE CARIBBEAN

10 PROTOCOLS FOR NATURE-BASED SOLUTIONS IMPLEMENTED IN URBAN AND PERI-URBAN AREAS

CITYADAPT PROJECT (2018-2023)

gef

UN environment programme

Nature-based Solutions Protocols

Clicking on this banner throughout the document will take you back to this menu.

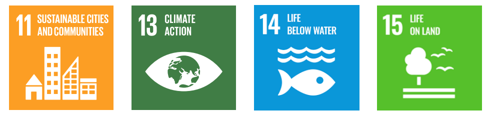
Mangroves rehabilitation in wetlands

Mangrove rehabilitation is a management intervention designed to restore mangrove forest cover and associated valuable ecosystem services of degraded, disturbed, or destroyed mangrove forests where self-renewal is no longer possible.

Rehabilitation creates an opportunity for stakeholders to be educated about restoring mangroves, the causes of successes and failures of restored mangrove ecosystems, as well as the value of mangroves and their restoration.

There are three types of rehabilitation principles and practices: i) planting alone (mangrove gardening), ii) hydrological restoration, and iii) excavation and fill. The underlying reason for degradation determines which principle or practice is implemented; however, in many cases, successful restoration involves a combination of all three.

Integration with international agreements



Sendai: Goal 3 – strengthening inclusive policy implementation through community engagement to improve livelihoods.

Duration

Results of mangrove restoration can be seen in 3 to 5 years after planting.

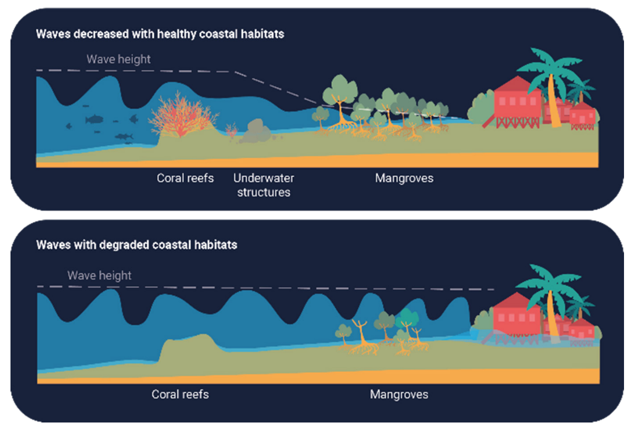
Place of implementation

- Mangroves are found in coastal and deltas environments in the tropical and subtropical latitudes.
- Where mangrove forest degradation is evident, and intervention is needed to avert the destruction of an entire ecosystem.
- Coastal communities which rely on forests to protect their property and livelihoods from climate change impacts.

Threats Addressed

- Sea level rise
- Intense rainfall
- Change in weather patterns

Coastal protection via coral reefs and mangroves



Main climate impacts addressed

Diminishes coastal flooding

Blue forest act as natural barrier by reducing wave heights with their dense vegetation and support coastline stabilization by trapping sediments in their roots systems during extreme events.

Reduction of salt intrusion and coastal erosion

Mangroves protects shorelines by reducing erosion from storm surges, waves, tides and currents. They support coastline stabilization as they reduce extreme events wave flow pressure and can dissipate wave energy. They reduce coastal water surges from extreme events, including hurricanes.

Social and economic co-benefits

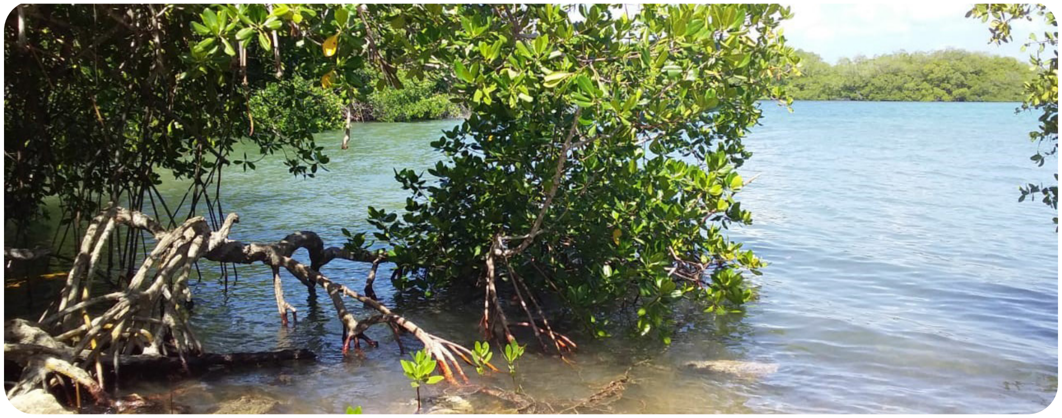
- **Improves water quality** by acting as filter for sediments and nutrients. They protect inland aquifers from salination, acting as pump and barrier between the see and the aquifer.
- **Provides habitat for species and promotes biodiversity** by providing food and shelter for various fish, marine invertebrates and birds.
- **Provides cultural services,** including recreation and education.
- **Provides direct economic goods and services** to communities for sustainable production and consumption of fuel, timber for construction, fishing, aquaculture, textiles, leather and a range of products such as pulp for paper and mangrove honey. It can also result in nature-based tourism opportunities.
- **Enhance education and awareness** on restoring mangroves, their value and the different ecosystems (sea grasses, coral reefs) they are connected with.
- **Contribute to climate mitigation** by sequestering and storing carbon dioxide from the atmosphere.

Implementation stages

1. Evaluate historical and current area coverage and site reconnaissance to determine the cause of degradation.
2. Install water level loggers to determine the depth, duration and frequency of tidal flooding if hydrology is suspected as the reason for degradation.
3. Decide on the rehabilitation goal and finalize the rehabilitation plan, including hydrological restoration and solid waste removal. Consider prioritizing natural and local materials, such as baboo and brushwood, and providing enough supply of sediment.
4. Obtain requisite permits and licences from government authorities. Doing this with enough time is crucial under a project timeline.
5. Engage community members to plant the seedlings, creating capacities and awareness on the benefits of these blue forests.
6. Implement the rehabilitation plan which may include creating channels to improve or restore hydrology and planting of seedlings if natural colonisation does not occur.
7. With the input of community members, monitor planted or self-generated seedlings to evaluate growth and success. Develop a maintenance plan to control and adjust the growth of the blue forest.

Implementation stages

- Planting seedlings without a detailed prior investigation can lead to waste and damage public trust in the process.
- Community engagement and involvement are critical to successful rehabilitation, especially in the case of heavily used, urbanized mangroves such as the Kingston Harbour.
- Mangrove seedlings should benefit from 'head-starting' or a period of hardening in a nursery or other controlled conditions.
- Seedlings should not be planted in rows or columns. Instead, they should be planted in clusters, with at least one metre of separation between clusters.
- Seedlings must be placed according to the typical mangrove zonation pattern or position to which the species are adapted.
- Installation of permeable structures can maximize the sediment capture to facilitate the mangrove recovery in a degraded area



Costs and inputs

Main inputs in determining the approximate cost for rehabilitation of 2 hectares of degraded mangrove area (Planting 2500 seedlings) include acquisition of equipment, transportation (via boat), removal of solid waste from the area, implementation of wetland modification, and ecosystem monitoring for 1 year.

Mangrove Rehabilitation	Cost in USD
Equipment and Tools	$4,664.20
Labour	$6,510.20
Transportation (Boat & Solid Waste Removal)	$5,887.20
Administration	**$4,260.40**
Total	**$21,302.00**

How to monitor implementation

Implementation is monitored by i) seedling density (number), ii) survival rate (percentage), iii) height, iv) node production (number), v) animal presence (number) and vi) natural recruits (number).

How to gauge impact

Implementation	• Number of seedling density • Number of node production • Wetland Status (hectares) {type of biodiversity}
Quantitative impact	• Survival rate of plant species (%) • Mortality rate of plant species (%) • Mean temperatures per annum (%) • Estimated Affected Population Due to Heavy Rainfall and Flooding
Qualitative impact	• Presence of permitting framework and guidelines that facilitate forested wetland • Mortality rate of plant species (%) • Mean temperatures per annum (%) • Estimated Affected Population Due to Heavy Rainfall and Flooding

References

Bee Professor. “How Much Honey Does a Bee Produce?” Bee Professor. Accessed . 2023.11.10 https://beeprofessor.com/how-much-honey-does-a-bee-produce/.

Ellison, Aaron M., Alexander J. Felson, and Daniel A. Friess, 2020. “Mangrove Rehabilitation and Restoration as Experimental Adaptive Management.” Frontiers in Marine Science 7 (327).

Kathiresan, K., and B. L. Bingham, 2001. “Biology of Mangroves and mangrove ecosystems.” In Advances in Marine Biology, 81-251, Academic Press.

Webber, Mona, Hilconida Calumpong, Beatrice Ferreira, Elise Granek, Sean Green, Ruwa Renison and Mario Soares, 2016. “Mangroves.” In The First Global Integrated Marine Assessment: World Ocean Assessment I, edited by United Nations, 877-886.

WB 2021. A Catalogue of Nature based Solutions for Urban Resilience

World Bank. 2019. “Forces of Nature: Assessment and Economic Valuation of Coastal Protection Services Provided by Mangroves in Jamaica”.

Establishment & Maintenance of Urban Tree Seedlings

Proper establishment and maintenance of forest trees support efforts to reforest urban, peri-urban denuded landscapes. Trees provide environmental and social benefits and promote cleaner and healthier living spaces. Adherence to specific guidelines for planting, such as the use of silvicultural prescriptions, as well as the development and execution of maintenance schedules, enhances the survival of planted seedlings in urban and peri-urban spaces.

Integration with international agreements

11 SUSTAINABLE CITIES AND COMMUNITIES · 13 CLIMATE ACTION · 15 LIFE ON LAND

Sendai: Goal 3 – strengthening inclusive policy implementation through community engagement to improve livelihoods.

Beneficiaries

Direct beneficiaries include local communities around the planted area that will benefit from decreased temperatures and floodings, thanks to the tree cover and its infiltration capacity. Community participation in the maintenance of these areas can be considered for engagement and long-term sustainability of these natural resources.

Duration

Results of planting tree seedlings can be seen in 3 to 5 years. In tropical countries such as Jamaica, planting is best done during the rainy seasons of April to June, and September to December.

Place of implementation

In urban areas, tree planting should be identified in conjunction with the urban planning regulation of each city: it can occur in side-walks, roundabouts, parks, etc., depending on the long-term impact on nearby infrastructure. Urban forest can also be established: phytoremediation forest in landfills and abandoned urban areas, ecological forest corridor along drainage lines, etc.

In peri-urban areas within the city's watershed, territories which have been subject to forest degradation or deforestation could be selected to address hydrological challenges in the upper watershed. The intervention could also avert destruction of ecosystems, increase biodiversity, improve environmental conditions, promote sustainable forest use, and foster community-based urban forest conservation.

Threats Addressed

- Increased temperatures
- Drought
- Changes in weather patterns

Main Climate Impacts & Threats Addressed

Flooding

Establishment of forest tree seedlings over time stabilizes the soil, thereby preventing runoff and reducing flooding.

Erosion

Soil stabilization mitigates the erosion effect of floods during heavy rains.

Landslides

With less water flow and flooding, the risk of landslides is reduced.

Undermining Urban Food Security

Planting tree seedlings helps to increase food security especially in socially vulnerable, low-income urban areas, providing a cost effective source of healthy, nutritious food.

Decrease in water availability and quality

Planting trees helps to improve water quality in urban and periurban areas. Trees prevent runoff and erosion, resulting in better water quality and availability.

Social, eco-systemic and economic co-benefits

Increased environmental awareness and community education

The process of planting trees and rehabilitating forest areas fosters greater environmental awareness in communities, as well as sensitivity to climate change.

Health benefits

Trees in urban spaces provide shade, supports climate regulation, captures CO_2 emissions and therefore improves air quality. Several studies have demonstrated direct benefits in mental health of surrounding urban populations.

Improved biodiversity

Planting trees supports improved urban and biodiversity a healthy ecosystem. Trees attract birds, bees, and other wildlife that have important ecosystem functions which support quality of life for communities.

Implementation Stages

1. **Planning how much and where to plant**. Identify the areas for intervention and establish access and the current use of the space among affected communities.
2. **Conduct on the ground assessments and surveys using Global Positioning System (GPS) technology.** Measure the direction of the slope and soil type to assess the level of humidity, velocity of stormwater, etc., and thus establish the best planting techniques and stages of maintenance.
3. **Develop silviculture plan.** Generate silvicultural prescriptions for planting sites, detailing the type of seedlings, how many are needed, and how seedlings should be planted and maintained. Consider the combination of seedlings to mimic endemic natural forest habitat.
4. **Establish a procurement plan.** Define the equipment and material needed for the intervention, including the requirements for the seedlings and the labour force to carry out the work.
5. **Prepare the land and carry out the planting according to the most relevant methodology.** Site preparation can include removal of waste or weeds, as well as the decision to nurse some crops prior to planting to facilitate their growth.
6. **Design an urban tree cover rehabilitation and maintenance plan** which takes into account the conditions of planting sites, species of seedlings, water availability and requirement, the needs of surrounding communities, and aesthetic considerations.

Important factors to consider

- **Suitable species:** Planting seedlings without appropriate silviculture guidelines can lead to loss of seedlings due to introduction of species which are not suitable for a specific area or ecosystem.
- **Community engagement:** Engaging and involving the community are critical to the success and sustainability of forest establishment and maintenance, especially in the case of heavily used and urbanized areas.
- **In case of urban forest planting, preventing forest fires**: Fire lines or breaks should be established at strategic points during the dry seasons to reduce the effect and impact of fire occurrences post-planting. Fire lines should reflect an area void of all vegetative fuel biomass to slow the progress of fires, and the width of these lines should be between 2.5 and 3 metres. Fire lines should be continuously maintained to ensure protection during the dry months.
- **In areas where there is less rainfall or areas which experience prolonged dry conditions,** consideration could be given to hiring personnel to water seedlings.

Costs and inputs

Activity for 1 ha	Total (USD)
Land Preparation (bushing & clearing, lining, cutting & supplying pegs, digging holes)	$872.69
Planting cost	$34.81
Seedling cost	$1,977.85
Replanting seedlings loss to mortality	**$580.08**
Weeding	**$2,557.59**
Protective firelines & boundaries established	**$2,199.45**
Road/Trail Maintenance (Once per year for 3 Yr)	**$539.49**
Sub-Total	**$8,761.96**

Indicators

Implementation	• Number of (seedlings) trees planted. • Number of seedlings produced and cost per seedling. • Area (hectares) reforested • Area (ha) of forest under sustainable forest management plans. • Number of guidelines developed for the establishment and maintenance of trees in urban settings and for use in culture, aesthetics and shade purposes. • Number of public education/awareness sessions and school awareness programmes delivered (by type and stakeholder
Quantitative impact	• Percent Change in status of forest cover (ha) • Survival rate of newly planted trees (%) • Percent renewables in electricity generation • Percent change in Soil Quality
Qualitative impact	• (Yes/No) Guidelines developed for the establishment and maintenance of trees in urban settings and for use in culture, aesthetics and shade purposes.

References

Forestry Department (Jamaica), April 2014. Standard Operating Procedure: "Field Establishment and Maintenance for Forest Tree Seedlings."

Forestry Department (Jamaica), June 2018. "Guidelines for roads and trails and firelines."

Forestry Department (Jamaica), 2014. "Guidelines for Pest and Disease Management.

WB 2021 A Catalogue of Nature based Solutions for Urban Resilience

Restauration of critical areas

The restoration of critical areas plays a fundamental role in conservation y recovery of our valuable natural ecosystems. You will discover the key steps involved in the restoration process, the benefit that could be achieved and the potential limitation that could will be arise. This comprehensive approach seeks to strengthen adaptation and mitigation in the face of climate challenges, promoting restoration of critical areas as a key task to protect that biodiversity, maintain ecosystem services and guarantee long-term sustainability.

Integration with international agreements

Sendai: Goal 3 – strengthen inclusive policy implementation through community engagement to improve livelihoods.

Description

The restoration of critical areas with native species is based on Ecosystem-based adaptation (EbA) approach, which combine the restoration of degraded ecosystem with the promotion of ecosystem services to face climate change. Through the strategic plantation of native species, the aim is improve the resilience of ecosystems, soil conservation, regulate water flow and increase carbon sequestration.

Place of implementation

It is advisable to prioritize degraded areas that have experienced a significant loss of native vegetation. In addition, it is important to consider accessibility and logistics, such as the existence of nearby roads and water sources. Agroforestry zones can also be integrated, such as the distribution of native trees within coffee crops as shade and live fences to delimit the areas.

Beneficiaries (~#)

Local communities by improving their quality of life and strengthening their resilience. Farmers and ranchers receive economic benefits and society in general benefits from conserving biodiversity and protecting the environment for future generations.

Social and economic co-benefits

Indirect economic benefits

- Improves ecosystem services such as water resources or protection against disasters.
- Ecosystem services benefit communities by reducing costs associated with floods, droughts, and crop failure.

Creation of educational spaces

Restoration of critical areas provides opportunities for environmental education and ecological awareness.

Employment generation

The restoration of critical areas entails the creation of employment in activities such as plant nurseries, sowing, maintenance and monitoring of the projects.

Carbon capture and storage

Trees absorb carbon dioxide from the atmosphere as they grow, helping to mitigate climate change by acting as carbon sinks.

For more information visit www.cityadapt.com

Threats Addressed

Extreme heat

Intense rainfall

Sudden temperature changes

Landslides

Main climate impacts addressed

Soil degradation

Hotspot restoration focuses on addressing soil degradation caused by intensive agricultural activities and deforestation, looking for restore soil health and quality.

Loss of biodiversity

The restoration of critical areas has as its main objective the reintroduction of native species and the restoration of habitats, which helps to stop the loss of biodiversity and promote the recovery of natural ecosystems.

Water Scarcity

Promotes water infiltration into soils, recharging aquifers and addressing long-term water scarcity.

Implementation methodology

Phase 1. Site evaluation

1 Evaluation and planning

Conducts a comprehensive assessment of the degraded area to understand its current condition and determine restoration objectives. Considers factors such as soil type, climate, hydrological conditions and resource availability.

Phase 2. Implementation

2 Selection of native species

For effective restoration, native species suitable for the local ecosystem must be identified and selected, considering their adaptability to changing conditions and their contribution to biodiversity. In addition, it is important to establish a plant nursery with species extracted from local seed trees, keeping in mind the specific objective of the restoration. For example, evergreen species are established in coffee plantations to avoid problems with the crop, deciduous ones can be located in fences or landscapes. Careful selection will ensure effective tree integration.

3 Selection of native species

To adequately prepare the ground, it is necessary to carry out a series of fundamental actions. These actions include removal of invasive species, removal of debris, and correction of drainage problems.

These measures are essential to ensure an environment conducive to the restoration of critical areas. In addition, correcting drainage problems helps ensure that water flows properly and prevents pooling that can harm the growth of native species.

4 Planting hole

The process of hollowing out the ground of 30 x 30 centimeters. The density varies according to the situation of the area where the selected species will be established. In open or degraded areas, a distance of 10 to 18 meters betweenntrees is recommended. On the other hand, in borders or fences of paddocks, the optimal distance is 5 to 10 meters.

These spacing parameters ensure proper species distribution and allow each tree enough space to grow and develop optimally.

5 **Sowing**

Carry out tree planting following specific guidelines for each species. Be sure to provide optimal soil and irrigation conditions to encourage plant establishment and growth.

In order to ensure the success of the planting, fertilizers such as 16-48-0 or organic amendment with a high nitrogen and phosphorus content can be used to enhance root growth.

6 **Maintenance and monitoring**

Regularly monitor the restoration to ensure long-term success. This involves implementing maintenance practices such as weed control, proper watering, and protection against pests and diseases. In addition, it conducts continuous monitoring to assess progress and make adjustments as necessary.

7 **Community participation**

Encourages the active participation of the local community in all stages of the restoration process. This includes awareness raising, training and collaboration in planting and maintenance activities.

Limitations

1 **Resource availability**

The lack of necessary financial, material and human resources could hinder the implementation of restoration projects.

2 **Access to quality seeds and native plants**

Availability and access to high-quality seeds and native plants could be limited, affecting the ability to carry out effective restoration.

3 **Land ownership and tenure**

Problems related to land ownership and tenure can create obstacles to the implementation of restoration projects, due to the need for proper access to critical areas.

4 **Land use conflicts**

Conflicts related to land use could make it difficult to restore critical areas, as different interests and activities may be in competition.

5 **Climatic and soil conditions**

Climatic and soil conditions could affect restoration success,as certain native species may require specific conditions togrow and develop properly.

6 **Community participation**

Although community participation is essential for the restoration of critical areas, it can be challenging to achieve active and engaged community participation in these projects.

1. Characteristics such as texture, altitude, climatic characteristics, topography, hydrology, sun exposure must be taken into account. To identify the species and density suitable for the terrain.
2. Agroforestry systems such as the cultivation of coffee or cocoa, which also require the presence of trees in order to provide shade for the optimal development and production of the crop.
3. Required: hoe, duplex shovel, pruning shears, wheelbarrow, machete, backpack pump, buckets, pickaxe.

Costs and inputs

- The cost of each activity will depend on the situation of the land and the objectives to be achieved.
- In a degraded area without the presence of trees at the time of sowing, it can be intensified to 900 plants/Ha that when it grows, the amount due to competition between them and environmental difficulties will decrease.
- In agroforestry system, because a main crop is already present, the density decreases by 70 plants/Ha.
- Added to the cost of the trees, labor must be added for the preparation of the land, planting, fertilization together with the necessary equipment and supplies.

Indicators

Implementation	• Number of trees planted • Number of intervened hectares
Quantitative impact	• Number of families benefited

References

Dirección General de Gestión Sostenible del Patrimonio Forestal y de Fauna Silvestre - DGGSPFF, & Dirección General de Política y Competitividad Forestal y de Fauna Silvestre - DGPCFFS. (2018). Lineamientos para la Restauración de Ecosistemas Forestales y otros Ecosistemas de Vegetación Silvestre. CENITAL Concept.

Ministerio de Medio Ambiente y Recursos Naturales. (2015). Programa Nacional de Restauración de Ecosistemas y Paisajes. MARN.

Proyecto Maximizando Oportunidades en Café y Cacao en las Américas. (n.d.). Un cafetal productivo tiene sombra que lo cuida.

Ministerio de Medio Ambiente y Recursos Naturales. (2017). Plan de Acción de restauración de ecosistemas y paisajes de El Salvador con enfoque de mitigación basada en adaptación. Proyecto 2018 - 2022. MARN.

Fruit Planting

The planting of fruit trees in urban areas and at the micro-watershed scale contributes to reducing the effects of climate change at the local level and boosts the interest of the population in recovering and maintaining tree cover in the city. Fruit trees participate in the improvement of a community's environmental conditions, as their presence diminishes the impact of prolonged events (such as drought) on the soil, and contributes to a microclimate's regulation at the local level. Likewise, they regulate the conditions of infiltration and water, protect the soil from erosion, and provide food from the fruits obtained.

Integration with international agreements

2 ZERO HUNGER · 6 CLEAN WATER AND SANITATION · 11 SUSTAINABLE CITIES AND COMMUNITIES · 13 CLIMATE ACTION · 15 LIFE ON LAND

Sendai: Goal 3 – strengthening inclusive policy implementation through community engagement to improve livelihoods.

Duration

The planting of fruit trees can be done in the first two months of the rainy season, not exceeding this period to take advantage of the water supply. The duration of the plantations will depend on the species planted and the needed maintenance.

Place of implementation

Fruit trees can grow in a wide range of soils as they can find water and nutrients at great depths. Most fruit trees do not tolerate very moist soils (except for bananas). In moist soils, it is necessary to dig a drainage channel to avoid damage to the fruit trees. Most fruit trees prefer direct sunlight.

Beneficiaries (~#)

Emphasis is placed on the collective scale, because it is an action aimed at generating the participation of the resident population in the community. The number of beneficiaries depends on the number of trees and the planed species.

Threats Addressed

- High temperatures
- Drought
- Changes in rainfall patterns

Social and economic co-benefits

Increasing inputs available

- Uses an area of soil already available and unused.
- Simple implementation, relatively low economic investment, low maintenance costs.

Production

- Produce food sources

Social cohesion

- Community strengthening, use and strengthening of community's capacities and/or cooperative capacities.

For more information visit www.cityadapt.com

Implementation stages

Main climate impacts addressed

Increase in temperatures at the local level

The planting of fruit trees will lead to a temperature regulation o the medium term, modifying the microclimate at the site.

Floods

Contribution to the water infiltration through the root system.

Erosion

Mitigation of erosion's effects, through the root system that forms an underground web thus keeping the soil elements together and preventing elements from detaching. It also absorbs the excess water.

Landslides

With a decreased water flow and less flooding, the risk of landslides is reduced.

Phase 1. Site and species assessment

1 Research to compile secondary information is necessary to obtain an updated baseline on the area of intervention, with the aim of learning from activities previously carried out in that area and identifying the local actors to articulate the interventions at the community, municipal or governmental level.

2 Coordination is carried out with representatives of the different communities, followed by inception and evaluation visits. It is important to create partnerships to provide information on food safety and production possibilities at the community level.

3 A mapping of the area then identifies the physical spaces for the plantation of the fruit species, taking as reference sectors of interest that impact the resilience of the communities.

4 An identification of which type of plants are of direct use for consumption and which fruit species are the most common and prevalent for use locally is part of the species' selection process.

5 The land's conditions are also evaluated, mainly assessing the availability of physical space and the possibility of plant development in the identified spaces.

6 Elaboration of a list of species to be used in arborization actions with fruit trees, in the selected sites. Species must meet some ecological criteria necessary to withstand climatic conditions in the environment, in order to ensure their survival as well as their ability to generate the expected environmental services.

Phase 2. Implementation

7 The plants are procured or grown in a nursery, ensuring that they are those with the best possible development, selecting the most vigorous ones.

8 The land where they will be planted is prepared; the planting must involve people from the community, in order to integrate them in the process.

9 The necessary materials and tools are delivered to carry out the sowing, and teams are formed with the participants.

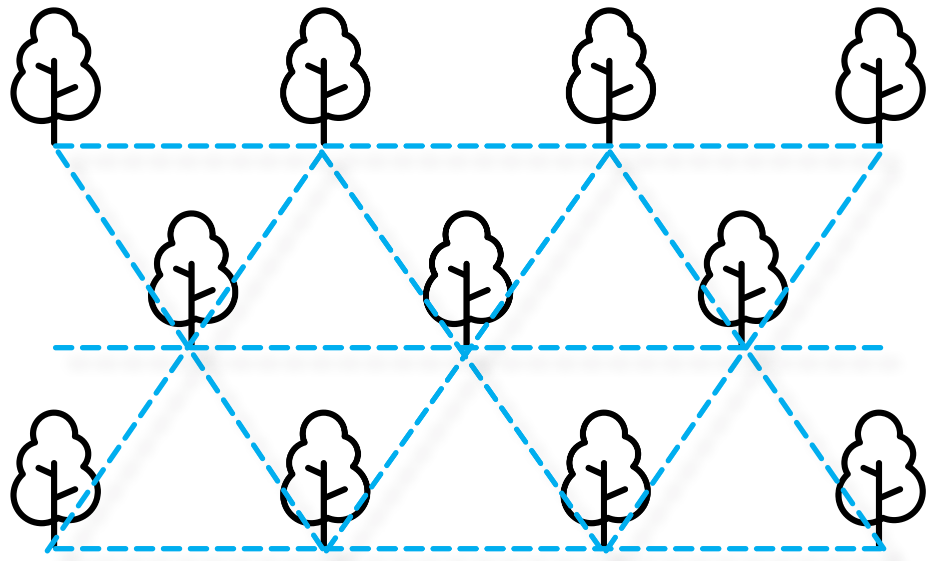
10 The site is cleaned, cutting plant species that could inhibit the growth of plants.

11 The sowing begins. When the space allows it, it is recommended that it be done with a triangular system, sowing the plants 3 to 4 meters of each other according to the species of interest. Sowing through a triangular system consists of planting the trees in rows, but ensuring that the plants in one row face a hole in the following

row (see the graph). This type of planting allows more trees to be planted per hectare and reduces selfshading among the planted species. The roots should never receive direct sunlight in order to avoid dehydration.

12 The sowing is done based on the availability of space and the selected species. Holes are dug with the help of duplex shovel or hoe, 40 cm in diameter and 45 cm deep, depending on the species to be planted.

13 The tree is planted by removing it from bag where it was sown, trying not to damage the main root and maintaining the substrate where the plant was developed.



Phase 3. Maintenance

14 **Fertilization:** benefits the trees, mostly at the time of planting. Usually 2 kg of compost should be applied when sowing, and then again every four months. Fertilizer or compost can be added before (never during) flowering, and again when the fruit is half ripe.

15 **Irrigation:** young fruit trees are very sensitive to droughts and need daily watering during the dry season in the first two years of their life. Older trees are more resistant.

16 **Pruning:** Some trees benefit from pruning. When planting, upper strong branches can be selected to become the tree trunk. As the tree grows, branches that are very close or rubbing against each other should also be pruned. This allows air and light to circulate through the tree, reducing pests and promoting fruiting.

Costs and inputs[1]

Description	Total
900 Fruit trees	$900
Tools [2]	$263
Inputs [3]	$99
Labour for prunning, drowning and sowing (70 jornales)	$700
Total	**$ 1,962**

1 This calculation corresponds to the value of 1 hectare of cocoa cultivated in El Salvador. However, the amount varies depending on the type of fruit, as well as the arrangement and planting system used.

2 4 duplex shovels, 4 chuzos, 4 azadones, 1 wheelbarrow, 2 corvos, 4 cumas, 1 backpack pump, 4 buckets.

3 A organic bonus, rock flour, foliar fertilizer.

Indicators

Implementation	Planted area (ha)
Quantitative impact	• Growth rate • Plant density per unit area • Number of producers involved • Number of systems deployed • Rate of involvement of women in cultivation and production processes • Local temperature • Humidity level

References

JICA (2017) Manual of the protagonist, Cultivation of Fruit Trees, National Technological Institute, General Directorate of vocational training, Managua, Nicaragua, 135 p.

Alonso Mielgo A. & J. Arcos Martin ( ) Good Practices in Organic Production, Fruit Cultivation, Ministry of environment and rural and marine environment, Government of Spain, 32 p.

Ishpingo Foundation (2012) Practical guide for the cultivation of fruit trees, Seed collection, nursery management, Agroforestry and fruit growing techniques; 52 p.

Technical data sheets of the main native and exotic fruit species-Alto Napo - Amazonia Ecuatoriana, Tena, 2012.

Resilient gardens

The resilient garden is a plot of land used for the cultivation and harvesting of food and can become a teaching and learning space in schools. It's characterized by a small size rich in flowers and shrubberies, which provide vegetables, aromatic herbs and fruits. They are implemented with an agroecological strategy, that involves food cultivation practices without environmental deterioration. It can also be adapted to limited conditions of water availability and include a drip irrigation mechanism, and in some cases, rainwater harvesting systems.

Integration with international agreements

Sendai: Goal 3 – strengthening inclusive policy implementation through community engagement to improve livelihoods.

Duration

The **installation** of a resilient garden can be carried out in a period of 4 to 6 months, from the selection of the site to the process of training, sowing, managing the cultivation and harvesting of the products.

Its **operability** can be long-lasting, based on the adequate crops' monitoring and the community organization for its sustainable management.

Place of implementation

It requires a minimum area of 24 m2 if implemented in schools. It can take larger dimensions in peri-urban and rural areas, depending on the beneficiaries needs and management capacities. Smaller gardens are not considered under this protocol.

Beneficiaries (~#)

The beneficiaries should be a group of a collective scale, considering this action aims at generating community participation. The number of beneficiaries depends on the size, diversity of species and number of crops.

Threats Addressed

Drought

Social and economic co-benefits

Increasing inputs available

- Savings on food purchases.
- Use of an available and unused area.
- Simple implementation and low maintenance costs.

Social cohesion

- Community participation, through a learning-and-doing training process that allows beneficiaries to be directly responsible for the management of the orchards.

Education

- It is a good experience to showcase ecosystem services and climate resilient livelihoods in the school and community.

For more information visit
www.cityadapt.com

Main climate impacts addressed

Reducing food security

The resilient gardens become a source of food supply for the community. Through crop diversification, food can be obtained throughout the year.

Loss of productivity

It provides a sustainable production system through the system's resilience that distributes losses in the event of extreme events due to rain or heat.

Need for more inputs

For a community consumption, the product's price is diminished as the supply chain from harvest to consumption is eliminated.

Spread of pests

With the planting of certain species that function as repellents, the resilient gardens provide a resilient system in case of spread of pests.

Implementation stages

Step 1. Site evaluation

1 **Choosing the place:** a minimum area of 24 m2 is required, preferably a flat ground, with water accessibility and exposure to sunlight. It is recommended to place it near a wall, to protect it from the strong wind. If there's no adequate land, a vertical garden can be established instead: by reusing local materials, both horticultural and ornamental plants can be grown in a vertical wall or pendant structure.

Step 2. Implementation

1 **Protecting the planting area:** it should be fenced with a wire mesh, aromatic plants and green fertilizers, to prevent the arrival of insects or animals that could damage it. For a community garden, as it is a large area, the construction of a fence with perimeter mesh is recommended.

2 **Provision of materials, inputs and local seeds:** with due anticipation, materials and inputs of the area should be collected, such as sand, black earth, leaf litter, ash, poles or rods for tutors and native seeds among others.

3 **Elaborating organic fertilizers:** this should precede the sowing of the different crops, for a timely incorporation when the soils are being prepared.

4 **Preparing the planting area:** It is necessary to create a soil with the right nutrients for plants to grow healthy and consistently. The ideal dimensions are 2 m long, 1 m wide and 60 cm deep, with corridors between each planting area measuring between 40 and 50 cm. The length of the planting area however depends on the available land.

5 **For the soil conditioning of the planting area, the double excavation process should be carried out:** it consists of loosening the soil, cleaning, applying lime or ash, sand, compost or natural fertilizers and soil mixture, to improve the texture and structure, and thus optimize fertility.

6 **Constructing seedlings:** for certain species (such as lettuce or tomato), it is necessary to plant the seeds in small seedlings before being transferred to the resilient garden. These are a tabletype structure where trays or other types of small containers are placed to plant the vegetable seeds, where the seedlings will grow. The seedbeds should be kept in such a way as to avoid rain, sun and direct wind and they should have protection against animals.

7 **Planting species of direct-seeding:** vegetables such as cucumber[1] , green bean[2] , pumpkins[3], radishes[4] , etc., do not need to go through the seedling stage so they are sown in the planting areas of the resilient gardens directly. Many or most of these can be planted in bags, pots or another type of container that guarantees positive root development.

8 **Planting species of indirect-seeding:** once the seedlings plants are ready, they can be moved to the resilient gardens too. The ideal timing depends on each species; for example: when lettuce has 4 to 5 leaves and when the tomato is 10 to 15 cm tall.

Phase 3. Maintenance

1 **Irrigation:** with the objective of adapting to climate change, the resilient garden optimizes the use of water and suggests the application of ideal techniques to supply the necessary amount of water avoiding its waste; therefore, a drip irrigation system should be implemented that allows for the humidity of the substrate to adequately supply the plant.

2 **Thinning:** it consists of removing the weakest plants and those that are too close, leaving a space of 5 to 7 cm between them. This work is done with direct-seeded vegetables.

3 **Tutoring:** it is done with some vegetables that need support, to avoid the contact of fruits or foliage with the soil (tomato, cucumber).

4 **Control of harmful insects and diseases:** with the objective of avoiding pests and potential damages to the crops to such a degree that they could affect their production, several technics of integrated management can be used, such as traps, crop rotation, barriers, planting of resistant varieties and use of plant extracts.

5 **Harvest:** if about 10 species are developed and sown in a staggered manner, harvesting would be continuous.

1. Cucumis sativus
2. Phaseolus vulgaris, also known as green beans or kidney bean.
3. Cucurbita argyrosperma
4. Cucurbita moschata

Costs and inputs[5]

Description	School[6] , With drip irrigation system with 1,100-liter tank (US$)	Community[7], with drip irrigation system with 2,500-liter tank and rainwater harvesting system (US$)
Tools[8]	172.50	439.00
Inputs [9]	75.00	288.00
Materials[10]	32.50	161.50
Drip irrigation system (includes 1 inch PVC pipe,irrigation tape, connectors and filter)	350.00	750.00
Water harvesting system (roof, gutter and pipe)	N/A	300.00
Total	630.00	$1,938.50

Indicators

Implementation	• Number of resilient gardens installed • Number of harvests obtained during the • Implementation period • Production obtained per unit area (kg/m^2)
Quantitative impact	• Percentage of food used for school or family consumption (kg) • Presence of pollinators at the site of resilient garden • Rate of involvement of girls and women in the implementation of the garden • Number of people who request inputs and • Information to replicate the gardens

References

Ministry of Education, 2018. Agreement 15-0145 Guidelines for the implementation of school gardens.

FAO, MUDE SEA 2009 The school garden as a teaching learning resource for the subjects of the basic education curriculum.Food and Agriculture Organization of the United Nations-FAO Santo Domingo, Dominican Republic, October 2009.

FAO 2009 The School Garden Guidelines for Implementation, Ministry of Education, Government of El Salvador.

Jiménez Diego 2014 School Garden project, IES EGA, San Adrián (Navarra), Spain.

5. The amount is calculated for a garden of 50m^2. it is considered for the effective implementation of an ecological garden, hiring the services of a professional in the field who provides advice and training in the development and application of organic fertilizers and repellents and garden management.
6. Is calculated for an area of 500 m^2 in the peri-urban area. It does not include the costs of perimeter fencing.
7. It is required: hoe duplex shovel, scissors for pruning, wheelbarrow, a toolkit for the care of the garden, germination tray, machete, atomizer backpack pump buckets, piocha, rake.
8. Seed aquetes, aromatic herb plants, quintals of black earth, quintals of bokashi, quintals of minerals, repellents, or organic insecticides.
9. Material to fence, tie-down wire, hose.

Greenhouse

A greenhouse is a structure, primarily made of transparent materials like glass or plastic, designed to cultivate and protect plants by creating a controlled environment. This environment is ideal for growing a variety of plants, ranging from flowers and vegetables that would not normally thrive in local climates or that can be affected by changes in weather pattern caused by climate change. Greenhouses can significantly strengthen communities in various ways, fostering not only agricultural development but also educational, social, and environmental benefits.

Integration with international agreements

SDG 2, SDG 11, SDG 13

Duration

A greenhouse can be installed in 5-10 days. The lifespan of a greenhouse largely depends on several factors, including the materials used in its construction, the quality of its build, the level of maintenance it receives, and environmental conditions. However, its use life is 5-10 years.

Place of Implementation

- The selection of a suitable location for a greenhouse is crucial for its functionality and efficiency. Things to consider when installing a greenhouse are: Sunlight exposure, Access to Water, Wind Protection, Drainage, Accessibility, Availability of Space, Ventilation, & Slope.

Beneficiaries - A 50 X 100 greenhouse can serve an estimated student population of 1435 students. The number of beneficiaries will be dependent on the size of the structure, what is cultivated within and the use of the produce.

Threats Addressed

- Increased temperatures
- Changes in rainfall patterns
- Heavy Rainfall
- Drought

Social, eco-systemic and economic benefits

Economic:

Local Food Production:

- Reduces food transportation costs and carbon footprint.
- Can lower grocery bills for community members through access to greenhouse produce.

Social cohesion

- Strengthens community cooperation including at key locations such as schools and community buildings

Education

- Climate Change Education: Greenhouses in schools and communities serve as excellent tools for educating people about climate change, sustainable agriculture, and environmental stewardship. They provide hands-on learning opportunities in subjects like biology, environmental science, and agriculture and enhances understanding of sustainability, plant life cycles, and food production

For more information visit www.cityadapt.com

Main Climate Impacts & Threats Addressed

Water scarcity: Greenhouses often use irrigation systems like drip irrigation or hydroponics, which are more efficient and reduce water waste. They are designed to recycle and reuse water, minimizing overall water usage.

Weather Extremes: Greenhouses provide a controlled environment that can protect plants from extreme weather conditions.

Change in weather patterns: They enable year-round food production, which can be crucial in areas where climate change has shortened or disrupted traditional growing seasons.

Implementation

1 **Site Selection**
- Choose a location with maximum sunlight exposure.
- Ensure the site is level and has good drainage.
- Avoid areas under trees or where structures may cast shadows on the greenhouse.

2 **Permit and Zoning Checks**
- Verify local building codes, zoning laws, and any required permits for greenhouse construction.

3 **Foundation Preparation**
- Clear the site of debris, rocks, and vegetation.
- Mark the perimeter of the greenhouse using stakes and string.
- Decide on the type of foundation (e.g., concrete, wood, or directly on soil) based on the greenhouse model and local climate.

4 **Materials and Tools Gathering**
- Acquire all necessary materials specified by the greenhouse manufacturer, including the frame, panels, fasteners, and any additional accessories.
- Prepare tools required for assembly, such as screwdrivers, hammers, drills, level, measuring tape, and safety equipment.

Installation Process

1 **Foundation Installation**
- For concrete foundations, pour concrete to the marked perimeter and level it.
- For wood foundations, secure treated lumber to the ground using anchors and ensure it is level.

2 **Frame Assembly**
- Assemble the greenhouse frame according to the manufacturer's instructions. This typically involves connecting metal or PVC pipes or wooden beams.
- Ensure the frame is square and level at every step of the assembly.

3 **Panel Installation**
- Install the panels (glass, polycarbonate, mesh or plastic) onto the frame. Begin from one corner and progress systematically to ensure proper alignment and fit.
- Secure the panels with the provided fasteners, clips, or glazing strips, ensuring a tight fit to prevent heat loss.

References

1. Schiller, Lindsay. Year- Round Solar Greenhouse: Step-by-Step Guide to Design and Build Your Own Passive Solar Greenhouse in as Little as 30 Days without Drowning in a Sea of Technical Jargon. Small Footprint Press, 2021.
2. Castilla, Nicolás. Greenhouse Technology and Management By. CABI, 2013.
3. Gatter, Mark, and Andy McKee. How to Grow Food in Your Polytunnel: All Year Round. Green Books, 2010.
4. Boodley, James William, and Steven E. Newman. The Commercial Greenhouse. Delmar Cengage Learning, 2015.

4 Door and Vent Installation

- Install the door frame and door according to the instructions, ensuring it opens and closes smoothly.
- Fit any roof vents or side vents, making sure they operate correctly for adequate ventilation.

5 Utilities Setup

- If required, install electrical wiring and plumbing for lighting, heating, and irrigation systems, adhering to local codes and safety standards.
- Ensure all utilities are tested and functioning correctly.

Post-Installation

1 Interior Setup

- Install any interior shelving, potting tables, or plant supports.
- Plan the layout to maximize space and light exposure for plants.

2 Landscaping and Exterior

- Consider adding exterior paths, gutters for rainwater collection, and shading materials if necessary.
- Landscape around the greenhouse to enhance drainage and aesthetics.

3 Final Inspection and Maintenance Plan

- Conduct a thorough inspection of the greenhouse to ensure all components are securely installed and functioning.
- Develop a maintenance plan covering cleaning, checking for damage, and ensuring the ventilation and heating systems are operational.

Safety and Maintenance Tips

- Always follow the manufacturer's instructions and safety guidelines during installation.
- Regularly inspect the structure for damage, especially after extreme weather conditions.
- Keep the greenhouse clean to prevent disease and pests.

Important Factors to Consider

1. Target Crops: Determine what types of plants or crops you plan to grow early, as this will influence many other decisions
2. Accessibility: Easy access to water, electricity, and other utilities, as well as for people who will work in or visit the greenhouse is important to consider
3. Drainage: Proper drainage to prevent waterlogging and disease.

Indicators

Implementation	Number of greenhouse systems installed Number of schools or community groups using greenhouse to support NbS farming practices Number of direct beneficiaries (% of which are females)
Quantitative	Percent change in sustainable practices and behaviors in the community or school as a result of the greenhouse utilization
Qualitative	Percent of schools which have applied targeted improved NbS practices or technologies in their curricula

Costs and inputs

School Greenhouse Size: 15X25	**Cost in USD**
Labour:	1,960.78
Equipment & Tools	3,267.97
Technician	1,307.19
Total	**6,535.95**

Container Gardens in Schools

Container gardens refer to the cultivation of plants in containers rather than planting them directly in the ground. These containers can be pots, tubs, boxes, baskets, barrels, or any other vessel that can hold soil and plants.

Container gardens, while primarily used for their versatility and space efficiency, can also contribute to mitigating some of the impacts of climate change, albeit on a smaller scale. They won't solve the global climate crisis, they are a step in the right direction. When combined with other sustainable practices and scaled up, they can be part of a broader strategy to address climate change impacts.

Integration with international agreements

SDG 6, 11, 13

Duration

2-5 days depending on the number of containers and the size of the area.

Place of Implementation

- **Versatility:** Container gardens are versatile and can be placed indoors or outdoors. They can be used on patios, balconies, rooftops, or even inside homes and offices.
- **Space-Efficient:** They are ideal for places with limited space, such as urban apartments or homes without large yard spaces.
- **Mobility:** Plants in containers can be easily moved. This is beneficial for adjusting to sunlight requirements or protecting plants from adverse weather conditions.

Threats Addressed

- Heavy Rainfall
- Changes in rainfall patterns
- Drought

Social, eco-systemic and economic benefits

- **Carbon Sequestration:** Plants absorb carbon dioxide (CO_2) during photosynthesis, which helps reduce the overall CO_2 levels in the atmosphere. Reduced transportation needs of external food items can also lead to a decrease in carbon emissions associated with transport.
- **Biodiversity Support:** Container gardens can support biodiversity by providing food or habitats for various insects, especially pollinators like bees and butterflies. This can be particularly impactful in urban areas where natural habitats are limited.
- **Reduced Soil Degradation:** Container gardening can reduce the pressure on land for agricultural purposes, leading to less soil degradation and deforestation.
- **Improved Air Quality:** Plants in container gardens can absorb pollutants and particulate matter, improving air quality. This is especially beneficial in urban settings with higher pollution levels.

For more information visit www.cityadapt.com

Main Climate Impacts & Threats Addressed

Increased temperatures: Container gardens can assist with the mitigation of Urban Heat Island effect. Urban areas often experience higher temperatures than their rural surroundings due to human activities and the prevalence of concrete and asphalt. Container gardens, especially when used extensively on patios, rooftops, and balconies, can help reduce the urban heat island effect by through the cooling effect of evapotranspiration.

Flooding: Containers gardens can support storm water management: If implemented at a wide scale, container gardens can contribute to stormwater management. When it rains, the soil in the containers absorbs water, reducing the immediate runoff that can lead to erosion and flooding. Additionally, using containers with saucers can further reduce water wastage.

Biodiversity loss: Container gardens can assist in managing phenological changes; containers make it easier to grow seasonal plants and adapt to a changing climate. Almost any plant can be grown in a container, from flowers and herbs to vegetables and small trees: plants can be replaced to face seasons' increased variability.

Implementation

1 **Installation**

Materials Required:
- Containers (pots, raised beds, or repurposed items)
- Soil (potting mix or garden soil)
- Seeds or seedlings (vegetables, herbs, or flowers)
- Watering cans or hose
- Gardening tools (trowel, gloves, etc.)
- Mulch (optional)
- Fertilizer (organic or inorganic)
- Labels and markers
-

2 **Procedure**

Site Selection:
- Choose a location that receives at least 6-8 hours of sunlight daily.
- Ensure the site is easily accessible for students and staff.
- Consider proximity to a water source.

Container Selection:
- Choose containers with adequate drainage holes.
- Ensure containers are of appropriate size for the chosen plants.
- Repurpose old items like buckets, tubs, or wooden crates to promote recycling.

Soil Preparation:
- Fill containers with a good quality potting mix or garden soil.
- Ensure the soil is loose and well-draining.
- Mix in compost or organic matter to enrich the soil.
- By using potting mix or soil specifically for containers, ensure the right soil selection for each plant. This is especially useful in areas with poor or contaminated ground soil

Planting:
- Follow seed packet or seedling instructions for planting depth and spacing.
- Water thoroughly after planting.
- Label each container with the plant name and date of planting.

References

Kasper, Carol, and Jen Matlack. Container Gardening: 250 Design Ideas & Step-by-Step Techniques. Taunton Press, 2009.

"Home: Urban and Peri-Urban Agriculture: Food and Agriculture Organization of the United Nations." UPA, 2022, www.fao.org/urban-peri-urban-agriculture/en/.

Nettle, Claire. Community Gardening as Social Action. Routledge, 2020.

Maintenance:

- Water plants regularly, ensuring the soil remains moist but not waterlogged.
- Monitor plants for pests and diseases. Use organic pest control methods when necessary.
- Fertilize plants as per their requirements.
- Mulch the soil surface to retain moisture and prevent weed growth.

Educational Integration:

- Integrate the garden into the school curriculum, and community trainings. Use it for lessons in biology, ecology, nutrition, and more.
- Organize gardening workshops for students/persons to learn about plant care, composting, and sustainable practices.
- Encourage students/persons to maintain a garden journal, documenting their observations and learnings.

Safety Precautions:

- Ensure students and other school personnel wear gloves while handling soil and plants.
- Store gardening tools in a safe and secure location.
- Supervise younger students during gardening activities.
- Avoid using toxic pesticides or chemicals.

Monitoring and Evaluation:

- Regularly assess the health and growth of plants.
- Document any challenges faced, and solutions implemented.
- Evaluate the impact of the garden on students' learning and well-being.

Indicators

Implementation	Number of Containerized Gardens Installed Number of direct beneficiaries Yield of fruit/vegetable plants planted per hectare, per annum; Savings in the cost of fruits/vegetables used in the school for school/ community feeding program,
Quantitative	Percentage of schools/ locations who have applied targeted improved NbS practices or technologies in container gardens
Qualitative	Level of participation of students in NbS training /knowledge building activities within Jamaica 4H Clubs schools (% of which females)

Costs and inputs

School Container Gardens	Cost in USD
Size of containers: 55 gallon barrel cut in half # of containers : 24 containers Labour: 2 persons 10 days across 3 months (240 hours)	980.40
Equipment & Tools	2287.57
Total	**3267.97**

Hydroponics

Hydroponics is a method of growing plants without soil, using water-based mineral nutrient solutions. In this system, plants may have their roots directly exposed to the nutrient solution or supported by an inert medium such as perlite or gravel.

This technique allows for precise control over the nutrients plants receive and can be used to grow a wide range of plants, including crops, medicinal plants, and ornamentals. Hydroponics is known for its efficiency in water usage, making it an attractive option for sustainable agriculture. It can be implemented in various settings, including greenhouses and urban environments, offering advantages such as reduced water usage compared to traditional farming methods and the ability to grow plants in areas with unsuitable soil conditions.

Estimated number of beneficiaries[1]: 300 persons

Integration with international agreements

SDG 6, 11, 13

Duration

Medium-scale Systems: For larger systems, such as those used in schools, community projects, or small businesses, the setup time can range from a few days to several weeks. This includes planning, sourcing materials, system assembly, testing, and initial planting. Depending on the level of maintenance, these systems can last 5-10 years.

Place of Implementation

Hydroponics can be implemented in various locations, offering flexibility and adaptability to different settings. They are particularly important in regions facing water scarcity, because of their water conservation features. Hydroponics' flexibility and efficiency make it suitable for a variety of applications, from small personal projects to large commercial ventures, and even in challenging environments where traditional agriculture would be difficult or impossible. Hydroponics are also suitable for places where soil is of poor quality; where planting is limited due to space or other constraints or in dry regions with little rainfall.

Threats Addressed

- High Temperature
- Changes in rainfall patterns
- Heavy Rainfall
- Drought
- Food scarcity

Social, eco-systemic and economic benefits

1. **Enhanced Food Security:** Hydroponics can increase local food production, especially in urban areas or regions with harsh climates or poor soil quality.
2. **Community Development and Education:** Hydroponic systems can be used as educational tools in schools and community centers, teaching people about sustainable agriculture, nutrition, and science.
3. **Improved Nutrition and Health:** By providing access to fresh, locally grown fruits and vegetables, hydroponics can play a crucial role in improving nutrition, particularly in urban food deserts where access to affordable fresh produce is limited.
4. **Soil Preservation:** Since hydroponics does not use soil, it eliminates the issue of soil degradation and erosion, which are significant problems in traditional agriculture. Healthy soil is crucial for carbon sequestration, and its preservation is essential for combating climate change.

For more information visit www.cityadapt.com

[1] The total yield expected from your system annually and divide it by the average consumption rate of your target crop per person

Main Climate Impacts & Threats Addressed

Water scarcity: Hydroponics is highly efficient in terms of water usage. It uses significantly less water than traditional soil-based agriculture because water in hydroponic systems is recirculated and reused.

Pests & diseases management: Since hydroponics does not use soil, many soil-borne pests and diseases are naturally avoided. This reduces the need for pesticides and fungicides, making hydroponic systems more sustainable and safer for growing food.

Urban heat island effect: Hydroponics can contribute to reducing the Urban Heat Island (UHI) effect, especially when implemented on a large scale in urban areas.

Implementation Stages

Decide on the type of hydroponic system that best suits your needs. Common types include:

- **Deep Water Culture (DWC):** Plants are suspended in a nutrient solution with their roots submerged. An air pump oxygenates the solution to prevent root rot.
- **Nutrient Film Technique (NFT):** A continuous flow of nutrient solution runs over the roots of plants placed in channels, allowing the upper part of the roots to remain exposed to air.
- **Ebb and Flow (Flood and Drain):** Plants grow in a grow bed filled with an inert medium. The bed is periodically flooded with nutrient solution, then drained back into the reservoir.
- **Drip System:** A slow feed of nutrient solution is dripped directly onto the base of each plant.
- **Aeroponics:** Plant roots hang in the air and are misted with nutrient solution at regular intervals.

1 Site Selection

Choose a location with enough space for your system and good light exposure. If natural light is insufficient, you'll need artificial grow lights.

2 Gather Supplies

Depending on your system, you'll need:

- A reservoir to hold the nutrient solution.
- A water pump (for systems that require active water movement).
- An air pump and air stones (for oxygenating the solution, essential in DWC).
- Grow trays or channels (for NFT or ebb and flow systems).
- Growing medium (if not using a water-only system), such as rockwool, clay pebbles, or coco coir.
- Hydroponic nutrients.
- pH and EC meters to monitor nutrient solution strength and acidity.
- Grow lights (if using indoors or in low-light conditions).
- Timer for lights and pumps (to automate the system).

3 Set Up the System

- **Reservoir:** Place your reservoir at a lower elevation than your grow beds or channels to facilitate water movement.
- **Pump and Irrigation:** Install the water pump in the reservoir, connecting it to the grow beds or channels to circulate the nutrient solution. Use a timer to control the flow in ebb and flow or drip systems.
- **Air Pump:** In DWC, place the air stones in the reservoir and connect them to the air pump outside the reservoir to oxygenate the water.
- **Grow Lights:** Install grow lights above the plants, ensuring they're at the correct distance to provide enough light without overheating the plants.

References

"Home: Urban and Peri-Urban Agriculture: Food and Agriculture Organization of the United Nations." UPA, 2022, www.fao.org/urban-peri-urban-agriculture/en/.

Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. Landscape and Urban Planning, 97(3), 147–155. https://doi.org/10.1016/j.landurbplan.2010.05.006

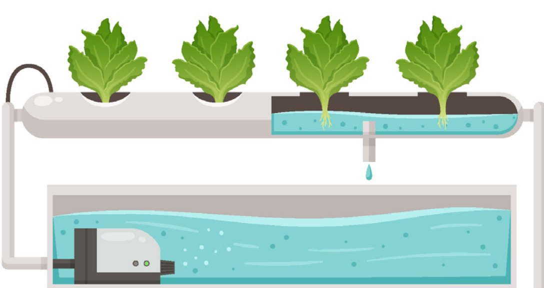
Yadav, Deepak. "Start Doing Hydroponics in 10 Easy Steps." Barton Breeze, 29 Dec. 2020, www.bartonbreeze.com/post/start-doing-hydroponics-in-10-easy-steps.

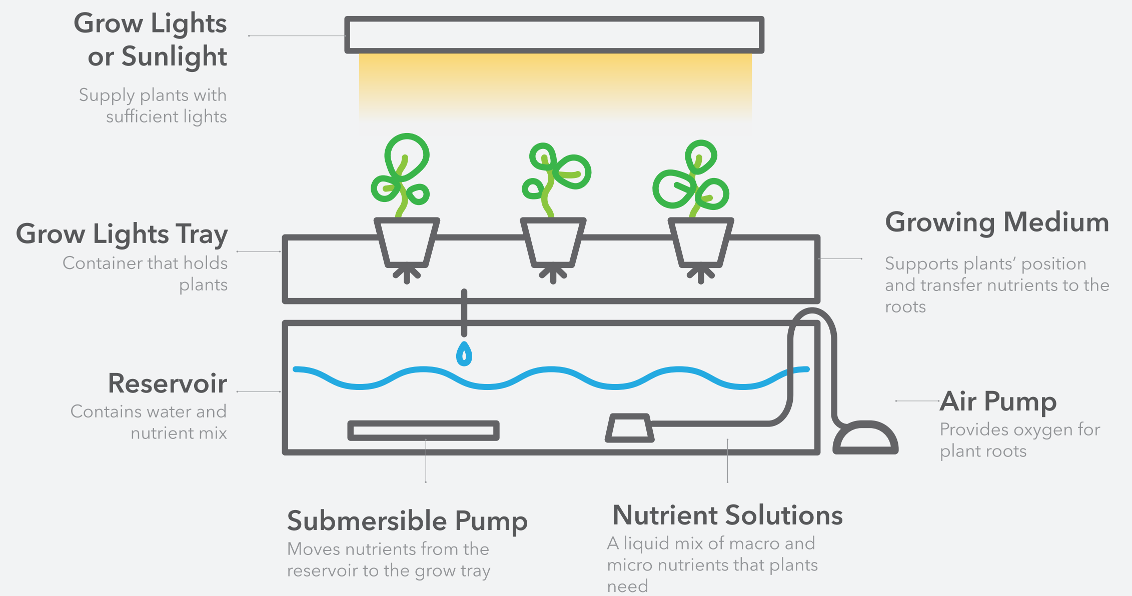
4 **Prepare the Nutrient Solution**
Mix water with hydroponic nutrients according to the instructions for your specific crops. Use the pH meter to adjust the solution to the appropriate pH level, typically between 5.5 and 6.5.

5 **Plant Your Crops**
- For systems using grow media, plant seeds or seedlings directly into the media.
- For water-only systems like DWC, place seedlings in net pots with their roots suspended in the nutrient solution.

6 **Monitor and Maintain**
- Regularly check the pH and nutrient strength (EC/ppm) of your solution, adjusting as necessary.
- Top up the water level in the reservoir to replace what's absorbed by plants or evaporated.
- Keep an eye on plant health and watch for signs of pests or diseases.
- Clean and sterilize the system between growing cycles to prevent the buildup of pathogens.

7 **Harvest**
- Once your plants have matured, harvest your crops. Many hydroponic systems allow for continuous harvesting, especially for leafy greens and herbs.





Indicators

Implementation	Number of hydroponics units installed
	Number of direct beneficiaries (disaggregated by gender and age)
Quantitative	Percent of Jamaica 4H-Clubs school members participating in collective NbS actions (Disaggregated by sex and age)
	Crop (fruits/vegetables) yield (weight)
	Cost savings of fruits/vegetables used in the school for school/community feeding program
Qualitative	Level of awareness and knowledge about nutrition and healthy eating habits

Costs and inputs

School Hydroponics 1500 sq feet	Cost in USD
Labour:	1,300.00
Equipment & Tools	3,500.00
Total	**4,800.00**

Beekeeping Protocol

Bees are essential pollinators for many flowering plants, including crops. Their pollination services contribute to maintaining biodiversity and ecosystem's health. As ecosystems face threats from climate change and habitat loss, promoting healthy bee populations through beekeeping can enhance pollination and support plant species diversity. Beekeeping provides an alternative livelihood for communities, not only in the rural areas but for urban & peri-urban areas as well. This economic opportunity can reduce dependence on activities that might be detrimental to ecosystems, thus contributing to their climate resilience.

To fully leverage the potential of beekeeping as an EbA strategy, it is important to practice sustainable and responsible beekeeping. This includes avoiding harmful pesticides, providing adequate forage resources for bees, ensuring proper hive management, and collaborating with local communities and experts to develop strategies that align with the specific needs and characteristics of the ecosystem in question.

Integration with international agreements

Sendai: Goal 3 – strengthening inclusive policy implementation through community engagement to improve livelihoods.

Duration

A beekeeping setup can be established within 5-10 days. The durability of the beekeeping infrastructure depends on various factors such as the materials used, the quality of construction, the maintenance provided, and the environmental conditions. Typically, the operational lifespan of such an installation range from 5-10 years.

Place of implementation

The selection of an appropriate location for beekeeping within an urban environment is essential for their success and productivity. Factors to consider when setting up beekeeping include: location & climate, sunlight exposure, available space, water source, forage availability. These elements will ensure the health and efficiency of the bee colonies.

Beneficiaries (~#)

One bee colony (traditional 10 frame deep box) can produce between 80-100 pounds of honey annually; 5 colonies can produce between 100 to 400 pounds of honey. (This depends on the size of the frame, health of the bees & climate.)

Threats Addressed

- High temperatures
- Drought
- Changes in rainfall patterns
- Heavy rainfall

Main climate impacts addressed

Biodiversity Loss

Bees contribute to the preservation of biodiversity by ensuring the survival of flowering plants through pollination. This, in turn, supports entire ecosystems, including a variety of other animals and plants, helping to maintain ecological balance even as climates change.

Agricultural Productivity

Many crops depend on pollination services that bees provide. In the context of climate change, which threatens crop yields due to extreme weather conditions and shifting temperatures, bees help stabilize food production and contribute to food security.

Urban Heat Islands

In urban areas, beekeeping can support the growth of green spaces through the pollination of plants and trees. These green spaces play a critical role in cooling urban environments, thus mitigating the urban heat island effect which is exacerbated by climate change.

Ecosystem Resilience

Pollinators like bees enhance the resilience of natural ecosystems against climate change impacts. By supporting a wide range of plant species, bees help maintain healthy ecosystems that can better withstand and adapt to changing environmental conditions.

Community Engagement and Education

Beekeeping initiatives can serve as practical tools for educating communities about climate change and environmental stewardship. They provide a tangible example of how local actions can have a global impact on climate mitigation and adaptation.

Social and economic co-benefits

Economic

- **Local Honey Production:** One of the most direct economic benefits of beekeeping is the production of honey, a valuable commodity. Honey can be sold locally, regionally, or even internationally, depending on the scale of the operation. This provides a steady source of income for many beekeepers.
- **Sustainable Agricultural Practices:** By enhancing pollination, beekeeping supports more sustainable agricultural practices, which can lead to better crop yields and more stable farm incomes, particularly important in areas dependent on agriculture

Social cohesion

- **Community Projects and Initiatives:** Beekeeping involves community-based projects that require collaboration. Communities that engage in beekeeping projects work together to manage the hives (colonies), share knowledge, and distribute the products. This collective effort enhances community bonds and fosters a sense of shared purpose.
- **Educational Opportunities:** Beekeeping serves as an educational tool that schools, clubs, and community groups can utilize to teach about biology, agriculture, and the environment. Educational programs around beekeeping can bring different age groups and people from various backgrounds together, promoting intergenerational interaction

Education

- **Climate Change Education:** Beekeeping in schools and communities acts as a powerful educational tool for understanding climate change, sustainable agriculture, and environmental stewardship. It offers practical, hands-on learning experiences in subjects like biology, environmental science, and agriculture, thereby enhancing knowledge of sustainability, the lifecycle of pollinators, and local food systems.
- **Research and Innovation:** Research and innovation in areas such as pollinator health, biodiversity, and climate-adaptive practices are essential for developing strategies to adapt to and mitigate the impacts of climate change, leading to innovative approaches in beekeeping and environmental management.

Biodiversity Protection

- **Habitat for Pollinators:** Greenhouses can serve as habitats for pollinators and other beneficial insects, which are crucial for ecosystem health and have been threatened by climate change.
- **Preservation of Plant Varieties:** They offer an environment to grow and preserve a diverse range of plant species, some of which might be threatened in their natural habitats due to changing climate conditions.

City Adapt RECONNECTING CITIES WITH NATURE LATINAMERICA AND THE CARIBBEAN UN environment programme gef

Implementation stages

Phase 1. Initial Setup and Installation

1 **Time Frame:** Setting up your beekeeping (apiculture) operation can take a few weeks. This includes:

- **Preparation:** Gather all necessary equipment, such as hives, bee suits, smokers, hive tools, and bees.
- **Installation:** Install the hives in your selected location. Placement should ensure adequate sunlight, wind protection, forage, and accessibility. Installing the hives and introducing the bees into them can be completed in 1-2 days. (Full colonies can also be purchased from an established Apiary).

Phase 2. Monitoring and Maintenance

2 **Routine Monitoring**:

- Weekly Checks: Inspect the hives weekly to monitor the health of the queen, the progress of the hive, and any signs of disease or pests.

3 **Maintenance Tasks:**

- Manage pests and diseases
- Ensure hives are not overcrowded to prevent swarming. Add supers (extra boxes for honey storage) as needed.

Phase 3. Dividing the Colonies

4 **Identifying Strong Colonies:** Choose strong colonies that show signs of overcrowding.

5 **Creating New Colonies:** Transfer frames with eggs, larvae, and some honey stores into a new hive box. Introduce a new queen or allow the bees to raise one from a young larva.

Phase 4. Extracting Honey

6 **Checking Honey Supers:** Ensure the honey is ripe (capped by the bees).

7 **Harvesting:** Remove the frames, brush off bees, and extract honey using an extractor.

8 **Processing:** Strain and bottle the honey for consumption or sale.

9 **Post-Extraction Tasks**

Returning Frames: Once extracted, frames can be returned to the bees to clean and refill, saving energy and resources for the bees.

Phase 5. Annual Review

10 At the end of each year, review the health and productivity of each colony. Plan adjustments for the next season based on the colony's performance and any challenges faced.

Costs and inputs

Description	Total
Materials for a complete hive	$200.00 per colony (full) $45.00 per empty box
Protective equipment for the beekeeper	$40.00-130.00
Equipment (smoker, hive tools, bee brush, excluder, feeder, seeds)	$150
Labour to deliver the boxes (depends on location)	**50.00-70.00 per colony**

Indicators

Implementation	Number of bee colonies of established
Quantitative impact	• Amount of honey produced per hive annually • Level of participation of students or community members in NBS knowledge building activities within urban and peri-urban areas
Qualitative impact	• Percent of schools which have applied targeted improved NbS practices or technologies in their curricula • Percent change in sustainable practices and behaviors in the community or school as a result of established Apiary’s

References

Bee Professor. “How Much Honey Does a Bee Produce?” Bee Professor. Accessed . 2023.11.10 https://beeprofessor.com/how-much-honey-does-a-bee-produce/.

Evan Engelsdorp D, Meixner MD. (2010). “A historical review of managed honey bee populations in Europe and the United States and the factors that may affect them.” Journal of Invertebrate Pathology, 103(S1), S80-S95. doi: 10.1016/j.jip.2009.06.011

Sanford MT, Shackleton K. (2009). “Beekeeping.” In Encyclopedia of Entomology. Springer, Dordrecht. doi: 10.1007/978-1-4020-6359-6_1033

Winston ML. (1991). “The Biology of the Honey Bee.” Harvard University Press. ISBN- 13: 978-0674074095.

Rainwater harvesting system

Rainwater harvesting systems (SCALL, acronym in Spanish for system described here) allow for the collection of rainwater from roofs (private or community buildings) through gutters and pipes that channel it to a tank or cistern, passing through a filter (and other treatments depending on the intended end use) that cleans and makes the water available for private or community consumption. The system can also strengthen the community through collective water management for agricultural production, livestock/animals, and hygiene.

Integration with international agreements

Sendai: Goal 4 - Reduction of damage caused by natural disasters

Duration

A SCALL for schools can be installed in 5 days, and, for homes, 1 day. Its use life is 20 years.

Place of implementation

Areas with rainfall greater than 800 mm per year. For limited agricultural use, they can be installed in areas with rainfall of 300 to 800 mm.

Beneficiaries (~#)

A water harvesting system with a storage capacity of 10,000 liters and a catchment area of 65 m² per filling can supply a family of 5 members for 40 days (minimum supply of 50 l/inhabitant/day, according to WHO).

Threats Addressed

- High temperatures
- Heavy rainfall
- Changes in rainfall patterns
- Drought

Social and economic co-benefits

Increasing inputs available
- Utilizes an already available and untapped resource for everyday needs
- Simple and economical installation with low maintenance
- Less energy for pumping and transporting water

Social cohesion
Strengthens community cooperation, including at key locations such as schools and public buildings

Education
Educational tool for efficient water use

Fires
Stored water can be used to fight fires

For more information visit
www.cityadapt.com

Main climate impacts addressed

Decrease in water availability
· Ensures a reliable source of water for multiple uses in periods of increasingly frequent shortages and unpredictable rainfall.
· Reduces consumption of drinking water from other sources (bottles, faucet, etc.).
· Decreases overexploitation of bodies of water and aquifers.
· Facilitates access to uncontaminated water for vulnerable populations (women, poor, children).
· Improves hygiene in private homes or public buildings.

Floods
Decreases flooding by reducing water runoff.

Erosion
Mitigates the erosion effect of floods during heavy rains.

Landslides
With less water flow and flooding, the risk of landslides is reduced.

Losses and/or damages
Provides water in times of drought for productive activities, including agriculture, and reduces loss and/or damage due to flooding and erosion, thus increasing food security.

Implementation stages

Stage 1. Basic questions to design the system

1 Is it feasible where I live? How much does it rain per year?

The system is designed with respect to:
- the building where the water will be collected, and where and how each component of the system will be placed.
- the calculation of the amount of water that can be captured, which depends on the chosen storage unit and local conditions. Please check weather service indications and the estimates of how many days per year the system can provide enough water (note: some places will receive less rain due to climate change).

2 Do I have the right surface for harvesting water?

Surfaces can be waterproof, smooth, uniform, and clean roofs, sheds, or even patios. The best materials are polycarbonate sheeting, steel, zinc, concrete roofing and, lastly, tile or other materials. Avoid cardboard sheets with hydrocarbons (oil or grease) and other materials with asbestos.

3 Do I have enough storage or space to build a cistern or place a water tank?

Calculate the space according to the storage required. If the building is under construction, opt for a cistern. If not, consider an area to place a rotomould tank. A 200 liter first water separator is recommended for every 5,000 liters of water.

4 What is the daily water demand?

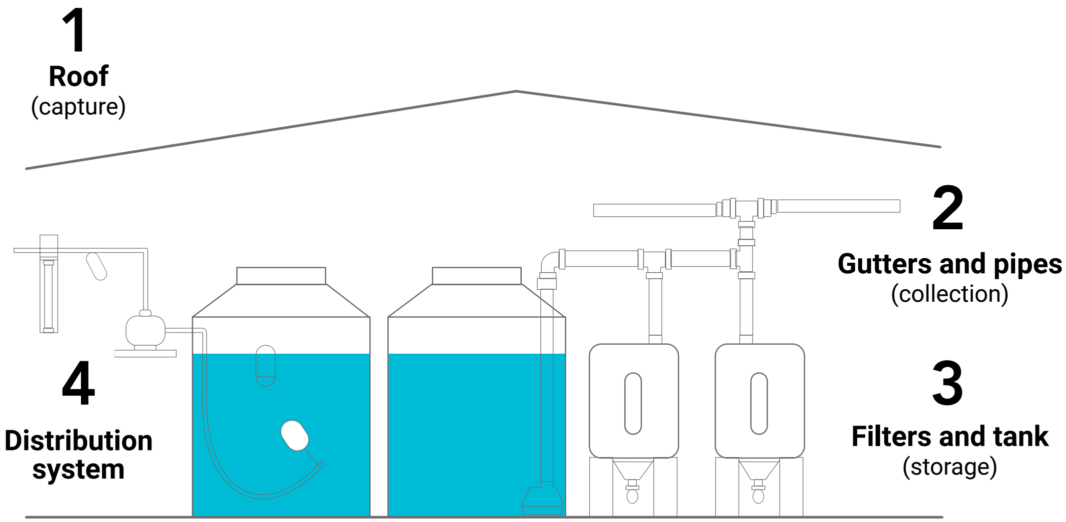
Determine whether the SCALL will be used by the community or private residences, or for human consumption or productive activities. Refer to WHO to estimate demand. In Mexico, for example, the demand is 150 to 250 liters per inhabitant per day, but varies according to each location's climate.

References

- **Video:** Captación de agua de lluvia
- **Haus. 2019.** Agua de lluvia: 7 grandes beneficios de recolectar, almacenar y aprovechar el agua del cielo.
- **Escamilla, P. 2020.** Captación de agua de lluvia, alternativa sustentable.
- **Sedema. 2019**. Cosecha de lluvia.
- www.islaurbana.com.mx
- **Valentini, G. 2018** ¿Cuáles son los beneficios de la captación de aguas pluviales?
- **Ministry of Environment of El Salvador (MARN), 2016.** "Guía Práctica de Captación de Agua Lluvia". San Salvador, El Salvador. 12 pages

Stage 2. Installation

A SCALL has four main components: roof (catchment), gutters and pipes (collection), filters and storage tank, and distribution system.



1 Gutters are installed at the eaves of the roof, along the entire edge or perimeter.

They should be made of PVC or metal, with sizes according to the calculation of water to be collected, reinforced structure for the weight of the water, and without obstructions or leaks. If gutters already exist, make sure their condition and size are adequate for the volume of rain to be collected.

2 Rainwater downspouts are installed, making sure that their dimensions are sufficient for the largest possible water flows.

The downspout connects directly to the first filter which prevents solid waste from reaching the tank. The piping system should be as direct as possible, without excessive changes in direction or long distances. It is recommended to use PVC pipes and fittings without any damage or leaks.

3 The catchment tank is placed, connected and installed (see graphic).

Depending on the type of system, gravity or pumping, complementary structures are installed, such as the water separator. Depending on the type of tank, additional instruments are installed, such as chlorine doser, float pump, and others.

4 The water passes to another filter so that the water can be used for different purposes.

At this stage the water is cleaned of any sediment or contaminants, odors and taste. A good practice is using the first rain for self-cleaning of the roof, gutters and pipes, and not to store it.

5 Depending on the intended use, you can then:

- Install an irrigation system for crops, green areas, orchards, etc.
- Connect the tank outlet to toilet and/or sink intake pipes for cleaning and maintenance of toilets, bio-gardens, among other options.
- If you would like to purify water for drinking, additional steps must be taken to install the appropriate filtration system, which will cost more to maintain.

Costs and inputs[1]

Cost in USD	Community System Two 5000-L Tanks	Home System One 2500-L Tank
Labor	$300	$73
Direct inputs	$1,804 [2]	$730
Indirect inputs	$375	$260
Technician and social promoter	$974	N.A.
Total	**$ 3,453**	**$1063**

1. Community system costs from CityAdapt El Salvador; home system costs from CityAdapt Mexico.

2. Includes workmanship, placing of gutters, two tanks, pumping system installation. For community use, consider the additional cost of batteries for 4 bathrooms (about $3500 USD), 6 community laundry stations (about $2500 USD), and biogardener (about 300 for 4m²).

Stage 3: Maintenance to ensure its operation

- Cleaning of gutters, filter and tank is required.
- The screen filter should be washed every 15 days.
- The activated carbon filter cartridge must be changed out every 6 or 12 months according to specification.
- Keep the screen or filter intact and in place to avoid creating breeding areas for mosquitos and related diseases.

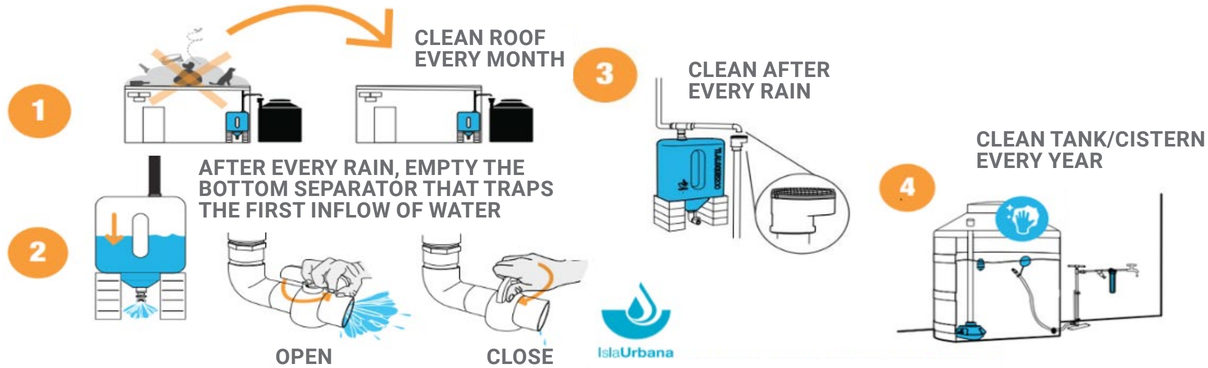


Diagram provided by Isla Urbana

Indicators

Implementation	Number of systems installed (#)
Quantitative impact	• Water demand without SCALL (m3) • Number of people directly benefited (#) • Savings in the cost of potable water service (USD$) • Volume of water used for human consumption (m^3)
Qualitative impact	• Perception of water supply vulnerability (before and after SCALL installation) • Perception of simplification of household chores • Time spent on some household chores (before and after SCALL installation) • Diversification of strategies to cope with water scarcity (e.g. using public sinks to wash clothes, sharing water, capturing rainwater directly for certain uses, etc.).

References

- **Japan International Cooperation Agency (JICA), 2015.** "Guía Técnica para Cosechar el Agua Lluvia: Opciones técnicas para la agricultura familiar en la Sierra". Chimborazo, Ecuador. 24 pages.
- **Food and Agriculture Organization of the United Nations (FAO), 2013.** "Captación y Almacenamiento de Agua de Lluvia: Opciones técnicas para la agricultura familiar en América Latina y el Caribe". Santiago, Chile. 272 pages.
- **Ventura. E.** Captación "in situ" del agua de lluvia para la producción de cultivos en regiones semiáridas. Autonomous University of Queretaro. C.U. Cerro de las Campanas, Querétaro, México.

FOR MORE INFORMATION VISIT OUR WEBSITE: WWW.CITYADAPT.COM

City Adapt
RECONNECTING CITIES WITH NATURE
LATINAMERICA AND THE CARIBBEAN

UN environment programme

gef