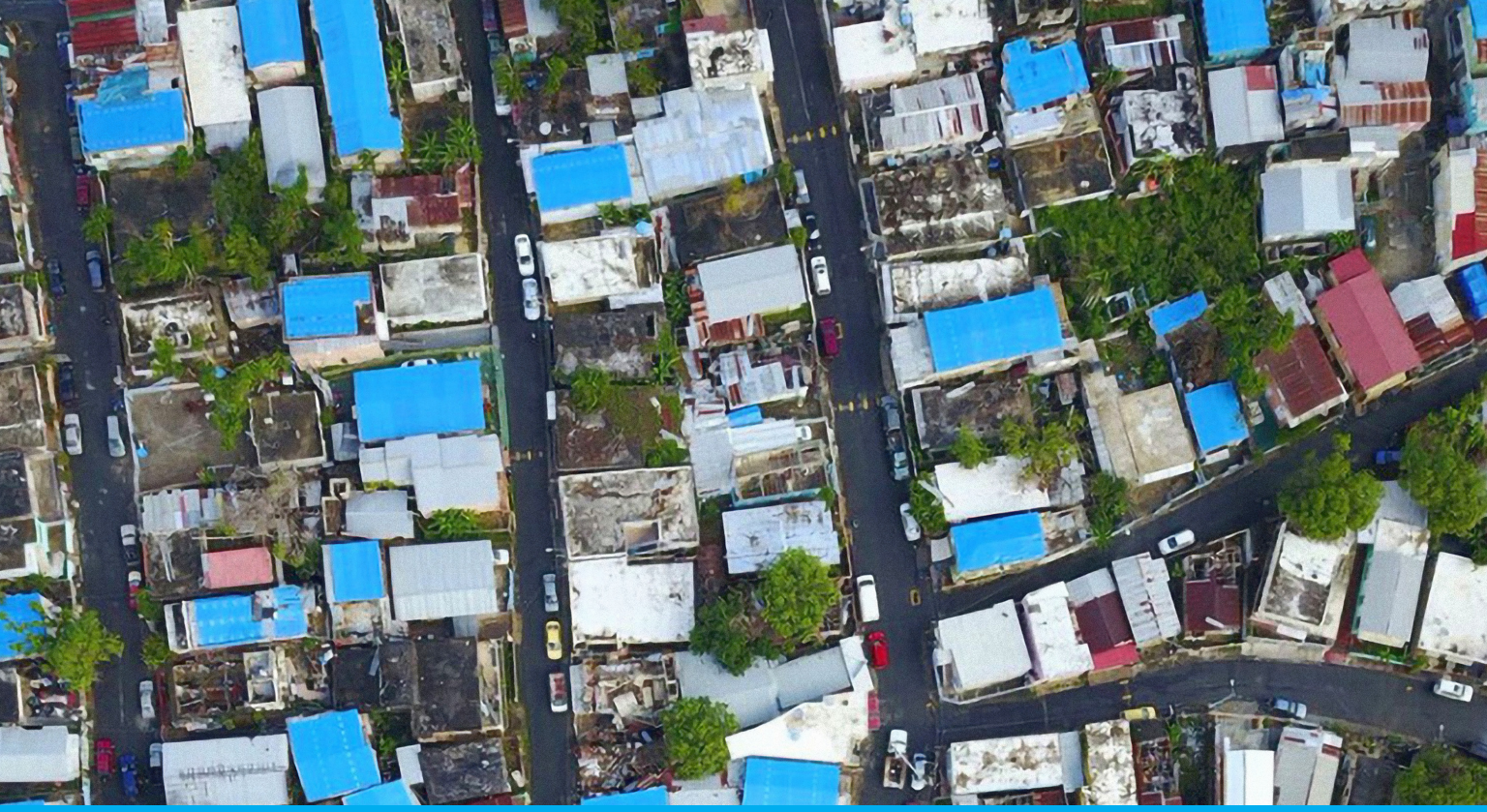


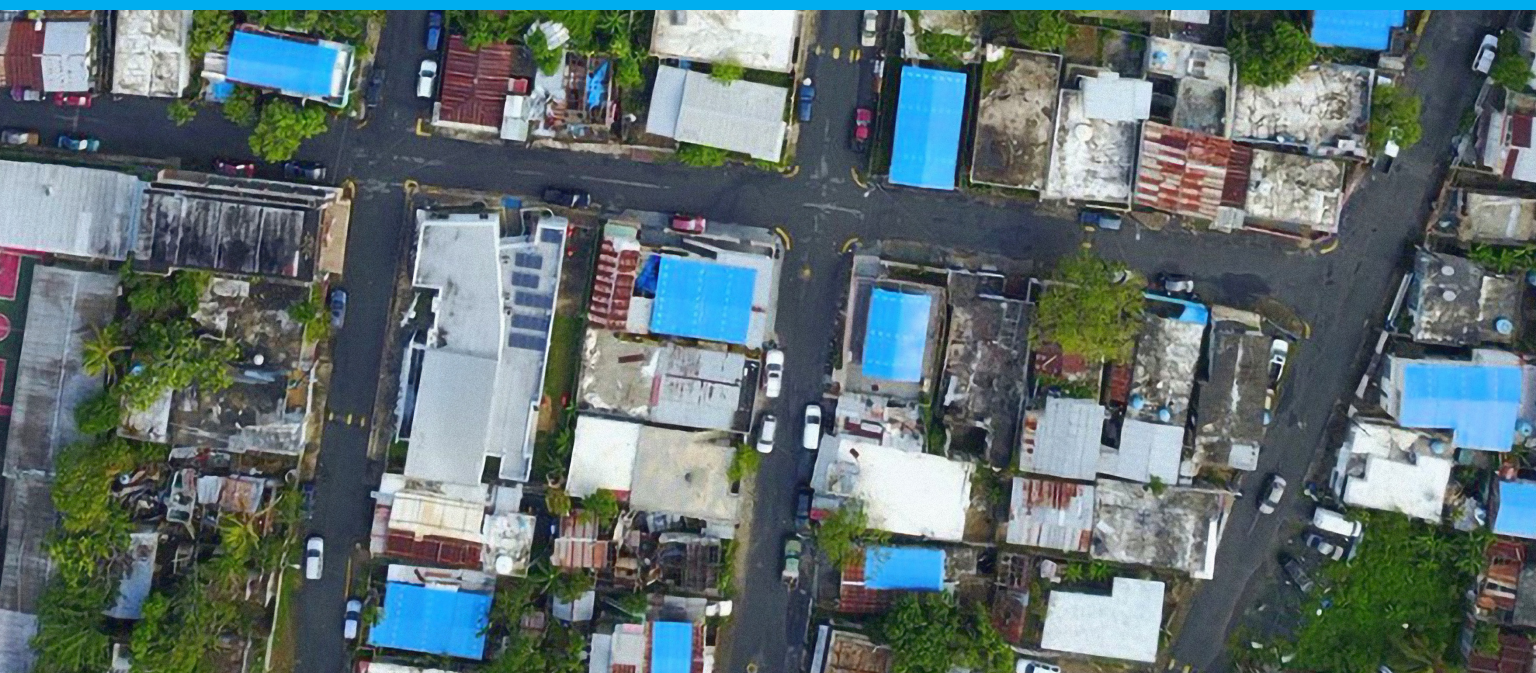
KEEP SAFE

A GUIDE FOR RESILIENT HOUSING DESIGN IN ISLAND COMMUNITIES

Enterprise®

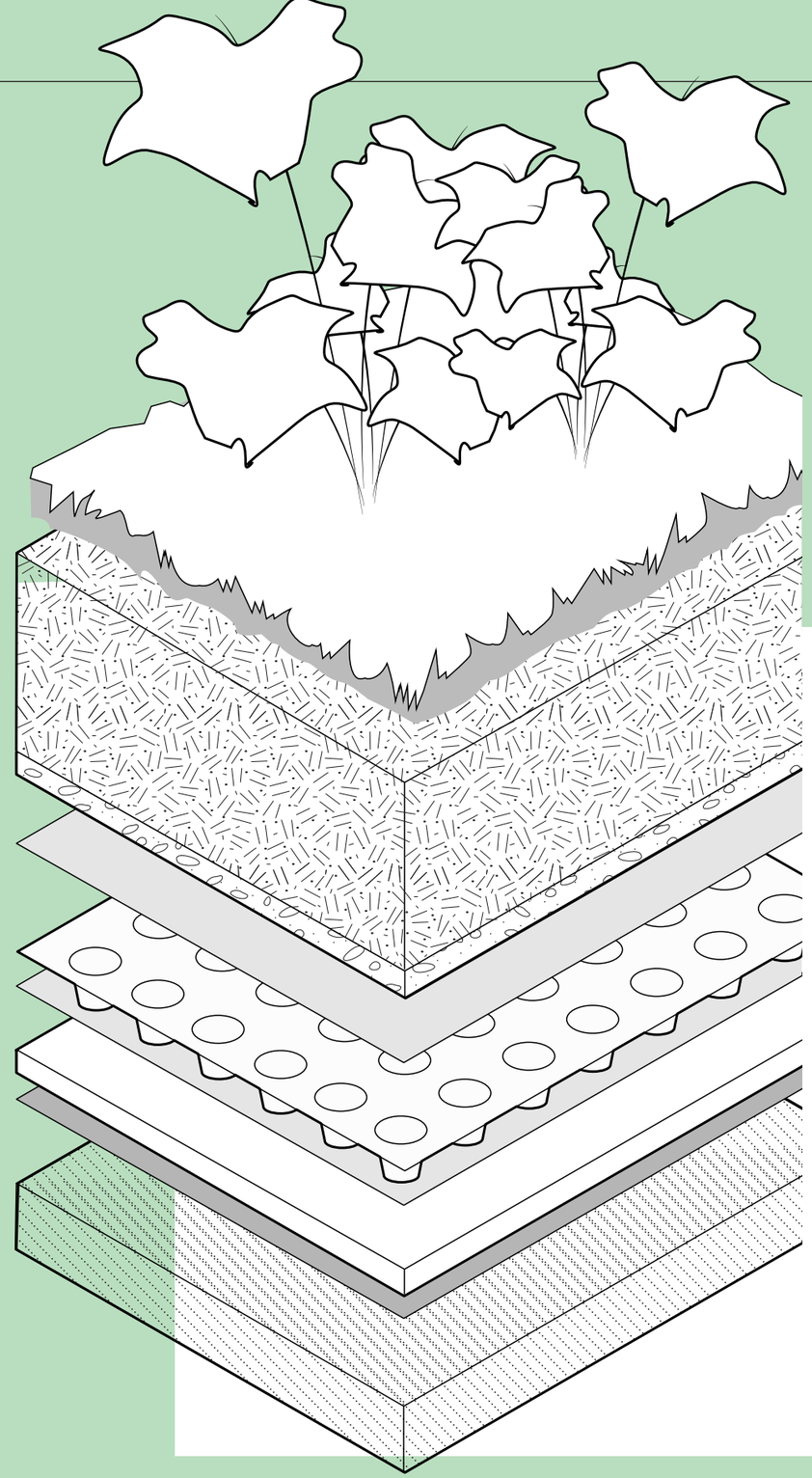
UNIVERSIDAD DE PUERTO RICO 1903

ASOCIACIÓN DE CONSTRUCTORES DE PUERTO RICO



CHAPTER

1



A SAFER SITE: SITE FORTIFICATION STRATEGIES

Fortify your site against extreme natural hazard risks.

TYPES OF STRATEGIES LISTED IN THIS SECTION

STRATEGY #

STRATEGY NAME/TITLE

DESCRIPTION

01	02	03
REINFORCE SITE WITH INFRASTRUCTURE	**REINFORCE SITE WITH VEGETATION**	**PLANT AN EDIBLE GARDEN**
Risks threatening a site like flooding and fire can be mitigated by designing green and gray infrastructure to work together. Green and gray infrastructure help manage risks from storm water, support heat reduction, manage drought, enhance air quality, and create recreational spaces. This strategy focuses on how to choose infrastructure elements that best suit your site.	This strategy describes the properties of soil, elevation, and plant types that are necessary for vegetation to serve as a protective element.	After a natural disaster strikes, primary resources, including food, can become scarce. This strategy focuses on how conscientious use of vegetation can offer a local back-up food resource and a year-round supply of food.
$-$$$	$	$

Climate change adaptation presents many opportunities to approach building and living in Puerto Rico more holistically; we need to lighten the load on existing power and water infrastructure systems, better integrate what is built with surrounding ecosystems, use resources and manage waste more sustainably, and provide better support for vulnerable populations. Addressing regional risks in this light broadens the options for fortifying your site against disaster. Adaptation also requires new collaborations, and case studies of projects and partnerships throughout the islands are included here for reference and inspiration.

Especially for islands in the Caribbean, geographical isolation compounds water and food security issues. Managing water—whether related to precipitation, flooding, stormwater runoff, storm surge, coastal erosion or subsidence—is the first step toward protecting your home from damage. Combining green and gray infrastructure features is an effective way to do this. Beyond your site, resilient infrastructure recharges aquifers, prevents subsidence, reduces vulnerability of the landscape and agricultural lands to drought, and reduces ambient temperatures.

While green infrastructure refers to projects that draw from nature to achieve desired results, gray infrastructure utilizes man-made, constructed infrastructure like pipes, sewers and sewage treatment works, ditches, dikes, and dams to manage risks of flooding.

This section presents a series of strategies that integrate green and gray infrastructure, including how to reinforce your site through appropriate hardscape and plantings, choose and plant vegetation that is suited to climate variability, and cultivate your own source of food and medicine through an edible garden.

STRATEGY

01 REINFORCE SITE WITH INFRASTRUCTURE

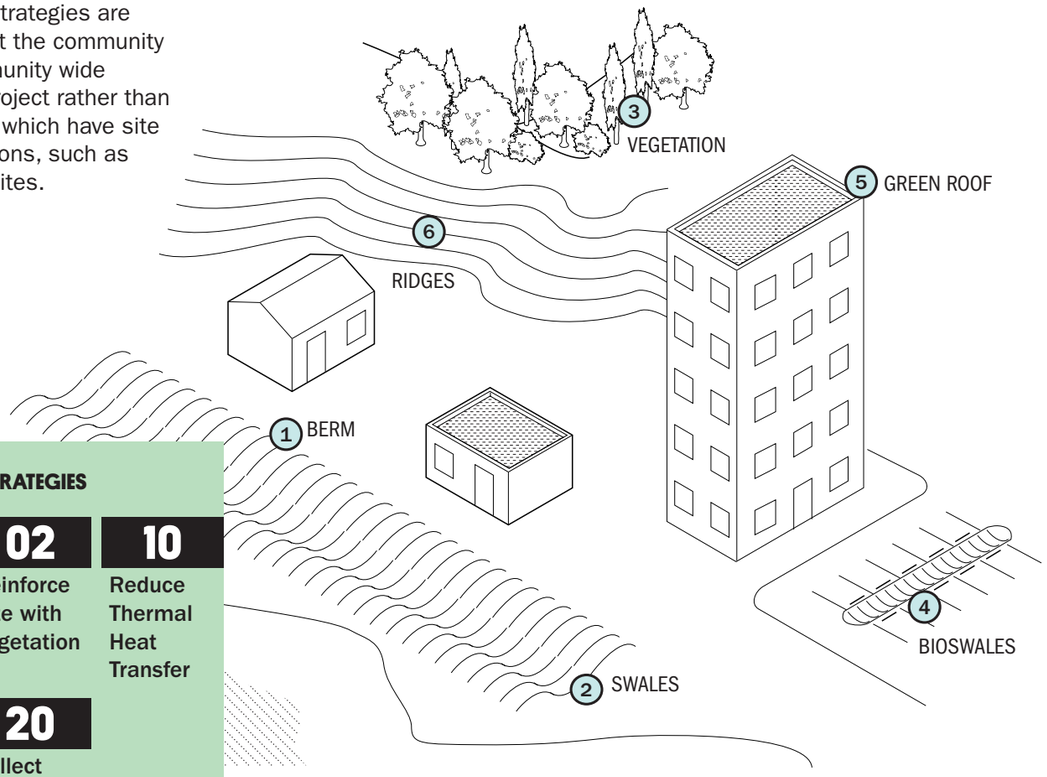
$-$$$

Risks threatening a site like flooding and fire can be mitigated by designing green and gray infrastructure to work together. Green and gray infrastructure help manage risks from storm water, support heat reduction, manage drought, enhance air quality, and create recreational spaces.

This strategy focuses on how to choose infrastructure elements that best suit your site.

WHAT YOU NEED TO KNOW

Many of these strategies are best deployed at the community level as a community wide infrastructure project rather than individual sites, which have site and size limitations, such as sister housing sites.

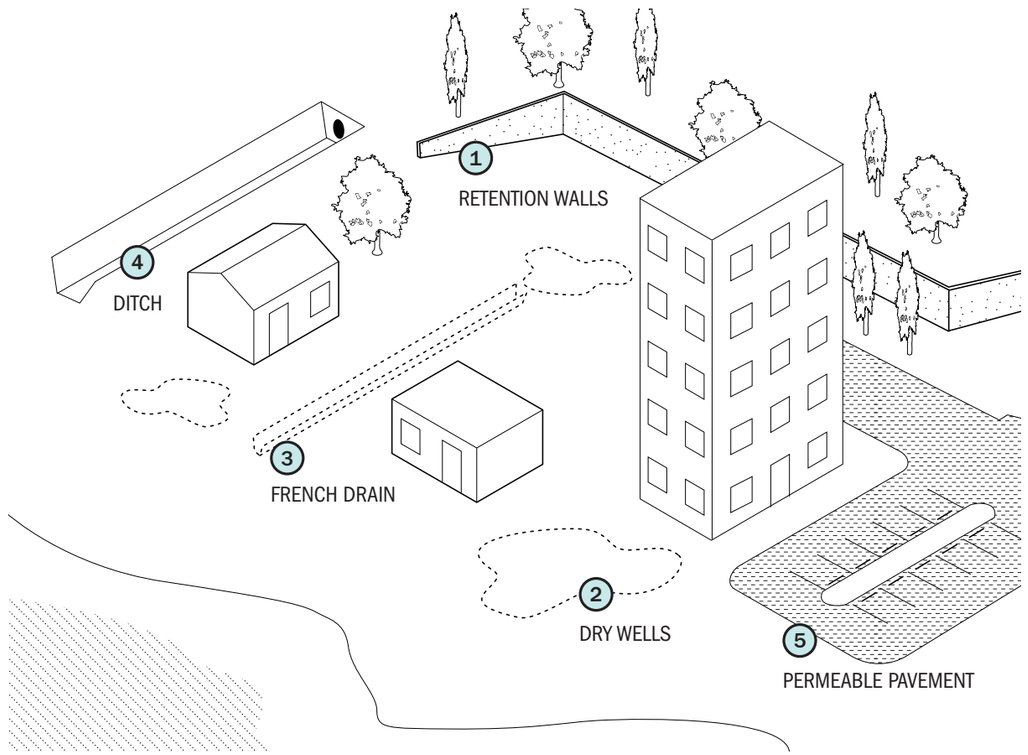


SUPPORTING STRATEGIES

01 Reinforce Site	**02** Reinforce Site with Vegetation	**10** Reduce Thermal Heat Transfer
15 Reduce Your Energy Use	**20** Collect and Use Rainwater	

STEP 1 - SITE HOUSING IN A SAFE LOCATION

- For New Construction, Site Housing in a Safe Location
- Don't site your house or facility in a floodplain or floodway as determined by FEMA: https://msc.fema.gov/portal/home
- Be careful not to site housing in an area prone to landslides. Consult with the resources listed below for a description of historical landslides.
- Ensure drainage paths go from the roof, down the wall, away from the house and the site, and into the street gutters to avoid dumping water onto your neighbor's site.
- Avoid locating your home or building in a very arid area without bringing water to the site to keep foliage from drying out and becoming “tinder.”
- Avoid locating your home, building, or associated infrastructure in coastal areas.



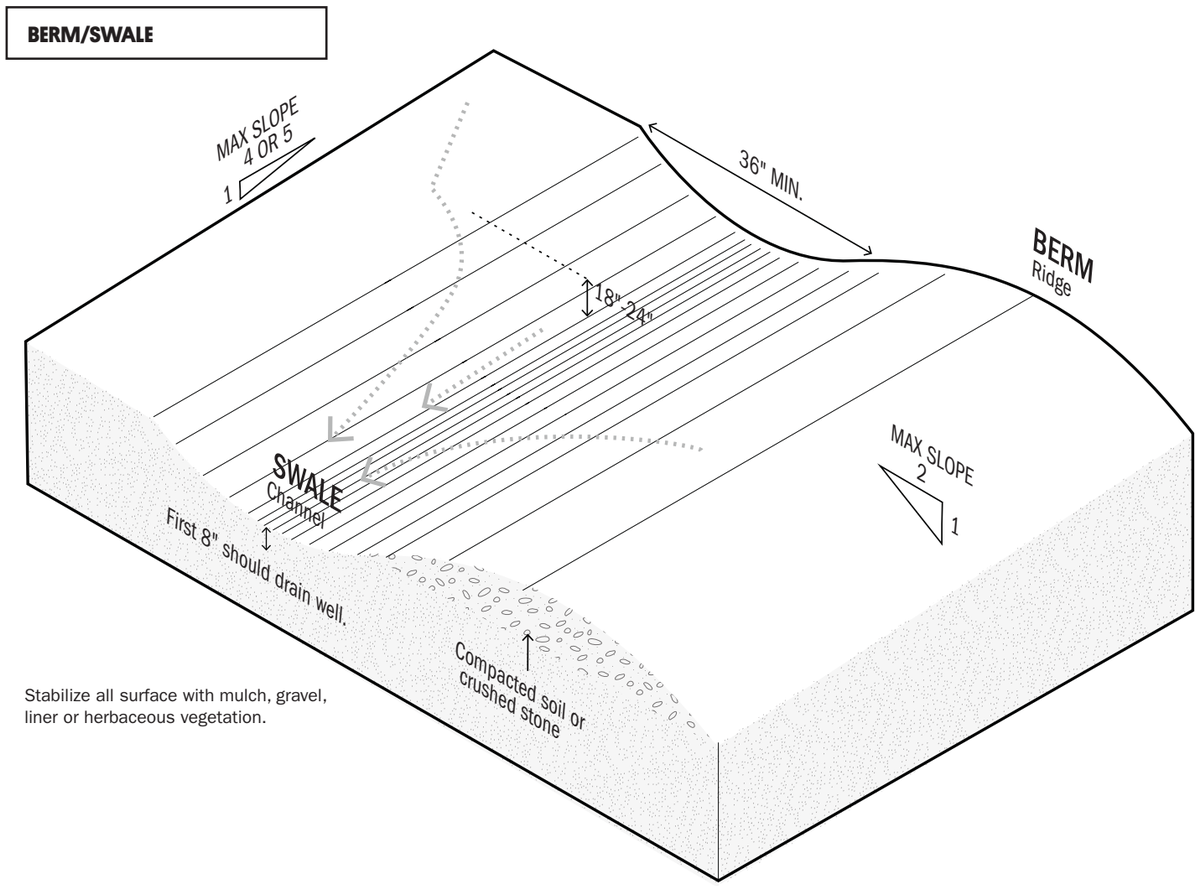
STRATEGY

01 REINFORCE SITE WITH INFRASTRUCTURE

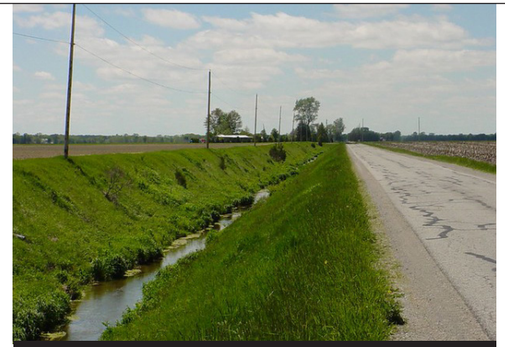
STEP 2 - IMPLEMENT GREEN INFRASTRUCTURE ON SITE

- Consult a contractor, civil engineer, agronomist, or the Agricultural Extension Service (SEA, by its Spanish acronym) to design green infrastructure systems as outlined below.
- Be cautious when choosing where to deposit water. If water is contaminated with debris, do not deposit into a lake, river, or sea.

BERM/SWALE



Stabilize all surface with mulch, gravel, liner or herbaceous vegetation.



A. BERMS

Berms are compacted earth or gravel ridges that slow water headed downslope from rain, riverine flooding, or storm surge in coastal areas and reduce erosion. Berms offer opportunities for other activities as well; frequently termed ‘berms with benefits,’ they create walking paths, exercise, picnic or meditation areas, and places for children to play.

NATURAL HAZARDS IT PREVENTS

- Landslides
- Flooding
- Erosion
- Storm Surge

WHAT YOU NEED TO KNOW

- The slope ratio of a berm should be around 1:4 or 1:5 and should be 18”-24” high. The purpose of the slope is to drain and direct. water.
- Pile compacted soil or washed stone parallel to ditch, opposite the water flow, at a maximum slope of 1:2.
- In most cases, herbaceous vegetation will help in stabilizing the berms.

B. SWALES

Swales are shallow channels with gently sloped sides that manage water runoff, filter pollutants, and increase rainwater filtration by directing water to a garden with adequate drainage (rain garden) or a buried dry well. It can also absorb water through the soil on site and protect natural waterways. A swale may be either natural or human created. Artificial swales are often infiltration basins.

NATURAL HAZARDS IT PREVENTS

- Landslides
- Flooding
- Erosion
- Storm Surge

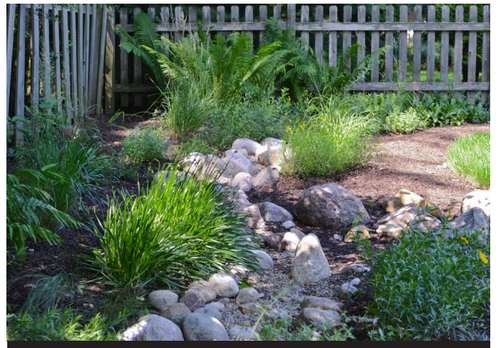
WHAT YOU NEED TO KNOW

- Dig the channel with sloped slides and a small slope in the direction of water runoff.
- The sides of the swale should flare so they extend out 3” to 4” more than they are tall, and the first 8” of soil should drain well.

STRATEGY 01

REINFORCE SITE WITH INFRASTRUCTURE

STEP 2 - IMPLEMENT GREEN INFRASTRUCTURE ON SITE



C. BIOSWALES/RAIN GARDENS

Bioswales/Rain Gardens receive water and filter it through different substrate layers and vegetation and help to absorb rainwater. They can be engineered to manage a specific amount of rainfall.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Storm Surge

WHAT YOU NEED TO KNOW

- A bioswale consists of:
- Vegetation layer on slope
- Mulch & top soil
- Geotextile fabric
- Trench with perforated pipe

D. BOULDERS

Boulders (also known as rip rap) are large pieces of rock that can be placed strategically to steer water, hold earth, or even act as wave-barriers (“rompeolas”) and mitigate erosion.

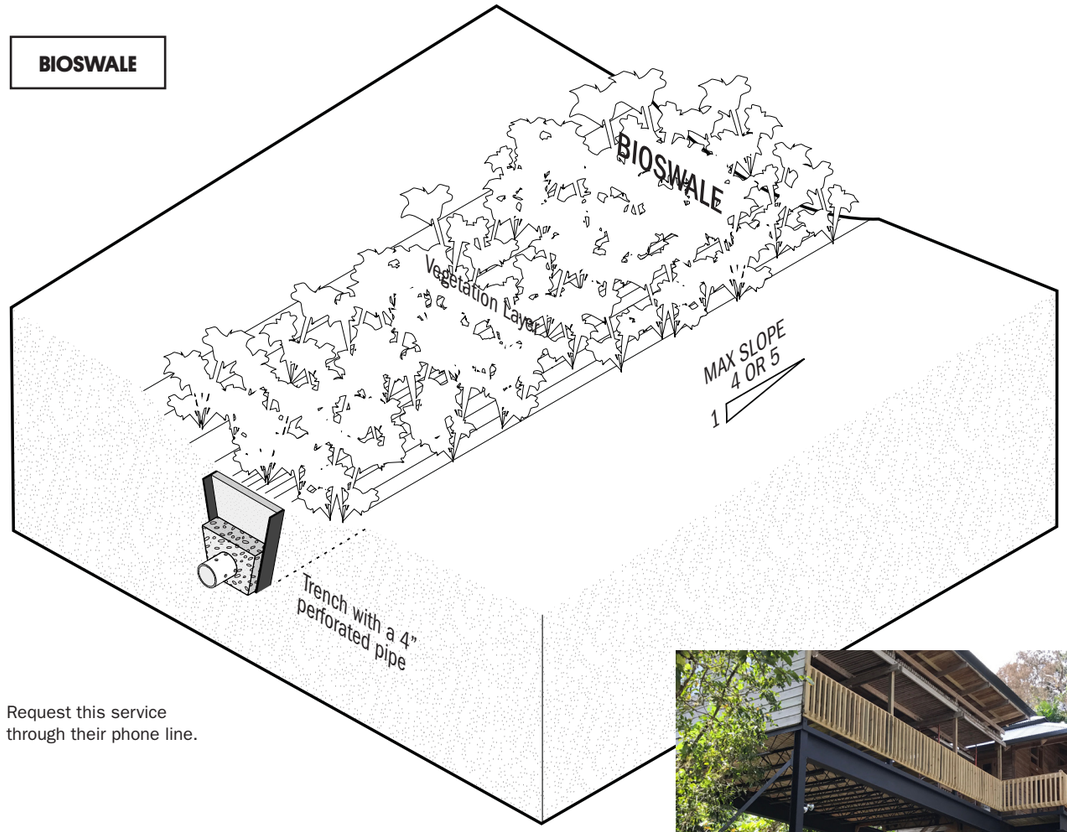
NATURAL HAZARDS IT PREVENTS

- Flooding
- Storm Surge

WHAT YOU NEED TO KNOW

- Shores: Boulders can be implemented in shores to reduce erosion or at the foot of a slope to give it structure and avoid mudslides in fields.
- They generally come in 3 sizes:
- Small – 4”-5”: good at preventing erosion and weed growth
- Medium – 6”-9”: prevents erosion, discourages walking traffic
- Large – 9” and up: absorbs wave energy more efficiently, prevents erosion on critical areas.
- Concrete rubble from demolitions can be repurposed for this.

BIOSWALE



Request this service through their phone line.

E. VEGETATION

Plants help anchor soil systems, which prevents earth movement while mitigating flooding damage. Superficial roots stabilize the top soil while deep and lateral roots fortify deeper layers.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Heat
- Fire
- Erosion
- Storm Surge

WHAT YOU NEED TO KNOW

- Identify a location for planting: the area should be separated from structures, aerial and terrestrial electric lines, water lines, and septic tanks.
- Select trees that do not damage structures or break easily with strong winds. Consider size, roots, flowering, fruits, and watering. See Strategy 11.
- Remove tree canopies that grow past the electric cables. Trees near electric lines should only be handled by the Electrical Authority of Puerto Rico (AEE, by its Spanish acronym).

STRATEGY 01

REINFORCE SITE WITH INFRASTRUCTURE

STEP 2 - IMPLEMENT GREEN INFRASTRUCTURE ON SITE

F. GREENROOF

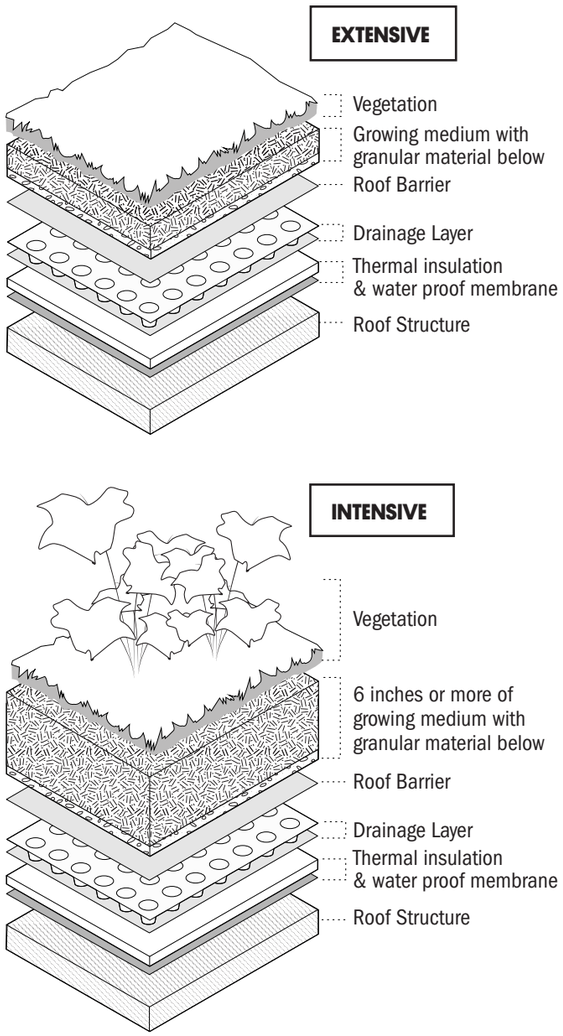
Roofs that are partially or totally covered with soil and a growing medium, planted over a waterproofing membrane. Ask an architect or structural engineer if your roof can support the added weight of soil, plants, and the water green roofs retain.

NATURAL HAZARDS IT PREVENTS

- Heat

WHAT YOU NEED TO KNOW

- Roofs that are partially or completely covered with vegetation and a growing medium can help mitigate excessive heat gain and manage storm water.



G. RIDGES

Boulders (also known as rip rap) are large pieces of rock that can be placed strategically to steer water, hold earth, or even act as wave-barriers (“rompeolas”) and mitigate erosion.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Storm Surge

WHAT YOU NEED TO KNOW

- Shores: Boulders can be implemented in shores to reduce erosion or at the foot of a slope to give it structure and avoid mudslides in fields.
- They generally come in 3 sizes:
- Small – 4”-5”: good at preventing erosion and weed growth
- Medium – 6”-9”: prevents erosion, discourages walking traffic
- Large – 9” and up: absorbs wave energy more efficiently, prevents erosion on critical areas.
- Concrete rubble from demolitions can be repurposed for this.

H. FIRE-WISE HOUSING

Strategically place plants and objects near home or property that are rated as not flammable.

NATURAL HAZARDS IT PREVENTS

- Fire

WHAT YOU NEED TO KNOW

- Remove dry vegetation from around and between dwellings.
- Avoid building in areas where access for emergency vehicles may be challenging, such as in flood-prone areas.
- Avoid building on steep hillsides, where fire may spread rapidly upwards.

I. DUNES

Coastal dunes typically consist of sand mounds that can range from a few feet to several dozen feet in height and may have vegetation as part of their composition. Coastal dunes are not static: they change in size, shape, and location depending on the time of year or impacts associated with storms and coastal wave events. The main benefit dunes provide is protection against coastal hazards, as well as providing sand for beach replenishment in times of need.

NATURAL HAZARDS IT PREVENTS

- Landslides

WHAT YOU NEED TO KNOW

- To build a dune, the most efficient way is to incorporate simple structures or vegetation that will serve as filters for retaining sand. In the case of structures (like wooden pallets or screens), they will need to be relocated as the dune increases in size, while the vegetation will grow with the dune to occupy the new space. In general, the best way to promote a healthy dune system is to avoid interfering with them or removing vegetation already in place.

STRATEGY 01

REINFORCE SITE WITH INFRASTRUCTURE

STEP 3 - IMPLEMENT GREY INFRASTRUCTURE ON SITE

- Consult a contractor, civil engineer, agronomist or the Agricultural Extension Service (SEA, by its Spanish acronym) to design gray infrastructure systems as outlined below.
- Be cautious when choosing where to deposit water. If water is contaminated with debris, do not deposit into a lake, river, or sea.
- Gray infrastructure may require special permits and a larger and more specialized professional team, can be more costly, and can be disruptive to the site if not properly designed and built.

RETAINING WALLS

Retaining walls are permanent barriers that prevent water from infiltrating the site. They are designed to contain the weight of the terrain on a steep slope that otherwise would collapse. Without a retaining wall, extreme rain might destabilize the exposed terrain and cause a landslide. These structures are beneficial in areas where erosion is inevitable or where critical infrastructure needs to be protected.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Landslides
- Erosion
- Heat

WHAT YOU NEED TO KNOW

- Built with reinforced concrete.
- Usually shaped as an inverted T.
- On the side of the terrain being stabilized, use a drain along the wall to keep water away from the structure.
- The drain consists of a PVC pipe surrounded by gravel and fabric that filters dirt and debris out.

DRY WELLS

Dry wells are underground tanks, usually made of concrete, that store water to percolate or drain slowly to another site or sewer. Their design is similar to a pool.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Erosion

WHAT YOU NEED TO KNOW

- A simple dry well is a 4”-6” deep and 3’ diameter pit filled with gravel or aggregate covered with topsoil.

FRENCH DRAIN

A French Drain system slowly drains surface water and can consist of a PVC tube with holes, different grades of rock or similar materials that allow percolation of water through the soil and out to a desired area.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Erosion

WHAT YOU NEED TO KNOW

- Perforate a PVC tube and place into a trench.
- Surround the tube with gravel and then cover with a permeable fabric.
- Direct water to a sewer, dry well, or other method of disposal.

DITCH

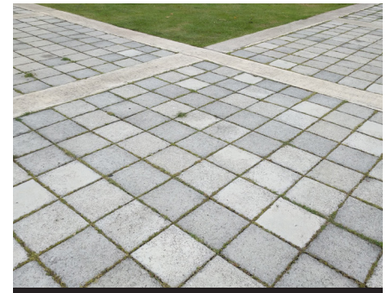
Ditches are channels that are used to redirect water flow. Historically, common practice has been to “re-canalize” or “re-channel” rivers to avoid flooding but in recent years communities are adapting to “living with water,” rather than channeling it off site, by allowing water to flow through sites.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Erosion

WHAT YOU NEED TO KNOW

- A simple dry well is a 4”-6” deep and 3’ diameter pit filled with gravel or aggregate covered with topsoil.



PERMEABLE SURFACES

Permeable surfaces consist of a paver, porous concrete, or other flooring system that allows water to pass through and percolate slowly into the soil, instead of solid pavement that reduces the area of the terrain that naturally percolates water.

- Usually made of asphalt, concrete, or planted surfaces.
- Areas with permeable pavement are usually utilized as an amenity for non-essential services like recreation.

NATURAL HAZARDS IT PREVENTS

- Flooding
- Heat

WHAT YOU NEED TO KNOW

- For pavers, the terrain is flattened and prepared prior to placement.
- The porous pavement or surface material is poured in place like regular concrete. Its porosity is a result of the permeable slab-like surface.
- If pavement needs to bear “loads” such as vehicles, it will need to be validated for load bearing capacity in advance of placement.

OPERATIONS AND MAINTENANCE TIPS

- Permeable surfaces used for parking, driving, or walking require periodic cleaning and inspection for weed growth on pavers or walls not designed to have vegetation.
- Keep a fire line on your site to prevent fire from encroaching on your site.
- Keep a clean site to keep hazards at bay.
- Keep draining systems free of debris.

STRATEGY

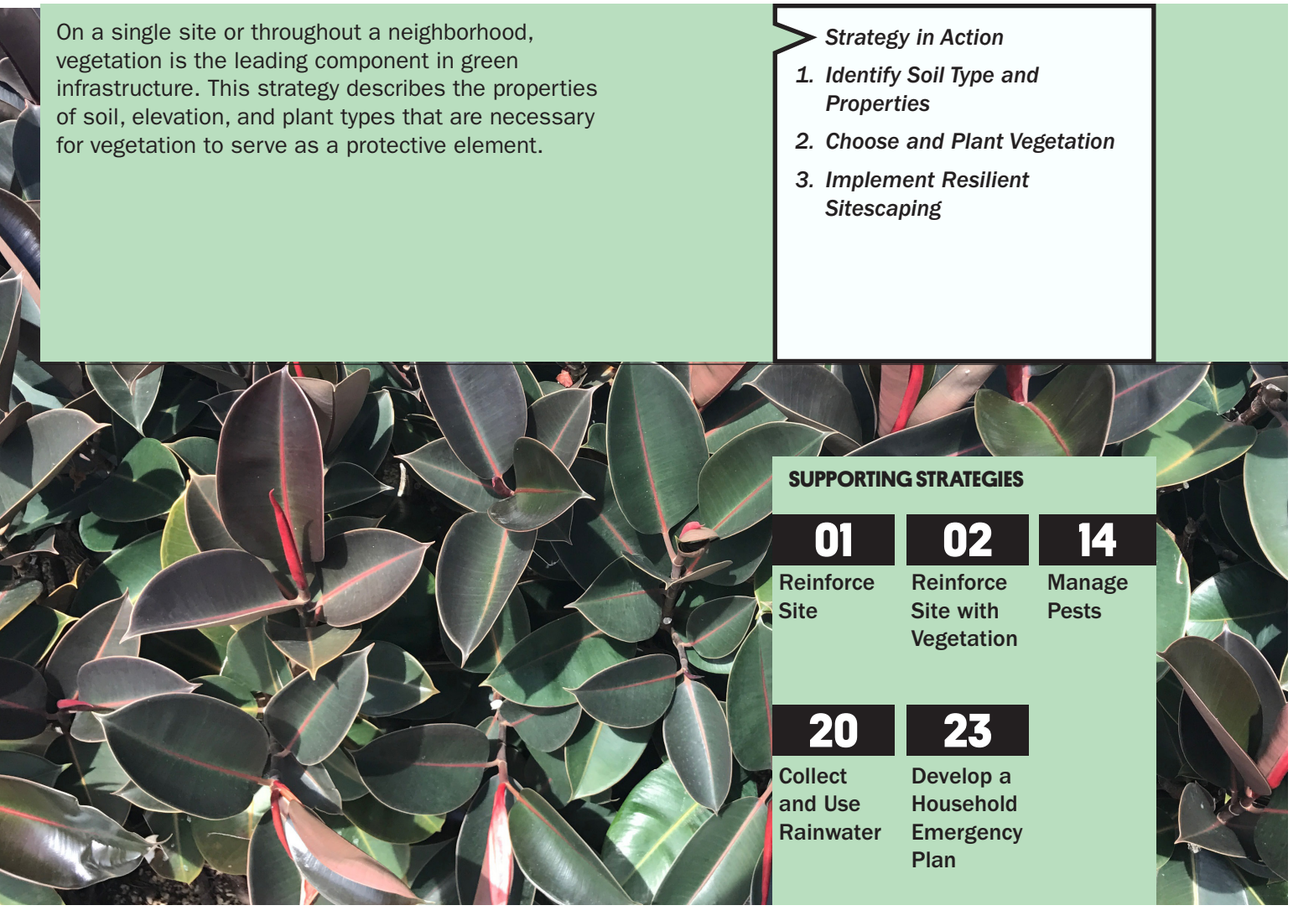
02 REINFORCE SITE WITH VEGETATION

$

On a single site or throughout a neighborhood, vegetation is the leading component in green infrastructure. This strategy describes the properties of soil, elevation, and plant types that are necessary for vegetation to serve as a protective element.

Strategy in Action

1. *Identify Soil Type and Properties*
2. *Choose and Plant Vegetation*
3. *Implement Resilient Sitescaping*



SUPPORTING STRATEGIES

01	02	14
Reinforce Site	Reinforce Site with Vegetation	Manage Pests
20	**23**	
Collect and Use Rainwater	Develop a Household Emergency Plan	

WHAT YOU NEED TO KNOW

The success of vegetation depends on:

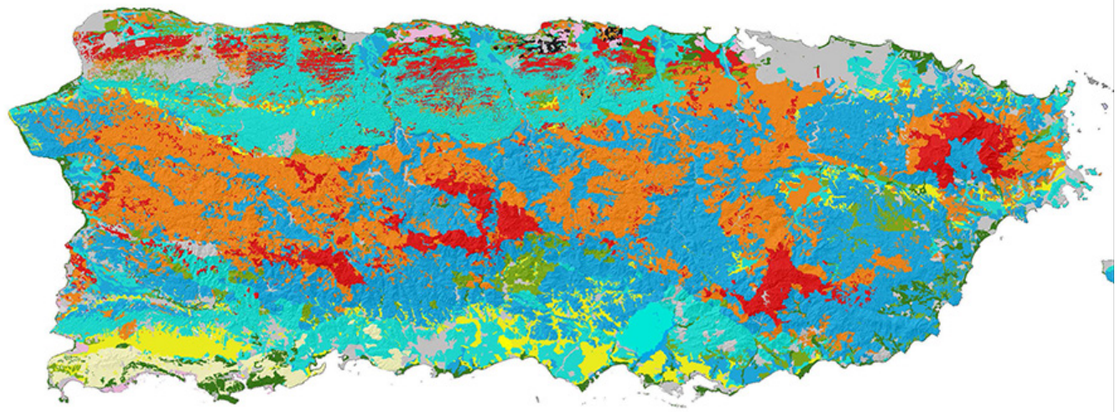
- Appropriateness of plant for soil type
- Health of plants and plant properties
- Maintenance and care
- Available light

Benefits of vegetation include:

- Soil stabilization
- Restoration of local ecosystems
- Creation of recreational spaces
- Shading and wind break
- Air and water quality enhancement
- Potential source of food or medicine (see Strategy 3: Plant an Edible Garden)

STEP 1 - IDENTIFY SOIL TYPE AND PROPERTIES

Soil Orders of Puerto Rico



SOURCE: USDA NATURAL RESOURCES CONSERVATION SERVICE

A. TYPE

There are several factors that determine the type of soil in an area: composition, climate, topography, plant activity, and minerals. The consistency of the soil can be classified as silt, sand, or clay. Sandy soil is found in rivers and beaches and is very loose and easy to work with, but has few of the nutrients that a plant may need. Silt is fertile and easy to work with. Clay has small particles and is very heavy when wet, making it difficult to work with. The combination of the three soil types—that is very fertile—is known as loam.

LEGEND

- **Alfisols**: semi-arid to humid areas
- **Aridisols**: arid or semi-arid climate
- **Entisols**: unconsolidated sediment or rock
- **Histosol**: organic materials
- **Inceptisols**: more developed unconsolidated sediment or rock
- **Miscellaneous**: Areas of human altered soil and non-soil areas
- **Mollisol**: semi-arid to semi-humid areas, typically under a grassland cover.
- **Oxisols**: tropical rain forest
- **Spodosols**: typical soils of coniferous or boreal forests
- **Ultisols**: product of continuous weathering of minerals in a humid, temperate climate
- **Vertisol**: high content of expansive clay minerals

STRATEGY

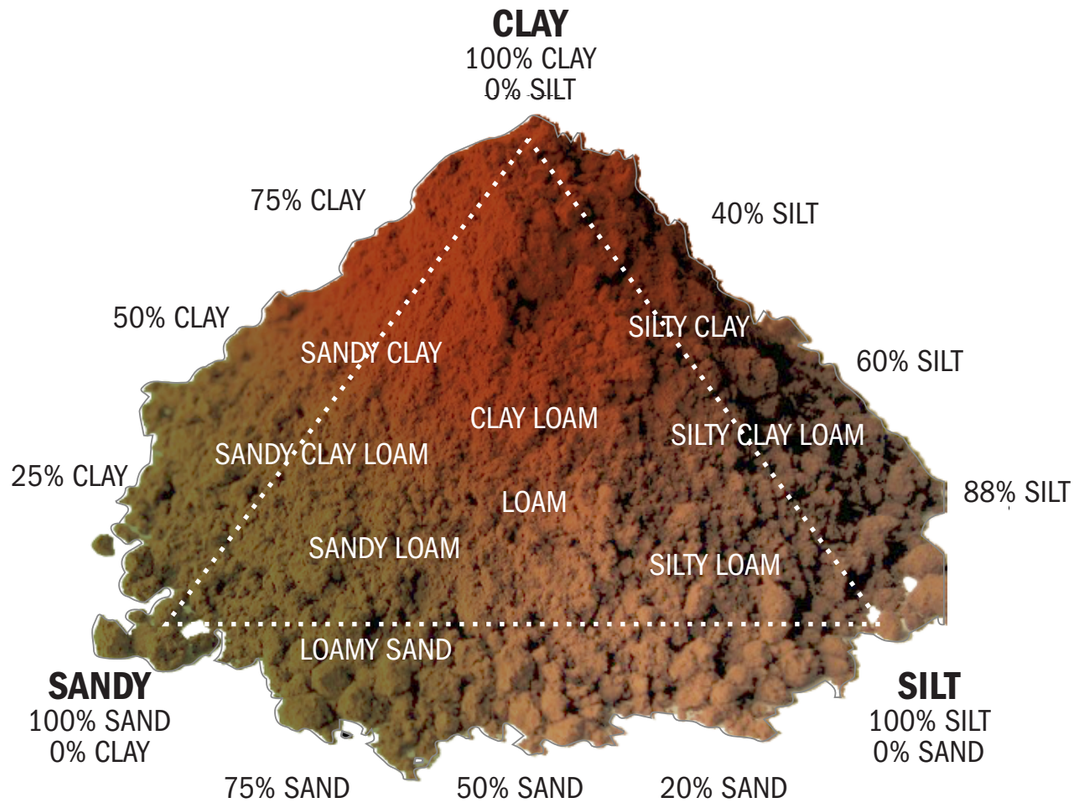
02 REINFORCE SITE WITH VEGETATION

STEP 1 - IDENTIFY SOIL TYPE AND PROPERTIES

IDENTIFY TYPE OF SOIL BY REGION

The consistency of soils naturally occurs as a mixture of the different kinds, as illustrated to the right.

The soils in Puerto Rico are variable and are classified as different types or diverse series depending on their localization within Puerto Rico. The soils that have similar characteristics conform a series. The most prominent series were classified in 11 groups. The two principal groups are in the mountainous and humid regions and the coastal valleys. The set of these series is known as the association, named after the areas in which they were identified. In the mountainous humid area, the associations include Tanamá-San Sebastián, Humatas-Los Guineos-Alonso, and Pellejas-Lirio-Ingenio; these are clay-like and loamy.



B. PROPERTIES

Properties of soil will vary based on location in the island, the relationship to coastal and water resources, altitude, and the proximity to developed communities. It's important to pay attention to the following elements as soil is selected.

- **Salinity**: A measure of the concentration of salts in water or soil.
- **PH Balance**: Measures the acidity or alkalinity of water or soil. The scale of PH is logarithmic and goes from 0 to 14. A PH of 7 is considered neutral.
- **Contamination**: Laboratory tests can be performed to detect contaminants in the composition of the soil.
- **Subsoil**: The layer just below the topsoil, which has less organic matter in its composition.

STRATEGY 02

REINFORCE SITE WITH VEGETATION

STEP 2 - CHOOSE AND PLANT VEGETATION

Native trees are those that are part of the natural landscape of Puerto Rico. Native trees are better at sustaining the local climate and may also have more capacity to survive extreme events like Hurricanes Irma and Maria.

- Choose vegetation based on your results from the chart above, the landscape available, and your intended purpose.
- Consult with agronomists, gardeners, or municipality agriculture experts about uses, recommendations, maintenance, and the resistance of trees under hurricane winds.
- Before covering an entire area with plants, test a small section and ensure that the plant is growing well without damaging the soil. If the test is not successful, move the plant to a different location or try another plant.
- Although they provide shade, it is best not to plant medium to big trees at a distance where they can fall on a home if toppled by hurricane winds. Nearby trees can also increase the humidity inside the home and can encourage mold growth.

STEP 2 - CHOOSE AND PLANT VEGETATION

- Plant trees in places that match its preferred conditions so that they won't need excessive care, like watering or adding nutrients. Consider the use compost to fertilize.
- Consult an arborist or an agronomist in case the tree has signs of a disease or insects. Consider the use of natural insecticides.
- Consider the use of natural insecticides.

SEASHORE DROPSEED
SPOROBOLUS VIRGINICUS

SALT HAY
SPARTINA PATENS

STRONGBARK
BOURRERIA SUCCULENTA

DESCRIPTION	A spreading perennial with green or purple flowers. Grows from 10 to 50 cm (4 to 20 inches).	Grass grown from 1 to 5 feet tall solitary or in small clumps.	Small to medium tree with green leaves arranged alternately, and it has fruit that goes from orange to red when ripe.
SOIL CONDITIONS REQUIRED	■ Soil Type: Sandy (stable dunes) ■ Salinity: High	■ Soil Type: Sandy ■ Growns on low dunes or sand flats ■ Salinity: High	■ Soil Type: Occurs in sand with a limestone substrate ■ Salinity: Moderately tolerant to salt ■ pH: High
BENEFITS	■ Dune stabilization ■ Provides habitat for animal species.	■ Dune stabilization ■ Provides habitat for animal species	■ Attracts pollinators and provides food for birds.

STRATEGY 02

REINFORCE SITE WITH VEGETATION

STEP 2 - CHOOSE AND PLANT VEGETATION

BEACH BEAN
CANAVALIA MARITIMA

DESCRIPTION

A perennial herb with a trailing or climbing stem

SOIL CONDITIONS REQUIRED

- Soil Type: Sandy Grows along coasts and edges of coastal bushland
- Salinity: High

BENEFITS

- Dune stabilization
- Provides habitat for animal species
- Can form a symbiotic relation with bacteria in the soil that enriches the soil.

SEA GRAPE
COCCOLOBA UVIFERA

DESCRIPTION

Medium tree that grows on the coasts. The tree has big rounded leaves and produces edible fruits.

SOIL CONDITIONS REQUIRED

- Soil Type: Sandy
- Salinity: High

BENEFITS

- Can be used as a hedge and wind breaker and shadig system.
- Tolerates drought.

ALLIGATOR WEED
ALTERNANTHERA PHILOXEROIDES

DESCRIPTION

Aquatic (freshwater). Often forms tangled masses in water. Good in shallow ponds, depressions, and ditches with fresh water.

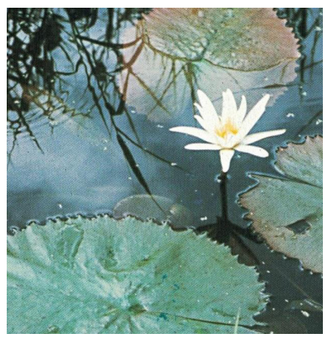
Considered invasive.

SOIL CONDITIONS REQUIRED

- Soil Type: Water (damp soil)

BENEFITS

- Can be used to stabilize soil and sites.
- Considered invasive and must be restrained to control its growth.



WATER LILY
NYMPHAEA AMPLA

DESCRIPTION

Aquatic (freshwater) plant that floats with a submerged root. Flowers are white and diurnal.

SOIL CONDITIONS REQUIRED

- Soil Type: Water (damp soil)
- Salinity: Freshwater

BENEFITS/ RISKS MITIGATED

- Provides habitat for animal species.
- Can be invasive.

WATER HYSSOP
BACOPA MONNIERI

DESCRIPTION

Aquatic (freshwater) succulent with leaves and small white or light blue flower.

SOIL CONDITIONS REQUIRED

- Soil Type: Water

BENEFITS/ RISKS MITIGATED

- Provides nesting and food for birds.

SOUTHERN CATTAIL
TYPHADOMINGENCIS

DESCRIPTION

Forms extensive colonies. Grows in rivers, beside lakes and herbaceous marshes.

SOIL CONDITIONS REQUIRED

- Soil Type: Water (damp soil)
- Salinity: Freshwater

BENEFITS/ RISKS MITIGATED

- Provides habitat and nesting sites for birds.
- Can be invasive.

STRATEGY 02

REINFORCE SITE WITH VEGETATION

STEP 2 - CHOOSE AND PLANT VEGETATION

BLACK OLIVE TREE
BUCIDA BUCERA

DESCRIPTION

A medium to large tree which can grow up to 100 feet.

SOIL CONDITIONS REQUIRED

- Soil Type: Can grow almost all over the island, in both humid and dry soils.

BENEFITS

- It can be planted to embellish and to provide shade. It is a large tree, so care must be taken when planting it near structures.

WHITE CEDAR
ABEBUIA HETEROPHYLLA

DESCRIPTION

A medium tree that can reach 60 feet. Its flowers are pink and tubular. Its delicate white seeds can be dispersed by the wind.

SOIL CONDITIONS REQUIRED

- Soil Type: The tree grows in the woods along the island.

BENEFITS

- It can grow in almost any type of soil and can be used for embellishment for parks.

ROYAL PALM TREE
RYSTONEA REGIA

DESCRIPTION

A palm tree that can reach 30 meters in height and has a distinctive sheath on the upper part of its foliage.

SOIL CONDITIONS REQUIRED

- Soil Type:
- Can grow in dry and humid soils.
- Common in the humid mountains.

BENEFITS

- Decorative; its fruit is an important source of food for birds and insects.
- Dry leaves that fall from the tree can be dangerous for cars and people.

ROYAL POINCIANA
DELONIX REGIA

DESCRIPTION

A medium tree distinctive for its showy red flowers and umbrella-like canopy.

SOIL CONDITIONS REQUIRED

- Soil Type: Will grow in almost any soil but needs good drainage, will tolerate drought.
- Salinity: Will tolerate salt.

BENEFITS

- Care must be taken when planting near homes because the root system will damage foundations or anything near it that is underground.

MANILA PALM
ADONIDIA MERRILLII

DESCRIPTION

A palm tree that can reach 20 feet high. Its fruit is distinctive and is important for bird species.

SOIL CONDITIONS REQUIRED

- Soil Type: Fertile soils with good drainage.

BENEFITS

- Used for embellishment and its fruit is an important source of food for bird.

JUNGLE GERANIUM
IXORA COCCINEA

DESCRIPTION

A shrub with very dense foliage, showy red flowers, and dark purple fruit. Its flowers attract bees and birds.

SOIL CONDITIONS REQUIRED

- Needs full sun but can tolerate some shade.

BENEFITS

- Can be used as a hedge.

STRATEGY 02

REINFORCE SITE WITH VEGETATION

STEP 2 - CHOOSE AND PLANT VEGETATION

NARRA
PTEROCARPUS INDICUS

DESCRIPTION

A large tree with many long branches, yellow flowers, and a distinctive round wing seed.

SOIL CONDITIONS REQUIRED

- Soil Type: Can be found in various types of soils, from sandy loams to clay.
- Salinity: Tolerates moderate levels of salt in the soil.

BENEFITS/ RISKS MITIGATED

- A nitrogen-fixing tree, it has been recommended for use in agroforestry systems and as a shade tree for coffee and other crops

TEA
AMYRIS ELEMIFERA

DESCRIPTION

Grows from a shrub to a small tree up to 6 meters in height. The leaves are aromatic when crushed. It has white flowers and bears fruit.

SOIL CONDITIONS REQUIRED

- Soil Type: Grows well in sandy soils and limestone soils. Can also grow in moist terrains with good drainage.
- Can be found in the Guanica Dry Forest.

BENEFITS/ RISKS MITIGATED

- Its fruit is a source of food for birds.
- The tree is very resinous, and its wood can be used as a torch.

WEST INDIAN SATINWOOD
ZANTHOXYLUM FLAVUM

DESCRIPTION

Grows from a shrub to a small tree up to 11 meters in height. The leaves are aromatic when crushed and its flowers are a greenish white color.

SOIL CONDITIONS REQUIRED

- Soil Type: Can grow in a sandy terrain and limestone.
- Can be found in the Guanica Dry Forest.

BENEFITS/ RISKS MITIGATED

- Its flowers attract pollinators (insects and bees).

MANGROVES

DESCRIPTION

- Also known: Button Mangrove, White Alling, Black Mangrove, Red Mangrove, White Mangrove
- Mangroves can survive on the threshold of water and terrain on the coast but are not limited to it.

SOIL CONDITIONS REQUIRED

- Soil Type: Water (damp soil) and sand in coastlines and estuaries
- Salinity: High
- Can also be found in estuarine waters.

BENEFITS/ RISKS MITIGATED

- Mangroves are known as nature's filters; the reason they have a distinctively sour smell is precisely because they cycle pollutants out of the water. Because of their high tolerance for varying levels of salinity and strong root systems, they are fantastic to use as natural sea walls or rompeolas against wave surges and for any type of shore suffering from erosion.

BLACKRODWOOD
EUGENIA BIFLORA

DESCRIPTION

Small to medium tree with green leaves of

1 - 2 cm and small white flowers. Gives small fruit that is red or black when ripe.

SOIL CONDITIONS REQUIRED

- Soil Type: Can be found in the coastal valleys, limestone substrate, and in the mountains.

BENEFITS/ RISKS MITIGATED

- Provides fruit for birds.

SERRETTE GUAVE
EUGENIA DOMINGENSIS

DESCRIPTION

- Small to medium tree with green leaves and white small flowers. Gives small round fruit which is red when ripe.

SOIL CONDITIONS REQUIRED

- Soil Type: Can be found in mountains, humid mountains, and coastal valleys.

BENEFITS/ RISKS MITIGATED

- Provides fruit for birds.

STRATEGY

02 REINFORCE SITE WITH VEGETATION

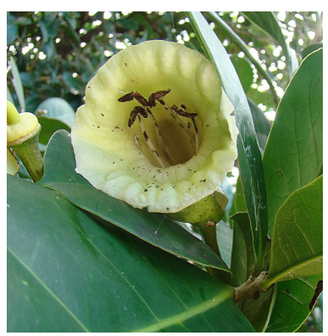
STEP 2 - CHOOSE AND PLANT VEGETATION

OPERATIONS AND MAINTENANCE TIPS

- Plant trees in places that match its preferred conditions so that they won't need excessive care, like watering or adding nutrients. Consider the use compost to fertilize.
- Consult an arborist or an agronomist in case the tree has signs of a disease or insects.
- Consider the use of natural insecticides.

WEST INDIAN BAY TREE
PIMENTA RACEMOSA

MAGA
THESPESIA GRANDIFLORA



BLACK CALABASH
AMPHITECNA LATIFOLIA

FIDDLEWOOD
CITHAREXYLUM FRUTICOSUM

MARICAO
BYRSONIMA SPICATA

DESCRIPTION	Small to medium tree with aromatic leaves.	A small to medium tree with large green leaves and a red to dark red flower.	Small to medium tree can reach 30 feet with a variable spread.a narrow crown, is moderately dense and of irregular form. Gives yellow flowers and green fruit.	A small to medium tree with extended top, irregular foliage and white flowers. It gives abundant fruit.	A medium tree with green leaves, though some are red, and others are yellow. The Maricao has yellow flowers and gives fruit irregularly through the year.
SOIL CONDITIONS REQUIRED	■ Soil Type: Can be found on hillsides but can grow in somewhat humid areas	■ Soil Type: Grows best in limestone hillsides and alluvial bottom between the hills. ■ Can grow in full sun and some shade.	■ Soil Type: The soil found in the coastal line. ■ Needs open space and good sun.	■ Soil Type: Can tolerate humid and somewhat dry soils.	■ Soil Type: Does not tolerate humid soils. ■ Needs good sun
BENEFITS	■ Its leaves are used to make an infusion with rubbing alcohol to relieve muscular pain (alcoholado).	■ Attracts pollinators and can be used for shade and embellishment in parks.	■ This upright, densely-foliated, evergreen can provide site shading and stabilization. Provides food for birds.		
BENEFITS/ RISKS MITIGATED				■ Provides food for birds and attracts bees.	■ Provides food to pollinators, including bats and birds.

STRATEGY 02

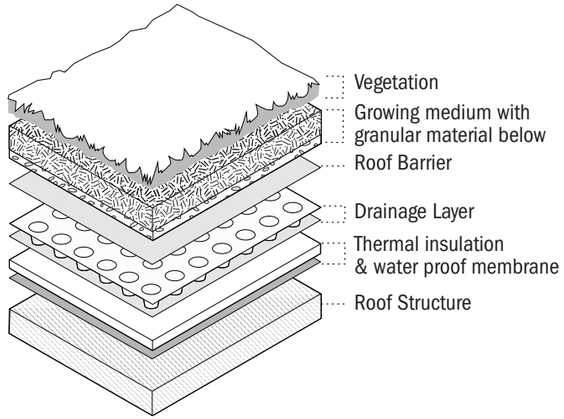
REINFORCE SITE WITH VEGETATION

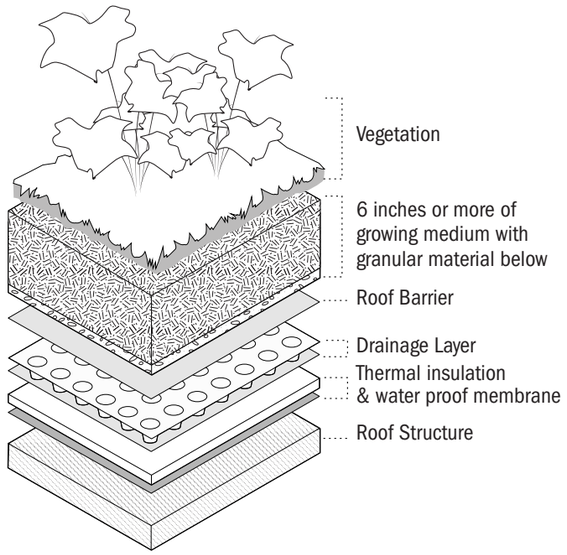
STEP 3 - IMPLEMENT RESILIENT SITE SCAPING

When planting vegetation that will need a minimum of care and maintenance, it's better to choose local vegetation, the ones that grows better within the conditions of the place where they will be planted.

A. GREEN ROOFS

- Roofs that are partially or completely covered with vegetation and a growing medium mitigate excessive heat gain and manage stormwater.
- Green roofs are classified according to the depth of soil or growing medium, which determines species it can support.
- A green roof consists of several layers including a membrane to protect the roof from water leakage, soil layers, a drainage layer and vegetation.
- Consult with building professionals to identify the load a roof can sustain with plantings, water and materials.
- Verify that roof vegetation is watered to prevent building flammability and maintain ability for roof habitat and benefits. This may require water pumped to the roof.





EXTENSIVE

- Does not require an irrigation system (thin soil layer).
- Recommended vegetation: succulents, cacti
- Pros: minimal maintenance required,
- Relatively inexpensive
- Cons: limited choice of plants, cannot grow vegetative species

INTENSIVE

- Requires irrigation systems (thicker soil layer).
- Recommended vegetation: virtually any plant or tree whose root system will not grow deeper than growing medium (generally less than 6 inches).
- Pros: can incorporate a greater variety of vegetation
- Cons: greater weight loading on roof, higher cost

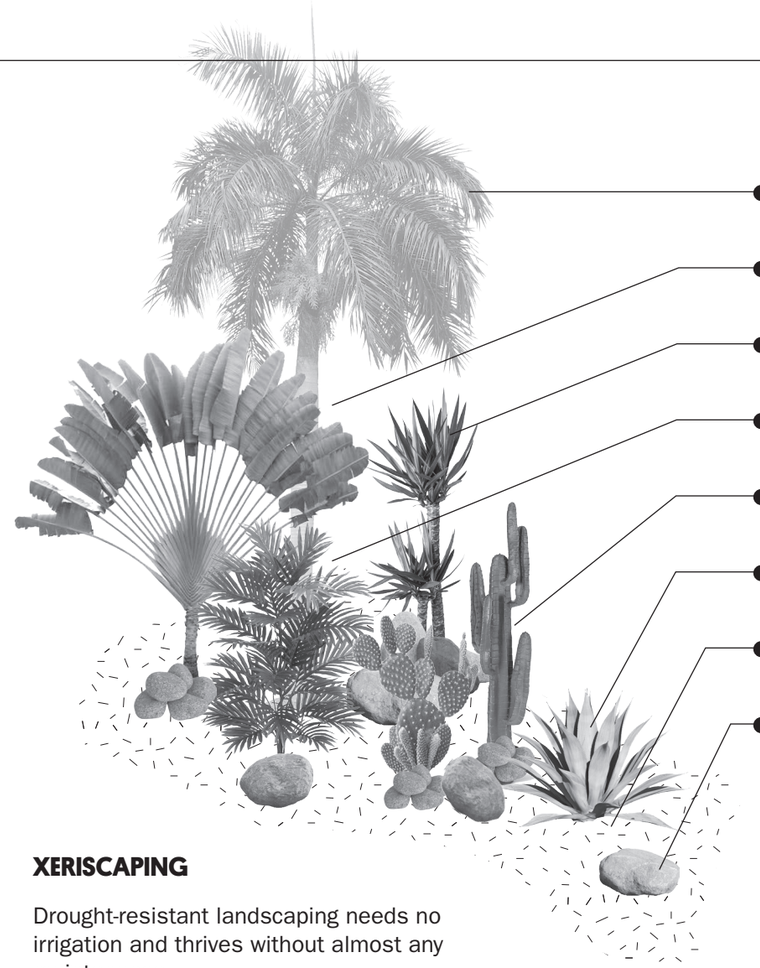
STRATEGY

02 REINFORCE SITE WITH VEGETATION

STEP 3 - IMPLEMENT RESILIENT SITE SCAPING

B. XERISCAPING

- A type of garden that requires little supplemental water. Creates breeze for areas that are very hot and do not receive much rain, such as Southern Puerto Rico.



XERISCAPING

Drought-resistant landscaping needs no irrigation and thrives without almost any maintenance.

OPERATIONS AND MAINTENANCE TIPS

- The height of a tree must not be longer than its distance to a structure so that the tree won't fall over said structure in case high winds overthrow it. Planting trees near homes also has the disadvantage of possibly damaging the structure of the home or damaging plumbing or service lines.
- Trim dead branches so that they won't turn into projectiles. Consider trimming all tree branches so that they won't exert resistance to the winds and survive hurricane winds. Trimming trees may require the work of a professional and the use of a crane or a bucket crane truck.
- Do not trim any branches by any near electrical lines. Call the authorities for that purpose whenever you see branches growing near or towards the lines. Do not plant trees near electrical lines.
- To cut a tree, obtain a permit from the Department of Natural and Environmental Resources (DRNA, by its Spanish acronym).

STRATEGY

03 PLANT AN EDIBLE GARDEN

$

REMEMBER

An Edible Garden is a Critical Part of a Resilient Home. Domestic gardens are affordable and easily manageable. They allow you to grow your own food and medicines and reduce supermarket costs. You can incorporate specific herbs to help ward off insects, specific plants to control thermal heat gain (see Strategy 14 Manage Pests), and redirect wind for better natural ventilation (see Strategy 11 Increase Ventilation).

After a natural disaster strikes, primary resources, including food, can become scarce. This strategy focuses on how conscientious use of vegetation can offer a local back-up food resource and a year-round supply of food. Additionally, it provides a range of other benefits like exercise, community building and cost savings. Another positive aspect is the consideration of growing medicinal plants which can improve the health of residents and the community.

Strategy in Action

1. Plan Your Garden

2. Plant Your Garden

WHAT YOU NEED TO KNOW

Importance of Edible Vegetation

Edible Vegetation promotes resilient communities by:
- Removing air pollutants
- Providing shade
- Fortifying the soil
- Supplying food
- Supplying homeopathic medicine
- Creating community bonding opportunities

Preparing the soil for growing food is a critical first step to any gardening activity.

Thoughtful design of the layout for your garden will determine its success. Optimal growing conditions include flat surfaces where the appropriate sun light ratio is available to the crops. However, don't let this deter you from trying to work on sloped surfaces or areas with a shade. While sloped surfaces will pose challenges of soil erosion and nutrient mobility, plenty of techniques exist to help you make use of any terrain available to you. Additionally, building your garden with enough plant variety will allow you to maximize its growing potential, even with varying access to sunshine in your garden.

SUPPORTING STRATEGIES

01 Reinforce Site

02 Reinforce Site with Vegetation

14 Manage Pests

20 Collect and Use Rainwater

23 Develop a Household Emergency Plan

STEP 1 - PLAN YOUR GARDEN

A. EVALUATE THE GROWING CONDITIONS OF YOUR FUTURE GARDEN

A successful garden will be supplied with healthy soil, plenty of sunshine, and water. Garden planning is all about allocating these resources.

Sun: If your plot is surrounded by large trees and/or structures, your future garden may suffer from sun deprivation. As a fundamental source of energy for plants, sunlight must be optimized. If your conditions allow, prioritize your garden location to south-facing areas with as much sun exposure as your land area allows.

Soil: Healthy soil may already be available in your plot. This is soil that is nutrient-dense, has good drainage, and is on a terrain that is relatively flat to avoid erosion. Sometimes, these conditions cannot be met. Use alternatives, such as container gardening with hydroponics, to persist with your gardening goals. Your Agricultural Extension Service (SEA, by its Spanish acronym) can conduct soil health testing and help you identify soil health and safety parameters.

Water: Your garden must be watered regularly. Adequate garden planning will help you devise a source of irrigation water that minimizes added costs and provides clean water to your garden. Consider ways in which you can collect and store rainwater (such as rain barrels). Check that your water source is always safe by monitoring water quality.

B. DETERMINE WHICH FOODS ARE MOST SUITABLE FOR YOUR GARDEN

Growing your own food allows you to choose among multiple fruit and vegetable varieties, which gives you the opportunity to try many new foods and flavors. Choosing the right variety of plants to grow will require consideration of your garden's capabilities (space limitations; access to resources like sun, soil, and water; and growing methods). Consider the following list of plants that are generally suitable for growing conditions in Puerto Rico. Choose among those which may thrive in the local conditions of your site and with the growing system you choose. Consider the amount of space available for the plants to grow. To decide on the proper space, consider the general rule of thumb which establishes that a plant will grow as big as it roots.

STRATEGY 03

PLANT AN EDIBLE GARDEN

Plant cycle | Shaded | Direct sun | Harvest cycle | Water once a week | Water 2-3 times a week | Water regularly

STEP 1 - PLAN YOUR GARDEN

VEGETATION FOR FOOD: TREES

COCONUT / PALM TREES

Plant cycle: 12 months — Fruits after 6-10 years, after flowering

CITRUS

Plant cycle: 6-8 months — Fruits after 3-6 years

PAPAYA

Plant cycle: 9-11 months — Fruits after 7-11 months

BANANA/PLANTAIN TREES

Plant cycle: 9 months — Fruit after 1 year

VEGETATION FOR FOOD: SHRUBS AND VINES

PUMPKINS

Plant cycle: 3-4 months

AVOCADOS

Plant cycle: 12 months

EGGPLANT

Plant cycle: 3-6 months

PANA / BREADFRUIT

Plant cycle: 12 months — Fruit after 5 years

STRATEGY 03

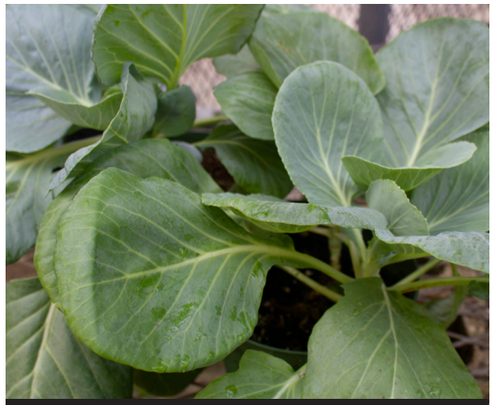
PLANT AN EDIBLE GARDEN

REMEMBER

An alternative for growing edible gardens at home with limited yard space is to establish a community garden in a park and allow community members' access to plots in the garden. Check that the soil is not contaminated. A list of resources on community gardens is included below.

STEP 1 - PLANT YOUR GARDEN

VEGETATION FOR FOOD: ROOT VEGETABLES



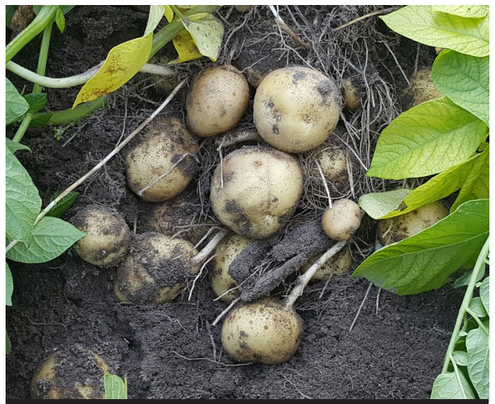
LETTUCE/CABBAGE FAMILY

PEPPER SPECIES

ONION/GREEN ONIONS - PLANT IN SHALLOW SOIL

SPINACH

Vegetable after 3 months



POTATOES/YAUTÍA/ÑAME/OTHER LOCAL TUBERS

TOMATOES

SWEET POTATO/YAM SPECIES

CARROTS

STRATEGY 03

PLANT AN EDIBLE GARDEN

DISCLAIMER

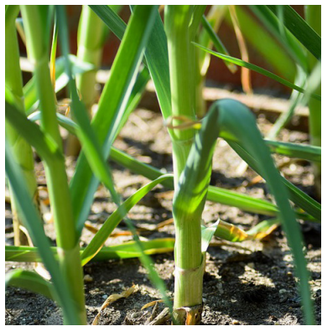
Consult with a medical professional before consuming these plants. Some plants might interact with certain medicines or may not be recommended for some diseases.

STEP 1 - PLANT YOUR GARDEN

MEDICINAL PLANTS

Medicinal plants can be used in a variety of ways:

- As tea, which is usually an infusion of Camellia sinensis, an evergreen shrub native to East Asia.
- As an infusion, which is prepared by pouring hot water over leaves, flowers, fruits or bark of plants commonly used for this purpose.
- As oil. Plant-based oils are extracted by different methods suitable for the part of the plant containing the oil. Some methods include cold pressing, distillation, and solvent extraction.
- As tincture, an extract of a plant dissolved in ethyl alcohol. Tinctures are ingested.
- The following plants, common in Puerto Rico, have been known for their medicinal properties. Given that most of these are herbs or small plants, they are all great alternatives for container gardening.



GARLIC

HOW IT GROWS

Bulb or tuber

HOW TO USE

It is used to prevent blood clots and cerebral aging. It aids digestion and prevents flatulence. It is also used as a mosquito repellent.

When eaten raw, it releases antiseptic properties.

BASIL

HOW IT GROWS

Plant or herb

HOW TO USE

Basil is commonly consumed for stomach problems such as spasms, loss of appetite, intestinal gas, diarrhea, and constipation.

It is also used in teas, infusions, baths, and botanical massage oils.

YELLOWCRESS OR WATERCRESS LEAVES

Plant

Watercress boasts many important vitamins and minerals, including over 100% of the recommended daily intake (RDI) for vitamin K. Watercress is extremely high in antioxidants which may help prevent chronic diseases, such as diabetes, cancer and heart disease. Add to salads and green juices/smoothies.

CINNAMON BARK

Tree [bark]

Has antibacterial, anti-inflammatory, and antioxidant properties. Cinnamon lowers blood glucose levels in patients with type 2 diabetes. Use in teas, add to jarabes or homemade cough syrups made with honey and lemon, suck on a single clove raw, and include it in botanical oils for the skin.

STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 1 - PLANT YOUR GARDEN

MEDICINAL PLANTS

ONION

HOW IT GROWS

Bulb or tuber

HOW TO USE

The possible health benefits of consuming onions include mood improvement, and healthy skin and hair. Use in food preparation.

Add to jarabes or homemade cough syrups made with honey and lemon.

CITRUS FRUITS [LEMON, ORANGE, LIME, GRAPEFRUIT]

HOW IT GROWS

Fruit shrub or tree

HOW TO USE

These fruits work as antidepressants (mood lifters). They have antiseptic properties; they can be used to clean and as stain removers. Add to teas, infusions, botanical massage oils, aromatherapy, alcoholates or alcoholados. Drinking their juice and eating these fruits releases some beneficial properties.

MARIGOLD FLOWERS OR CALÉNDULA

HOW IT GROWS

Flowering plant

HOW TO USE

Supports new tissue growth during wound healing process and decreases swelling in the mouth and throat.

Use this flower for your tea, make it into an infusion, and use in baths.

CLOVE

HOW IT GROWS

Flowering Plant

HOW TO USE

Clove oil contains a chemical called eugenol that may help decrease pain and fight infections, but more research is needed.

Use it to make tea, add it to jarabes or cough syrups made with honey and lemon, suck on a single clove raw, and use it in botanical oils for the skin, alcoholates or alcoholados

EUCALYPTUS LEAVES

HOW IT GROWS

Tree

HOW TO USE

Might be able to break up mucus in people with asthma. Eucalyptus oil contains chemicals that might help pain and inflammation.

Use these leaves for teas, infusions, green juices/smoothies, baths, botanical massage oils and ungüentos or medicinal ointments.

GINGER

HOW IT GROWS

Root

HOW TO USE

May help relieve or prevent nausea and vomiting. Some studies show that ginger may help nausea caused by chemotherapy.

Use in teas, infusions, green juices/smoothies, baths, botanical massage oils and ungüentos or medicinal ointments, compresses, condiments, alcoholates or alcoholados.

STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 1 - PLANT YOUR GARDEN

MEDICINAL PLANTS

LEMONGRASS

HOW IT GROWS

Plant/Herb

HOW TO USE

Lemongrass is an insect repellent, it helps to treat anxiety, gastrointestinal problems, and induces sleep.

Use for teas, juices and green smoothies, baths, and essential oils for your skin.

"MALAGUETA" OR WEST INDIAN BAY TREE LEAVES

HOW IT GROWS

Woodsy Shrub/tree

HOW TO USE

These leaves help treat muscle pain and work as a natural insect repellent.

Use in baths, botanical massage oils and ungüentos or medicinal ointments, compresses, and alcoholates or alcoholados.

MARJORAM

HOW IT GROWS

Plant/Herb

HOW TO USE

Marjoram is commonly used to relieve symptoms such as runny nose or cough, as well as to treat colds, infections, and various digestive problems. However, there is no clear scientific evidence to support these or any other uses.

Use in teas, infusions, green juices/smoothies, baths, botanical massage oils and ungüentos or medicinal ointments, alcoholates or alcoholados, and compresses. It is also included in condiments, in vinaigrettes, and is added raw in salads.

LEMON BALM OR "TORONJIL"

HOW IT GROWS

Plant or herb

HOW TO USE

Lemon balm is used for digestive problems, including upset stomach, bloating, flatulence, vomiting, and colic. Many people believe lemon balm is calming, so they take it to treat anxiety, sleep problems, and restlessness. It is used in infusions, green juices/smoothies, baths, botanical massage oils, ungüentos or medicinal ointments, and compresses. It is also used in condiments, vinaigrettes, and added raw in salads. Lemon balm is proven to treat herpes simplex virus 1 and 2.

MINT

HOW IT GROWS

Plant or herb

HOW TO USE

Mint oil is used topically for tension headaches.

Mint is also used in tea blends, infusions, green juices/smoothies, baths, botanical massage oils, ungüentos or medicinal ointments, compresses, condiments, and even in home cleaning products.

NIM OR NEEM

HOW IT GROWS

Tree

HOW TO USE

Used in traditional medicine for skin conditions and for stomach ailments. It is also used as a disinfectant against pests and parasites. The oil is used to get rid of pests in agriculture.

Neem leaves are used in capsules. Additionally, oil is extracted from its seeds and is used as a curative massage oil.

STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 1 - PLANT YOUR GARDEN

MEDICINAL PLANTS

OREGANO

HOW IT GROWS

Plant or herb

HOW TO USE

Oregano is taken orally for respiratory tract disorders such as cough, asthma, allergies, croup, and bronchitis; it is also taken orally to treat stomach disorders such as heartburn, bloating, and parasites. Oregano oil is used for skin conditions including acne, athlete's foot, dandruff, canker sores, warts, wounds, ringworm, rosacea, and psoriasis; it is also used to treat insect and spider bites, gum disease, toothaches, muscle and joint pain, and varicose veins. Oregano oil is also applied to the skin as an insect repellent.

It is included in tea blends, broths, condiments, baths, botanical massage oils, ungüentos or medicinal ointments, compresses, jarabes or homemade cough syrups, alcoholates or alcoholados, and even in home cleaning products.

BLACK PEPPER [SEEDS OR FRUITS]

HOW IT GROWS

Flowering Vine

HOW TO USE

Black pepper might help fight germs (microbes) and increases the flow of digestive juices. Black pepper is applied as a natural topical pain reliever.

It is also used as a condiment, is chewed raw or included in tea blends. It can be included in baths, botanical massage oils, ungüentos or medicinal ointments, and alcoholates or alcoholados.

BUSHY LIPPIA [LEAVES]

HOW IT GROWS

Flowering Plant

HOW TO USE

This plant is a mint but its ingestion can prove toxic for the liver.

It is used in teas, infusions, green juices/smoothies, baths, botanical massage oils, ungüentos or ointments, compresses, and alcoholates or alcoholados.

ROSEMARY LEAVES

HOW IT GROWS

Plant, can grow to become a bush.

HOW TO USE

Rosemary is used for digestive problems, including heartburn, flatulence, and loss of appetite. Rosemary is also applied to the skin for preventing and treating baldness. It treats circulation problems as well.

It serves as a condiment, tea, aromatherapy essential oil, massage oils, and ungüentos or ointment.

BLUE/MEXICAN ELDERBERRY LEAVES AND FLOWERS

HOW IT GROWS

Bush, can grow to become a tree

HOW TO USE

Reduces cold and flu symptoms. While berries are rich in nutrients, raw elderberries are inedible and must be properly cooked before they can be ingested. Use elderberries to make teas, jarabes or cough syrups, green juices and smoothies, baths, and alcoholates or alcoholados.

ALOE VERA OR "SÁBILA"

HOW IT GROWS

Thick-leafed plant

HOW TO USE

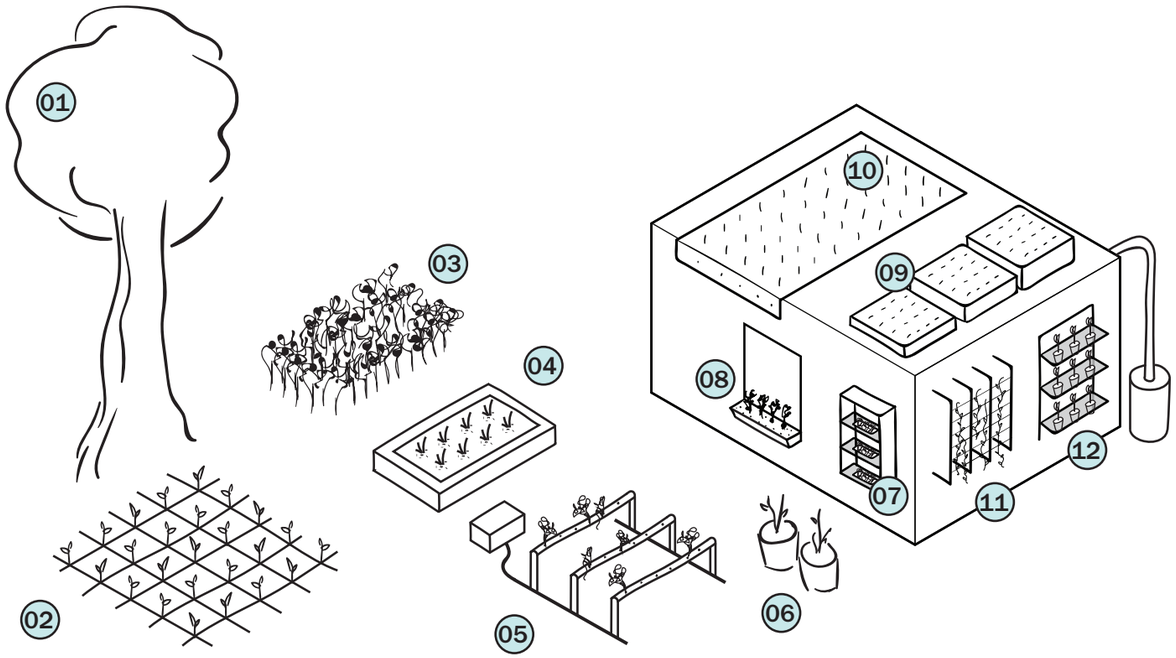
Helpful for minor burns, aloe vera gel should not be confused with aloe juice or aloe latex, both of which contain potent laxative substances. You can harvest its "crystal", the slimy and transparent flesh interior, by carefully skinning each leaf with a knife. Use in infusions, green juices/smoothies, jarabes or homemade cough syrups, compresses, and other applications.

STRATEGY

03 PLANT AN EDIBLE GARDEN

STEP 2 - CHOOSE AMONG GROWING METHODS

Based on the conditions of your garden—available land, layout, soil quality, and budget—you may choose to use soil as the growing medium for your plants or a water-based medium that delivers nutrients to plants grown in hydroponic systems. This section includes information to consider when determining the growing method for your garden.



01 Fruit Trees
02 Direct Soil Gardening
03 Fruit or Herb Bushes
04 Raised Bed Planter
05 Hydroponic System (Ground or Roof)
06 Planters
07 Window Green House
08 Window Sill Planters
09 Extensive System / Trays vary in depth
10 Intensive System / Built into roof depth
11 Light Mesh for Climbing Species
12 Shelve or Pocket System

SOIL PLANTING $

- This method utilizes nutrients available in the soil to grow food or herbs.
- A vertical garden is a technique used to grow plants in soil or on a medium vertically, using a trellis, fence, wall or similar surface with soil at the bottom.

LOCATION

- Outdoors (single family house with yard, multifamily housing with community garden, exterior walls, and balconies)
- Indoors (herbs and microgreens in greenhouses

PROS

- Grows a wide range of native species.
- Provides site shading.
- Helps control pests on site.
- Helps manage stormwater and drainage.
- Can be linked to a home's graywater system.
- Absorbs soil nutrients.

CONS

- Prone to insect infestation, mold growth, and contaminants in the soil and water.

HYDROPONIC PLANTING $

- This method uses mineral nutrient solutions in a water solvent on mediums such as perlite, Rockwool, clay pellets, peat moss, or vermiculite to grow plants without soil. Because this method is employed indoors, it requires artificial sources of UV rays (sunlight).

LOCATION

- Indoors (greenhouses)
- Outdoors on a covered structure (terraces or balconies)

PROS

- Yields a quantity of leafy greens (like basil, cilantro and arugula) that is three times more than a traditional soil system can provide.
- Grows in indoor and outdoor conditions. Gardener has more control over crop exposure to light, insects and natural elements if grown indoors.
- Enables experimentation with different crops throughout the year.
- Enables food production in areas where soil is contaminated.

CONS

- Requires higher initial investment.
- Ongoing utility cost related to lighting and pumps.
- Prone to pest infestation (aphids) and powdery mildew.
- Water needs a specific pH balance.Requires nutrients to be imported from the garden.
- Needs electricity to power up motor, lights, and fans.
- The system needs added nutrients.

STEP 3 - GROWING STYLES

If you choose to use soil as your growing method, there are various styles of gardening among which you can choose from and adapt to your land and resource availability.

PLANTERS

Planters can be any type of container that holds soil for plant growth. They come in various materials, shapes and sizes.

LOCATION

- Indoors
- Outdoors (ground, walls, roofs)

PROS

- Grows in indoor and outdoor conditions.
- Works in a variety of configurations, including vertical.
- Alternative if ground soil is contaminated or infertile.
- Can run with an automatic drop water system.
- Can be moved around which is helpful in gardens with limited sunshine access
- Nutrients and water are retained longer, so there is less leaching.
- Simplified pest control as these will be localized (if they appear).

CONS

- Will limit a plant's growth particularly trees
- Grows a limited range of native species due to limited root growth in containers.

STEP 3 - GROWING STYLES

VERTICAL

Plants, particularly vines, can be placed vertically and trellised along a wall. Growing plants vertically maximizes space use, making it an ideal alternative for growing edible plants indoors (herbs, microgreens, lettuces).

LOCATION

- Indoors
- Outdoors (ground, walls, roofs)

PROS

- Grows in indoor and outdoor conditions.
- Works in a variety of configurations.
- Can run with an automatic drop water system.
- Grows a limited range of native species.will limit a plant's growth particularly trees
- Grows a limited range of native species due to limited root growth in containers.

CONS

- Grows a limited range of native species.

GROUND $

This method provides the most versatility in terms of plants that can be grown. Root vegetables and tubers, for example, may do better directly in the soil. Additionally, growing foods directly from the soil supports shading of property and improves the soil's structural stability (decreases the risk of runoff during flooding).

LOCATION

- Outdoors

PROS

- Grows outdoor.
- Works in a variety of configurations.
- Can run with an automatic drip water system.
- Benefits from intra-species soil biodiversity.

CONS

- If soil is contaminated, ground growth is impossible.

OPERATIONS AND MAINTENANCE TIPS

- Test the soil for contaminants prior to planting. Ensure your planting terrain is contaminant-free so that harvested goods are safe. Send samples to laboratory to check soil health.
- Monitor the health of your plants. Pay attention to how your plants react to weather changes as well as insects, heat, and water changes.
- Monitor your water. If your plants are drying out, you might want to increase water diet. Consider automating irrigation with a time release pump to ensure delivery of water per schedule.
- Watch out for pests. Minimize use of pesticides by enlisting Integrated Pest Management (IPM) to manage pests. IPM is a system for managing pest problems using a range of safe and least-toxic methods. This system is a sustainable alternative to using traditional toxic-laden pesticides and agrochemicals commonly introduced to Puerto Rico since the 1940's and onward.
- Protect your garden from atmospheric events. Trim tree branches; store any tool, equipment or machinery; and pick up any debris that can affect the garden.
- Remove climbing plants from the fences and secure any structure that could be affected by strong winds. Include crops that can survive hurricane winds, like root vegetables.
- Collect your harvest before the storm and check that you are covered during and immediately after the event.

STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 4 - BUILD YOUR GARDEN

A. IDENTIFY YOUR PLOT AND POTENTIAL LAYOUT

If Planting directly in the soil:

- Although we are often limited in terms of available plots for gardening, seek to design your layout such that you maximize south-facing exposure such that your plants can benefit from maximum sunshine in the mornings.
- Elements that could limit sunshine exposure include: large trees, walls, and surrounding buildings.
- Parts of your plot that are exposed to shadows are great for seed starting (seedlings) and shade plants.
- As is described in the next sections, the type of soil in which you will be planting should be considered when determining if a slope is beneficial for your garden. If your plot tends to have high amounts of clay, you may benefit from locating your plot along a slight slope such that drainage is facilitated.
- You may create a narrow (1”W by 10”L) ditch on the highest point of your garden to control the speed of the water that runs down the profile of your plot.
- Although less relevant in urban settings, make sure there is a barrier between your garden plot and any large animals such as dogs, cats, rats, or chickens. These can physically alter your garden and/or introduce unwanted pathogens.

Planting in containers, outside:

- Your criteria for locating planting containers outside should be very similar to the ones outlined for in-soil planting.
- Containers will give you additional benefits: Your garden can be spaced out to maximize sun availability, you will have better control of your soil health (moisture, and nutrient mobility), it will be easier to control for pests as these will be localized (if they occur).
- Containers, however, will limit a plant’s growth extent. Managing drainage properly will also vary based on container type and may require some initial trial-and-error.

Vertical Gardens:

- If building in a greenhouse consider ventilation and circulation of air, siting of greenhouse to take advantage of full sun so you don’t need to provide lighting.
- Ensure the greenhouse can withstand strong winds, fires and flooding like any other structure.
- Manage the pest problems through IPM to reduce chemical pollutants from entering the air inside the greenhouse

B. SCHEDULE OF PLANTS: ANNUAL OR PERENNIAL PLANTS

- Annuals are plants that have just one growing cycle. Perennials grow and multiply for three-plus years. The avid gardener should prepare to create a garden that is in continual bloom by the using both annuals and perennials. If growing food, emphasis should be placed on repeat plantings. Tomatoes plantings on a continuous basis, for example.
- A tactic linked to biodiversity, is to design garden with crops that have differing harvest times. By staggering the times throughout the year when crops ripen, you not only ensure a supply of fruit and vegetables for your kitchen for longer than a single growing season, you avoid exposure to an insect population bloom decimating your entire harvest.

TIP: ENCOURAGE BIO-DIVERSITY!

- Annuals are plants that have just one growing cycle. Perennials grow and multiply for three or more years. The avid gardener should prepare to create a garden that is in continual bloom by using both annuals and perennials. If growing food, focus on repeat plantings (for example, tomato plantings on a continuous basis).
- Another tactic, which is also linked to biodiversity, is to design a garden with crops that have differing harvest times. By staggering the times throughout the year when crops ripen, you not only ensure a supply of fruit and vegetables for longer than a single growing season, but also avoid exposure to an insect population boom that could decimate your entire harvest.
- Hydroponics or greenhouse grown plants offer more variety regarding scheduling plants throughout the year.

COMMON PROBLEMS WITH PLANTS

Yellowing:
Lack of light or the pot is too small

Root Rot:
Too much water

Spindly Stems:
Lack of light or fertilizer

Leaves falling:
Could be due to any of the following: the pot is too small, lack of humidity, too much fertilizer, excessive heat, excessive water, lack of water or insufficient light.

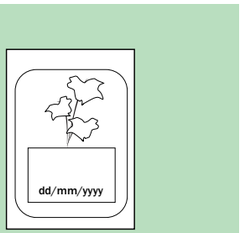
STRATEGY

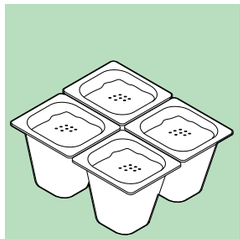
03 PLANT AN EDIBLE GARDEN

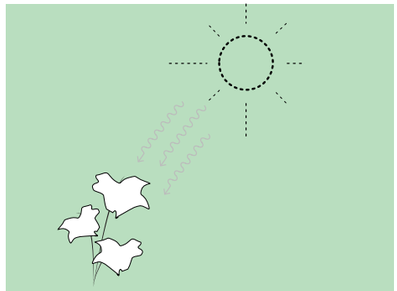
Soil-Based Systems

STEP 4 - BUILD YOUR GARDEN

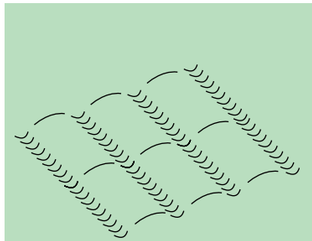
C. BEGIN THE PLANTING PROCESS

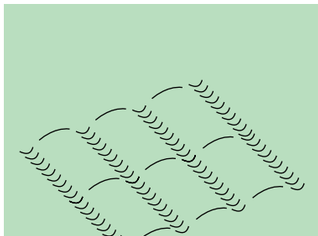


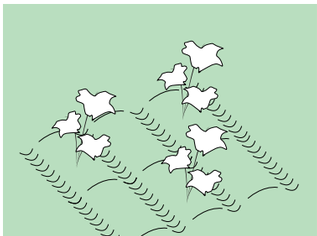




STEP	1	2	3
DESCRIPTION	■ Buy seeds at a store or at a seed sharing community. Store in a dry and dark place. ■ You can begin your garden by sprouting seeds or by getting plant seedlings or cuttings, from a local nursery or neighbor, that have already grown to 6 inches or more.	■ Plant seeds in a shallow, perforated planter, also known as a seed starter.	■ Choose your planting location according to plant requirements. Pay attention to the: ■ Type of soil ■ Available sunlight or shade ■ Identify closest source of water
TIP	■ Track the date the seeds were planted. ■ Purchase heirloom seeds: these are passed down from generation to generation and are not genetically modified. A good place to buy them is Seed Savers Exchange. For more information, visit www.seedsavers.org/ ■ Prepare the soil, especially if its sandy or loamy: Sandy loam leaks organic material and improves with organic mulch and compost that can be prepared on site.	■ Do not plant your seeds in too deep! A good rule of thumb is to place them less deep than their own width. ■ An egg carton can double as a seed starter planter.	■ You will need about 6 to 9 inches deep of good quality soil for best results. ■ Although you are often limited in terms of available plots for gardening, design your layout in such a way that you maximize south-facing exposure so that your plants benefit from maximum sunshine in the mornings. ■ Elements that could limit sunshine exposure include large trees, walls, and surrounding buildings. ■ The parts of your plot that are exposed to shadows are great for seedlings and shade plants. ■ Lay out the garden toward the sun for maximum light. Avoid laying out the garden in depressions where water may accumulate, hillsides subject to a lot of water runoff, and where trees, shrubs and buildings would shade site. ■ Site your garden in flat land if possible. If not flat, then lay it out in terrace land to create flat surfacing.







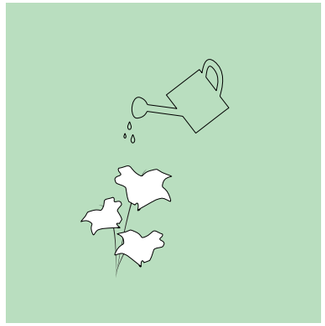
STEP	4	5	6
DESCRIPTION	■ Know your soil and prepare it: – Remove all weeds – Till to oxygenate the soil.	■ Prepare your soil with nutrients ■ Add organic nutrients if necessary.	■ Once they reach a height of 6-8 inches, transplant your seedlings from the seed starter to the site.
TIP	■ Plant directly into your soil if it is dark and has good drainage. ■ You will need to determine type of soil in which you will be planting to determine drainage capacity of soil. If your plot has high amounts of clay, you may benefit from relocating your plot along a slight slope to facilitate draining. ■ Create a narrow (1” W by 10” L) ditch on the highest point of your garden to control the speed of the water that runs down your plot. ■ Although less relevant in urban settings, check if there is a barrier between your garden plot and any large animals such as dogs, cats, rats, or chickens. These can physically alter your garden and/or introduce unwanted pathogens.	■ If soil is too loamy, water and nutrients will wash out of the soil. Keep soil healthy for nutrient retention. ■ If it the soil is too dry, you may need to add nutrients to it by mixing it with potting mix and peat moss.	■ Move roots carefully and protect them from sun or damage with a cloth. ■ Place gently in a dug-out hole, and pat and water with care so as not to overwater.

STRATEGY

03 PLANT AN EDIBLE GARDEN

STEP 4 - BUILD YOUR GARDEN

Soil-Based Systems



STEP	7	8	9
DESCRIPTION	■ Water plants according to its species' needs.	■ Continue to add nutrients to soil as needed.	■ Till between crop cycles to oxygenate soil
TIP	■ Healthy plants are more resilient to pests. Check that the soil is healthy, that its fertility is maintained, and that soil temperature is kept relatively stable with mulch. Preserve organic matter in the soil to hold soil moisture and diminish water stress in plants. ■ Watch out for any plagues or pests. Increase your plants immunity by maintaining healthy balance of water, liight and well aerated soil which supports the variety of bacteria, protozoa, fungi and algae that supports the root zone around your plant and your plants immunity to disease.	■ You can add a natural fertilizer, like homemade compost, up to once a month. ■ Keep track of the rain so you do not saturate the plants with water.	■ Keep track of the rain so you do not saturate the plants with water.

C. BEGIN THE PLANTING PROCESS

Hydroponic Gardening

- a. Hydroponics is a method of growing plants without soil by using mineral nutrient solutions in a water solvent.
- b. The nutrients used in hydroponic systems can come from an array of different sources; these can include, but are not limited to, byproduct from fish waste, duck manure, or purchased chemical fertilizers.
- c. Growing medium can be a range of substrates. Each substrate has pros and cons ranging from cost to weight. Most common types are:
  - Rockwool (spun wool substrate)
  - Lava rock
  - Clay pebbles
  - Coco coir (made from coconut husks)
  - Peat moss
- d. For all techniques, hydroponic reservoirs are built of plastic, but other materials have been used, including concrete, glass, metal, vegetable solids, and wood. Containers should exclude light to prevent algae and fungal growth in the nutrient solution.
- e. With hydroponic farming, there are two types of watering systems: continuous flow or static. In continuous flow systems, water needs continuous circulation through the system and this requires a pump; nutrients are delivered to the system in a continuous method. In a static system, water does not circulate continuously and nutrients are delivered to the system.

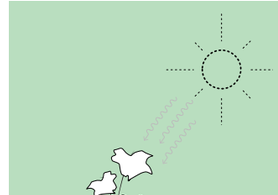
STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 4 - BUILD YOUR GARDEN

TYPES OF HYDRO SYSTEMS

PLANT NAME	NUTRIENT FILM TECHNIQUE (NFT)	AQUAPONICS	WICKING
			
HOW IT GROWS	A solution with nutrients is recirculated through channels where the plants grow. The roots are not completely submerged in water.	It works as a combination of raising both fish and vege-tables or aquaculture and hydroponics.	Nutrients and water are led to the plant by capillary action from a container with the mixture.

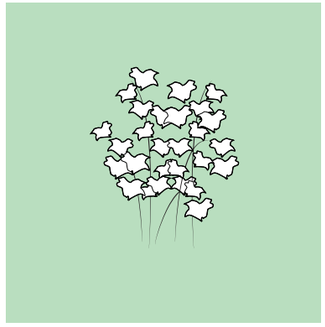
STEP	1	2	3
			
DESCRIPTION	■ Identify your budget for equipment as well as greenhouse assembly.	■ Identify site location and whether you will be growing indoors or outdoors.	■ Identify plants (and if you also want to support aquaponics system with fish)
TIP	■ Consider cutting costs by fabricating your own containers and channels for the growing systems.	■ Consider a site with the following resources: ■ Access to electricity for lighting, fans or pumps. ■ Access to full sunlight (and if there is not enough sunlight, lighting must be supplemented) ■ Access to full ventilation for stem and plant growth. ■ Access to potable water, which can come from a well or domestic plumbing. ■ Access to drainage when discharging tanks. This can be a slope or site design that can utilize and manage water. ■ When growing indoors, you will need to supplement natural light with artificial light. ■ If you are building a greenhouse, consider air circulation and the greenhouse site to take advantage of full sun availability and remove the need to provide lighting. ■ Verify that the greenhouse can withstand strong winds, fires and flooding just like you would with any other structure.	■ Consider vine crops, like tomatoes, that can be vertically grown in areas of smaller size. ■ Consider fast growing or “bolting” herbs that can be quickly cycled through the system as well as highly valuable herbs for bartering, taking to market or that are well-preserved.

STRATEGY 03

PLANT AN EDIBLE GARDEN

STEP 4 - BUILD YOUR GARDEN

Hydroponic Gardening



STEP 4

DESCRIPTION

- Choose growing substrate

TIP

- Always allow the substrate to drain in between watering times since this invites new and oxygen-rich air inside. Confirm that whichever hydroponic substrate you choose does not contain too much salt or elements that are harmful to plants and/or people.
- Rockwool (spun wool substrate)
- Lava rock
- Clay pebbles
- Coco coir (made from coconut husks)
- Peat moss

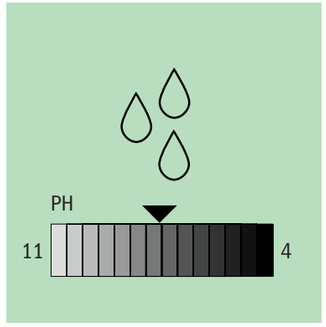
STEP 5

DESCRIPTION

- Types of Nutrients

TIP

- Growers can buy a 'pre-mixed' nutrient solution which simply needs to be diluted (for liquid concentrates) or dissolved in water before use. There are problems that can, and often do, arise with deficiencies of one or more of the nutrient elements. Common problems in-clude: (1) low nutrient strength, resulting in insufficient nutrients for the plants in general; and (2) The nutrient formula you are using may not be completely bal-anced, and one (or more of the elements) may be defi-cient. If growing fish, you will need to ensure they have enough food available, in addition to plant roots.



STEP 6

DESCRIPTION

- Water and pH level maintenance

TIP

- Ensure that there is a source of potable water on site.
- Ensuring correct pH levels in the water of the plants keeps them healthy in a hydroponic gar-den because it affects how plants “uptake nu-trients”. The pH level is a measure of the acid / alkaline balance of the water in your hydropon-ic system, also known as the nutrient solution. An incorrect pH level will reduce or completely lock out the amount of nutrients a plant can ab-sorb and eventually destroy it. A pH of 7 is neu-tral and most plants prefer a neutral pH, alt-hough some plants do better within a certain pH range.

STEP MAINTENANCE

TIP

- As you add nutrients to your garden, you may notice an increase or decrease in the pH level of the soil or water in your garden.

*If you are growing fish, their waste product will in-crease pH level. Therefore, monitor the pH level to en-sure fish survival.

HARVEST!

- Utilize integrated pest management (IPM) for all crops. This is a method used to manage pests without pesticides or harmful chemicals (See Strategy 14 Manage Pests).
- Purchase nutrients from organic sources.

THREE USEFUL HOME REMEDIES FROM YOUR GARDEN

Jarabe or “Cough Syrup”

- Crystal from two aloe vera stalks/leaves
- 1/2 raw yellow/white onion
- 2/3 Cup of lemon juice
- Honey [choose unfiltered for maximum benefit]

Blend all of these ingredients together and let mixture rest until foam that forms on the surface is gone. Drink before meals and before bed. Yields enough for 1 adult, 4 doses [1 day].

Hand Sanitizer

- ½ part “alcoholado” infused with “Malagueta”
- to do this, take 1 bottle of “alcoholado”, empty ¼ part and fill up with malagueta to the brim. Leave to infuse at a cool, dry place and use whenever needed.
- ½ part water

Put in a spray bottle and use as a sanitizer for your body and around the house.

Juices/Teas to alleviate chikungunya, dengue and zika virus symptoms

[anti-inflammatory properties]

- Blend 1 papaya tree leaf [without central vein] with 4 to 6 ounces of water. Drink 2 ounces at a time, at least 4 times a day until symptoms recede.
- Freshly pressed orange juice fortified with aloe vera and honey. Drink liberally.
- Green mango tea made by boiling peel and flesh together with cinnamon bark and West indian bay tree seeds. Drink at least 4 times a day until symptoms recede.

ORGANIC SEEDS/ECOLOGICAL

- Place: Desde Mi Huerto, Department of Food (Trastalleres), Freshmart (Hato Rey)
- Contact: Raúl Rosado raul@desdemihuerto.com

- Place: Estación Experimental de Lajas
- Cost: They make donations to groups. From communities
- Contact: Bryan Brunner 787-889-1530 / 787-372-1269 brbrunner@yahoo.com

COMPOST

- Place: Vivo Recycling
- Cost: $20.00 the meter of compost
- Contact: They have a compost plant in Caguas that serves one meter of compost for $20.00 and you have to pick it up: carr #1, km 32.3 Caguas, 00725
- www.vivopr.com 787-258-1870

Place: University of Puerto Rico, by the ROTC parking

- Cost: Free if you demonstrate it is not for lucrative activity, and they will offer a permit for one year
- Contact: Wilfredo Febres (supervisor) 787-504-6747
- Rafael Hernández (supervisor) 787-447-1748
- Miguel Grajirenes (digger) 787-455-5184
- Georgie Villanueva (bobcat) 787-306-8036

SEMILLAS ORGÁNICAS/ ECOLÓGICAS

- Place: Johnny Seeds (Internet)
- Contact: www.johnnyseeds.com

VERMICOMPOST (WORMS) FOR FORTIFYING SOIL

- Contact:Roberto Morales 787-602-6202
- Myrna Ramos 787-396-0640

HUERTO URBANO

- Place: Jardin Botanico, UPR-Rio Piedras
- Cost: Free
- Contact: This is the facebook page of the garden manager- he is a great resource to the community and welcomes anyone who wants to learn hands-on. Trained agronomist: https://www.facebook.com

AGRICULTURE EXTENSION SERVICE

- Place: Various: San Juan, Mayaguez, Aguadilla
- Cost: Free
- Contact: https://www.facebook.com/pages/Servicio-De-Extension-Agricola-UPR/571551529678835

LA JAQUITA BAYA / COMEDERÍA

Interviewee: Xavier Pacheco; Jaquita Baya, Miramar

Description: Puerto Rican chef Xavier Pacheco announced the closing of the Jaquita Baya Restaurant in Miramar, after seven years of showcasing the local cuisine with his own brand of creative cooking based on the farm-to-table approach. This happens as a direct result of the challenges brought by the impact of Hurricane Maria to the current economic situation. Jaquita Baya closed its doors to the public during this difficult period. However, in the months that followed Maria, Pacheco enabled the space to help his team of workers.

INTERVIEW

In the aftermath of hurricane Maria, I witnessed the needs of the people around me and decided to take action. The immediate response was to adjust to the new reality we faced; I had to learn how to navigate the situation as a businessman (especially how to avoid capitalizing on it), and determine how we could do our part to help the people around us. Another response that was expected from our sector was to provide food at a low cost.

In the future, I think I would hit the streets more and establish stronger partnerships to help me to take food to other places, while also sustaining my business and helping my employees, who are my immediate community. From this situation, we definitely learned that we need to look for ways in which local restaurants can provide support during the recovery process while simultaneously maintaining their operations. In this way, we help others, be it by providing food or by becoming employers for those who, for one reason or another, lost their jobs. So we are looking for alternatives as we work towards this goal.

Lessons Learned

As a result of Hurricane Maria, there were experiences that demonstrate effective practices of community wisdom and civic leadership.

CENTRO DE ADIESTRAMIENTO PARA PERSONAS CON IMPEDIMENTOS (CAPI, INC.), AIBONITO

Description: CAPI is a non-profit organization located in the municipality of Aibonito. Its mission is to promote and provide employment opportunities through different modalities to help people with significant disabilities.

Vision and Mission: The Training Center for People with Impaired, Inc. provides services to support the development of people with disabilities to improve the quality of life of people with disabilities in Aibonito and surrounding towns. Services include employment, life management and business development employment placement for youth with disabilities, visual services and home care for the elderly, as well as training in hydroponic agricultural systems and transition services for students from 14 to 21 years old, among others.