



BGCI Technical Review

The role of botanic gardens in practising and promoting environmental sustainability



**BOTANIC
GARDENS**
CONSERVATION
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Association





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The role of botanic gardens in practising
and promoting environmental sustainability

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Tree planting (Worcester Tree Initiative)



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Waste at Kew (Paul Smith)



INTRODUCTION

University of Warsaw Botanic Garden

In September 2018, BGCI's 11th International Congress on Education in Botanic Gardens, which was held in Warsaw, focused on increasing the impact of education and public engagement in botanic gardens. Attracting more than 500 million visitors a year, botanic gardens have the opportunity to interact with and influence a large section of society. In this context, environmental sustainability emerged as an area in which botanic gardens could have a significant impact.

There was also the sense that we are currently not doing enough about sustainability, particularly in influencing behavioural change amongst visitors and in this way achieving real impact. The delegates felt that it was appropriate that we show leadership as the world struggles to slow and reverse environmental degradation, and mitigate and adapt to the effects of climate change. This is appropriate because environmental sustainability is consistent with our values, because our visitors are high consumers and influential, and because we have technical knowledge and skills that could be applied to solving problems and providing solutions for a more sustainable planet. In addition, of course, many of BGCI's member gardens are already changing their practices and interactions with visitors related to water saving, food, energy, carbon, recycling and so on.

This Technical Review, commissioned by BGCI's International Advisory Council, is a first step towards sharing some of the best practice in our sector (and outside it), then mainstreaming and scaling up such approaches. As with our previous Technical

Reviews, it is based on an extensive online survey and literature search. One thing that we expected, and is borne out by the results of our research, is that while many gardens are engaged in changing or modifying their business practices, fewer gardens are challenging or trying to influence their visitors. When it comes to achieving real impact, this is where the big wins are, and this is the area of our work that we need to scale up significantly.

This Review is arranged in such a way that it differentiates between the things we are doing ourselves and the things we are doing to influence others, and our intention is to focus future efforts on the latter. BGCI will be launching a 'Sustainability Challenge' later this year that seeks to create a community of best practice aimed at influencing visitor behaviour change and measuring the impacts of that behavioural change in water saving, energy consumption, responsible sourcing, carbon emissions and other measures. We believe that by working together, we can precipitate behavioural change amongst tens of millions of people over the next few years. Undoubtedly, this will mean that we have to deliver some uncomfortable messages (something we have not been good at in the past) but, provided these are accompanied by information, tools and approaches that empower people to make change, and we lead by example in these areas, then those messages should not be too unpalatable.

We hope that you will take inspiration from what our community is already doing, as set out in the case studies presented in this Review, and join us in changing the world.

ENVIRONMENTAL SCHEMES AND STANDARDS

There is a wide range of environmental standards, schemes and toolkits that can support botanic gardens and their sustainability efforts. Some of the key standards and schemes are outlined below.

BGCI Botanic Garden Accreditation

The BGCI Botanic Garden Accreditation is aimed at botanical institutions wishing to establish their credentials as botanic gardens. The BGCI Conservation Practitioner Accreditation recognises botanic gardens with a conservation-oriented approach. Advanced Conservation Practitioner Accreditation recognises botanic gardens with a focus on conservation actions that support local, national or global conservation goals. Organisations applying for accreditation will be assessed on criteria encompassing leadership, collections management, horticulture, public education, community/cultural activities, conservation actions, scientific research, staff, networking and sustainability. Sustainability is a key target within the scheme and each BGCI Accreditation requires applicants to implement a number of in-house sustainability activities or efforts to change visitor behaviour with regards to sustainability.

Building Research Establishment Environmental Assessment (BREEAM)

BREEAM is the world's longest established method of assessing, rating, and certifying the sustainability of buildings. Its categories evaluate energy and water use, health and wellbeing, pollution, transport, materials, waste, ecology and management processes.

The Climate Toolkit

The Climate Toolkit provides an opportunity for museums, gardens and zoos to share, mentor, learn and inspire one another to aggressively address climate change in their operations and programs. The toolkit serves as a milestone tracker, information repository and contact network, with a special focus on initiatives that arise from an institution's relationship to the specific needs faced by the region it serves.

ISO 14001 Environmental Management Standard (EMS)

ISO 14001 is perhaps the best-known environmental standard. This internationally recognised system requires, as a minimum, legal compliance with relevant environmental legislation and year-on-year continual improvement. This is demonstrated by means of an annual, external audit of the EMS and its implementation. Although there is an annual cost associated with ISO 14001 compliance, adherence to the system allows for comprehensive delivery of environmental sustainability and usually delivers significantly more savings than costs. The annual external audit, combined with the discipline required to maintain the standard, helps to maintain focus and momentum within an organisation.

Leadership in Energy and Environmental Design

LEED (Leadership in Energy and Environmental Design) is the most widely used green building rating system in the world. Available for virtually all building types, LEED provides a framework for healthy, highly efficient, and cost-saving green buildings.

Living Building Challenge

This is an international building certification programme, advocacy tool and philosophy that defines the most advanced measure of sustainability in the built environment possible today and acts to rapidly diminish the gap between current limits and the end-game positive solutions we seek. It is the built environment's most rigorous performance standard. It calls for the creation of building projects at all scales that operate as cleanly, beautifully and efficiently as nature's architecture. To be certified under the Challenge, projects must meet a series of ambitious performance requirements including net-zero energy and water over a minimum of 12 months of continuous occupancy. The Challenge is comprised of seven performance categories called Petals: Place, Water, Energy, Health and Happiness, Materials, Equity and Beauty.

The Association's Public Gardens Sustainability Index

The Public Gardens Sustainability Index is a suite of Attributes intended to inspire gardens to advance their own garden sustainability programmes and operations to further the mission of their institution while connecting to local, national, and global sustainability efforts. The Index helps drive public garden professionals to assess, develop, and adopt practices in hopes of meeting goals and strategies set forth in the United Nations Sustainable Development Goals. The Index also shares examples of gardens that meet standards of excellence on environmental, social, and economic topics, recognizing them for their achievements.

Sustainable SITES Initiative

This is the most comprehensive system for creating sustainable and resilient land development projects. Land is a crucial component of the built environment and can be planned, designed, developed and maintained to protect and enhance the benefits we derive from healthy functioning landscapes. SITES certification is for development projects located on sites with or without buildings — ranging from national parks to corporate campuses, streetscapes to homes, and more.

The Planet Mark

The Planet Mark recognises outstanding achievements, encourages action, and builds an empowered community of like-minded individuals. The programme was developed in 2012, and aimed to create a truly effective people-driven sustainability programme for any organisation of any size, any sector, any place in the world. The Programme has since developed into an internationally-recognised and trusted sustainability certification that has helped 400 organisations reduce their carbon year-on-year.

WELL Building Standard

This international standard is based on creating buildings and building practices that are not only better for the planet, but also for people. It is the first standard of its kind that focuses solely on the health and wellness of building occupants. It identifies 100 performance metrics, design strategies, and policies related to air, water, nourishment, light, fitness, comfort and mind, that can be implemented by the owners, designers, engineers, contractors, users and operators of a building. The standard is based on a thorough review of the existing research on the effects of spaces on individuals and has been advanced through a thorough scientific and technical review. In order to achieve the certification requirements, the space must undergo a process that includes an on-site assessment and performance testing by a third party.

METHODS

This Review has been compiled using the results of two sustainability surveys of botanic gardens (and associated institutions) that were conducted in late 2019. The surveys were a joint effort between BGCI and Phipps Conservatory and Botanical Gardens.

The first survey looked at the sustainable practices of the organisation or institution. The second focused on ways in which gardens educate and challenge their visitors to consider their own sustainable behaviour. Subjects covered in the surveys included water saving, energy consumption, renewable energy, sustainable building construction, carbon offsetting, waste and recycling, composting and sustainable food.

In total, 99 institutions responded to our survey on in-house sustainable practices representing 36 countries across our global network.

In addition, 61 institutions representing 26 countries responded to our survey on ways in which gardens educate and challenge their visitors to consider their own sustainable behaviour.

When considering the data summarised in this review, the following should be noted:

- Not all institutions who took part in the surveys, completed both sustainability surveys;
- Not all institutions completed all questions within each survey;
- For some questions (e.g. How are you reducing your water loss?) multiple answers could be selected.

In addition, this Review includes a series of best practice case studies. Some of these were developed through information provided in the surveys. Other case studies have been collected through online website searches, direct contact with individual gardens as well as case studies provided by other organisations/resources such as the American Public Gardens Association's *Sustainability Index*, Phipps Conservatory and Botanical Garden's *Climate Toolkit* and BGCI's manual, *From Idea to Realisation: BGCI's manual on planning, developing and managing botanic gardens*.

The results of these surveys and additional data collected are therefore only a snapshot of the botanic garden sector and our efforts as a community to carry out sustainability programmes, practices and outreach.

This review is split into individual chapters, which align with the relevant sections of the sustainability surveys:

Sustainable Development Goals

Water management

Energy consumption

Carbon offsetting

Waste, recycling and composting

Sustainable food

Each section uses a standard format:

Introduction

Results of the Sustainable practices survey
(including case studies)

Sustainable practices

The in-house practices of an organisation to meet sustainability targets and address climate change (e.g. green buildings, renewable energy supply, sustainable staff travel)

Results of the Encouraging visitor sustainable behaviour survey (including case studies)

Encouraging sustainable behaviour in visitors

The ways in which organisations educate and challenge their visitors to consider their own sustainable behaviour (e.g. reducing food waste, switching to renewable energy, sustainable individual travel)

SUSTAINABLE DEVELOPMENT GOALS



On 1 January 2016, the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development — adopted by world leaders in September 2015 at an historic UN Summit — officially came into force.

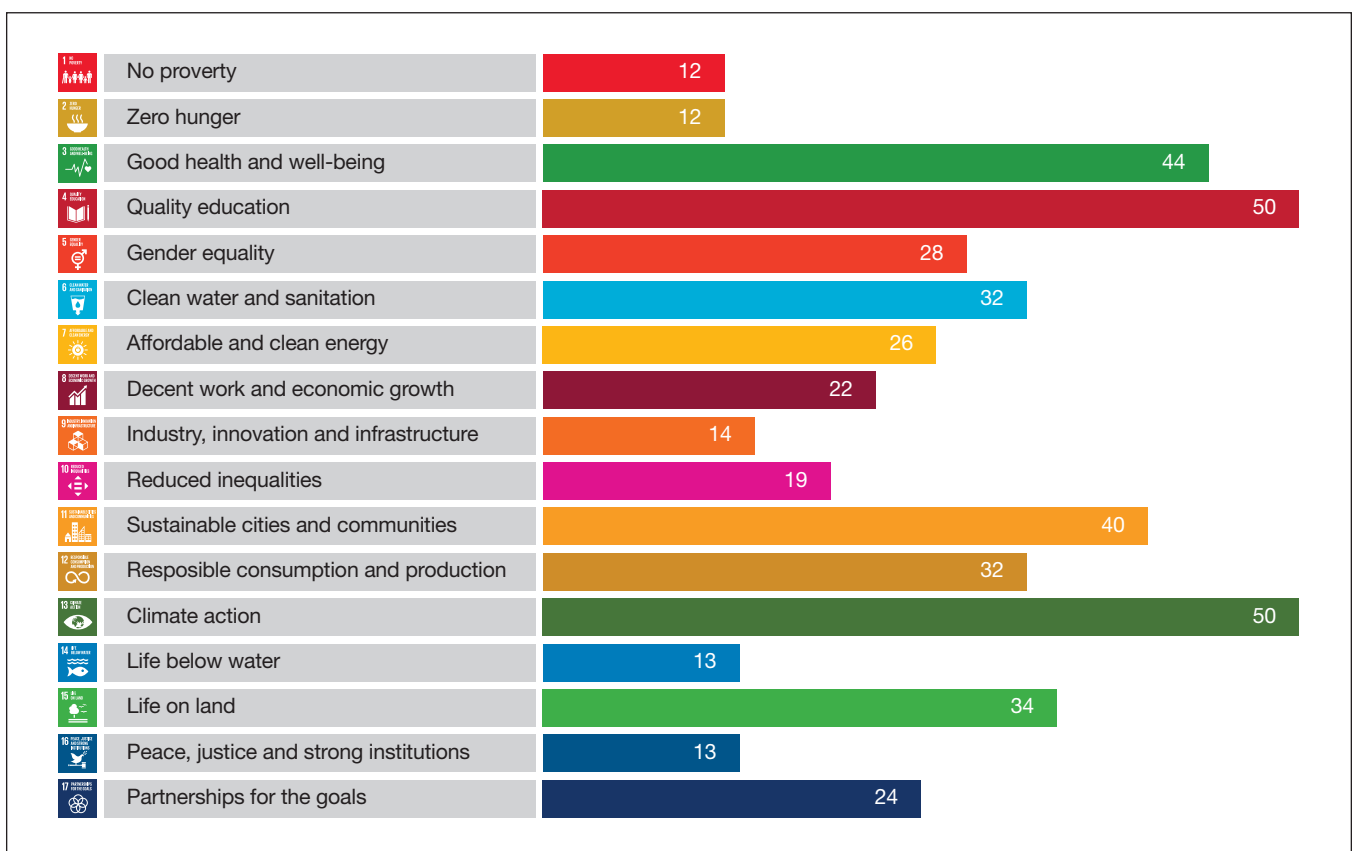
The SDGs, also known as Global Goals, build on the success of the Millennium Development Goals (MDGs) and are unique in that they call for action by all countries, poor, rich and middle-income to

promote prosperity while protecting the planet. They recognise that ending poverty must go hand-in-hand with strategies that build economic growth and address a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection.

In 2017, Sharrock & Wyse Jackson published a paper *Plant Conservation and the Sustainable Development Goals* that reviewed and highlighted the contribution that plant conservation can make to achieve the SDGs. The work of botanic gardens as centres of plant conservation and education are therefore strongly aligned with many of the SDGs.

In our survey, 65% of respondents have determined that one or more of the SDGs are a priority for their garden. The most commonly addressed SDGs are SDG4: Quality Education and SDG 13: Climate action. In addition 20% of respondents reported that the SDGs are referenced in a strategic or master plan for their garden.

Finally, 32% of organisations described future goals for expanding sustainability efforts at their gardens.



Sustainable development goals worked toward by gardens (99 survey respondents)

WATER MANAGEMENT

Introduction

As organisations with important plant collections, access to sufficient water is essential for healthy, well-maintained displays as well as day-to-day organisational needs. However, this also means that water consumption rates can be high. This is a challenge for all gardens but is especially important for gardens in areas that experience droughts and have a limited water supply. There is therefore a need to implement more efficient water use systems, drought tolerant planting (where relevant) and ensure that where possible water use is reduced and recycled.

For visitors, botanic gardens can have a role to play in promoting simple water saving actions such as turning off taps, using water saving devices in showers and toilets, and learning about the most suitable species for local garden planting.

Links to



In-house practices

In our in-house sustainable practices survey, 81% of respondents stated that they are working to reduce their water use. The most common method used to reduce water consumption was collecting and using rainwater in water barrels and reservoirs.

A 0-20% reduction in water use was reported by 59% of respondents. Of the four gardens that reported an 81-99% water use reduction, three collected and used rainwater in barrels and reservoirs, and one used a high efficiency watering system throughout their garden.



Shelby White and Leon Levy Water Garden at Brooklyn Botanic Garden (Lexi Van Valkenburgh)

Ways in which gardens are reducing water use

- Rainwater collection and re-use
- Water monitors/sensors
- Efficient toilets/water aerators
- Water/storm water treatment systems
- Automated drought mitigation
- Efficient irrigation systems
- Drought tolerant planting
- Gator bags on plantings
- Mulching
- Rain gardens
- Green roofs (excess rainwater collection)
- Treating and reusing sanitary water (blackwater)

CASE STUDY

Brooklyn Botanic Garden – Water conservation project, USA

The Water Conservation Project is a multifaceted, sustainable approach to outdoor water management at Brooklyn Botanic Garden (BBG) – the first project of its scale and complexity in North America and a model for reducing use of freshwater and lessening overflow into the city's combined sewer system. The first phase of the project, the Shelby White and Leon Levy Water Garden, opened in September 2016, and the project was completed in April 2019.

This innovative new infrastructure allows the garden to filter and recirculate captured rainwater collected throughout a significant portion of the grounds and channel it through the Water Garden pond, the Japanese Hill-and-Pond Garden pond, and catchment sites along the brook system. The project will reduce BBG's outdoor freshwater consumption in the brook and pond system by almost 96% from 22 million gallons to less than a million gallons per year.

The Water Conservation Project also plays a major role in detaining runoff. Through integrating cloud computing with adaptive monitoring and control technology, the garden can monitor weather and discharge water from the detention pond prior to storm events. This reduces the annual wet-weather burden on the storm-water system from 8 million gallons to only 2.5 million gallons.

Visit: https://www.bbg.org/collections/gardens/water_conservation_project

CASE STUDY

Auckland Botanic Gardens – Sustainable rainwater management, New Zealand

Typically, rainwater is collected by drains and piped away to be released untreated into streams, waterways and the sea. Auckland Botanic Gardens now incorporates sustainable rainwater management wherever possible. Rainwater is collected from the roofs of the visitor centre and structures in the children's garden. This is stored in tanks and used for other needs such as running a water feature, flushing toilets and demonstrating irrigation. Living roofs act as a trap for rainwater, decreasing the rainwater volume flowing off it by up to 65% and slowing the water speed down to a trickle.

A large number of New Zealand's native species are planted around the lakes and along streams in the gardens, which act to clean the water, slow rainwater flow and reduce the risk of bank erosion.

Rainwater pits treat large volumes of rainwater from roads and car parks and the use of an infiltration trench has provided rainwater treatment. Finally, the wetland naturally collects surface run-off and ground seepage from the surrounding lawns and gardens. Wetlands effectively treat the collected rainwater, trapping sediment and other contaminants and correcting the water's pH and temperature levels. Over long periods of time they also help store carbon.

Visit: <http://www.aucklandbotanicgardens.co.nz/science/sustainability/sustainable-water-management>



Riparian plantings at Auckland Botanic Gardens (Jack Hobbs)

CASE STUDY

Royal Botanic Gardens Victoria, Melbourne – Working wetlands, Australia

Water conservation is the top priority for this 38-hectare (94 acre) garden. With climate change models predicting Melbourne to become much hotter and drier, executives at the garden are building a water-use plan to match the 2090 climate projections for the area. Efforts toward water conservation have already started with the garden's Working Wetlands project. The Working Wetlands are man-made wetlands designed as floating islands that are small enough to fit in a large pond or small lake. These mobile wetlands can then be moved by motorboat to areas in need of remediation, or lifted out and transported to another body of water.

The Working Wetlands are part of the garden's efforts to use stormwater runoff from the city to irrigate their collections. When it rains, stormwater throughout the city is diverted to the streams and ponds at RBG Melbourne, where the wetlands remediate the water. Once clean, the water can then be pumped through the garden's irrigation system. In addition to their environmental benefits, the Working Wetlands also have significant economic value. Reusing stormwater decreases the garden's dependence on buying city water for irrigation, lowering costs for the garden as well as reducing demand on the city's supply of drinkable water.

Designed to be a beautiful addition to the garden's waterways, the Working Wetlands are an environmentally and economically responsible way to help RBG Melbourne adapt to the climate risk in its future.

Garden profile provided by the Sustainability Index

Visit: <https://www.publicgardens.org/sustainability-index/attributes/royal-botanic-garden-melbourne-case-study>

CASE STUDY

Naples Botanical Garden – Water quality, USA

Florida's southwestern coast suffers from regular outbreaks of red tide and blue-green algae, including a months-long infestation of both in 2018 that devastated the region's tourism-based economy. Scientists believe nitrogen- and phosphorus-laden stormwater runoff contributed to the blooms' growth and severity.

This 10-year-old garden was designed around a five-stage, nature-based stormwater treatment system, engineered to slow runoff and allow plants to capture nutrients before they flow into its lakes, one of which is used for irrigation. Eventually, water from the garden ends up in nearby Naples Bay, making treatment all the more critical. As part of its water quality commitment, the garden grows and displays regionally appropriate plants that thrive in Southwest Florida's heat, humidity, intermittent dry and wet seasons and sandy soil. By doing so, the garden minimizes fertilizer and irrigation needs.

Since Southwest Florida's 2018 algae infestation, the garden has intensified public outreach, education and consultation around stormwater management and landscaping best practices. The garden staff have teamed up with Collier County Pollution Control on stormwater education classes to teach property owners about best management practices. The garden renewed its commitment to the Greenscape Alliance, a landscaper training collaborative aiming to reduce fertilizer and irrigation use. It has hosted the state's new chief science officer, Department of Environmental Protection representatives, and the Governor's Blue-Green Algae Task Force, encouraging them to adopt nature-based solutions to the state's nutrient pollution problem. Finally, the garden is working with Collier County to design a demonstration landscape at a new community sports and events complex.

Garden profile provided by the Sustainability Index

Visit: <https://www.publicgardens.org/sustainability-index/attributes/naples-botanical-garden-1>



Water quality (Naples Botanical Garden)

Encouraging sustainable behaviour in visitors

In the sustainable behaviour change survey, 44% of respondents reported that they provide water saving advice to their visitors, for example by advising on low water usage plants or the role of native plant species. In addition, 5% of respondents reported selling water saving devices to their visitors.

Other ways in which gardens educate their visitors to save water include demonstrating water saving practices, holding customised water management activities, and through posters and exhibitions.

Survey results also showed that 18% of respondents host programmes to educate/challenge community members to save water. Programmes include gardening courses, workshops, seminars and talks.

Ways in which gardens are promoting water use to visitors

- Advice on low water usage plants
- Selling water saving devices (e.g. cistern water displacement bags and rain gauges)
- Public information programmes that promote simple water saving actions

CASE STUDY

Eden Project – Make the Change, UK

Make the Change is an Eden Project initiative to challenge visitors to help fight climate change and biodiversity loss through small actions. This includes a Make the Pledge campaign where individuals can sign up, pledging to do one or more simple sustainable actions. Among the 11 Top Tips there should be something for everyone. Eden's approach is a regenerative one, with focus on optimism and solutions to inspire and empower people to take positive action.

The Make the Change pages include information on a range of subjects such as creating a wildflower meadow, building a compost heap, saving fuel, making an insect home and greening a visit to the garden. The resources also include information on simple water saving actions that individuals can do such as turning off taps, using cistern displacement devices in toilets, installing a water barrel, and installing a water meter.

Visit: <https://www.edenproject.com/make-the-change>



Plants for your Place guided tour (RGBV Cranbourne)

CASE STUDY

Royal Botanic Gardens Victoria - Cranbourne - Plants For Your Place guided tour, Australia

The Plants For Your Place tour highlights which Australian native plants are ideal for planting at home. The tour also follows the garden's story of water in the Australian landscape, explaining the relationships between native plants and water, as they are vital to a successful water friendly garden at home. A volunteer Garden Ambassador hosts the one hour guided walk and engages audiences about the importance and ease of using native plants in home gardens. The guide also introduces basic gardening information, skills and practices such as the use of mulch in the garden, knowing the soil type, pruning, composting and fertilizing.

The tour aims to inform and excite people about Australian plants in their own home garden and aims to show that whether you have a large backyard or a small inner-city courtyard, Australian plants are ideal for all gardening situations and conditions as they are perfectly adapted to the Australian climate. Tour content is regularly reviewed and updated to ensure information is current, accurate, valid, and useful to share with guests.

CASE STUDY

Denver Botanic Gardens – One World One Water Center, USA



The One World One Water (OWOW) Center is a key collaboration between Denver Botanic Gardens and the Metropolitan State University (MSU) Denver and focuses on joint initiatives on water issues. This relationship strengthens both institutions' ability to

impact varied water issues and benefits multiple audiences: MSU Denver students pursuing an interdisciplinary Water Studies degree; the garden's visitors and members; and communities near and far facing a myriad of water issues.

The center has a number of initiatives to encourage people to act more sustainably. This includes water-efficient product testing and demonstrations. The garden partners with entrepreneurs and both government and corporate entities to showcase and test water-efficient innovations. For example, a collaboration with Zero Mass Water (a company working to develop innovative water solutions) incorporates solar-powered atmospheric water harvesting into plant displays to test suitability for irrigation use in areas without reliable fresh water sources.

The center also has an international outreach focus, the garden works with governments, NGOs and other academic institutions to advance cooperative water management.

Visit: <https://www.msudenver.edu/owow/>



Solar-powered atmospheric water harvester demonstrated on campus (Denver Botanic Garden and Zero Mass Water)

ENERGY CONSUMPTION

Introduction

The energy demands of a botanic garden can be quite significant, involving the powering of various buildings, glasshouses, vehicles and machinery. To save money and meet the objectives of the SDGs, consideration should be given to reducing energy consumption, using (and producing) cleaner energy and building greener, more energy efficient buildings.

For visitors, botanic gardens can have a role to play in promoting renewable energy, sustainable building design and raising awareness of simple energy saving actions such as turning off lights and devices when not in use and using energy efficient lighting and heating systems.

Links to



In-house practices

In the in-house sustainable practices survey, 89% of respondents stated that they are working to reduce their energy and fuel consumption.

When asked how much energy and fuel reduction had been completed already, over 50% of those that answered the question reported a 0-20% reduction. Two gardens reported an 81-99% reduction, achieved through a mix of electric vehicles, installing efficient lighting and installing renewable energy systems.

When asked about energy sources, 60% of respondents confirmed that their organisations source up to 20% of their energy from renewable sources, with a small number of organisations (4%) stating that 100% of their energy is renewably sourced.

In addition, 43% of respondents report that they produce some renewable energy on-site (e.g. through solar panels, etc.) with two gardens using renewable energy produced on-site for 100% of their annual energy needs.

When asked about sustainable building construction, 65% of respondents reported that they are constructing all new buildings in a sustainable way. In a further question, 70% of respondents confirmed that they have or plan to renovate a proportion of their buildings to reduce energy consumption. In addition, 12% of respondents confirmed that their site has buildings designed and operated to be zero energy.

Ways in which gardens are reducing their energy consumption

- Sustainable building construction
- Energy efficient LED or other efficient lighting systems
- Electric vehicles
- Renewable energy systems
- Condensing boilers
- Atmospheric boilers
- Heat pumps and programmable thermostats
- Timer controlled heating and lighting
- Radiant floor heat and geothermal energy
- Electric equipment
- Energy audits
- Incorporate passive energy design in new buildings.
- Upgrade to energy efficient equipment and appliances
- Eliminate combustion
- Use of Phase Change materials

CASE STUDY

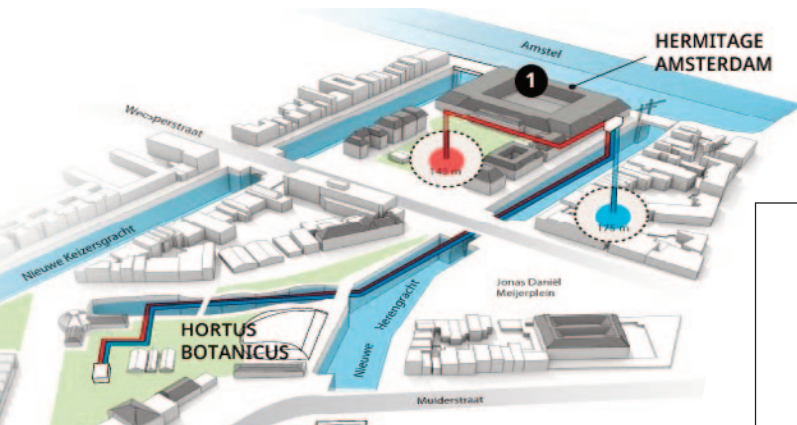
Gardens By The Bay – Cooled conservatories, Singapore

Comprising two glass biomes, the cooled conservatories – Flower Dome and Cloud Forest - replicate the cool-dry climate of the Mediterranean and semi-arid sub-tropical regions, and the cool-moist climate of the Tropical Montane region respectively. They house a diverse collection of plants that are not commonly seen in this part of the world.

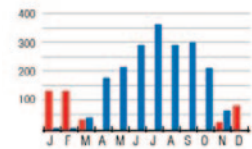
The energy used for powering the chillers of the cooled conservatories is produced by a biomass furnace that burns horticultural waste collected island-wide from parks and gardens in Singapore.

The cooled conservatories are a statement in sustainable engineering and apply a suite of cutting-edge technologies that provide energy-efficient solutions in cooling. The two structures are fitted with a glass material that allows optimal light in but cuts out a substantial amount of heat. They also apply the strategy of cooling only the occupied zones, thus reducing the volume of air to be cooled. The air in the conservatories is first de-humidified by liquid desiccant, which reduces the moisture content of the air. This cuts down the amount of energy required in the cooling process. This suite of technologies can help to reduce energy consumption, compared to conventional cooling technologies.

Visit: <https://www.gardensbythebay.com.sg/en/the-gardens/sustainability-efforts.html>



1 De Hermitage beschikt over een klimaatsysteem ten behoeve van de kunst in het gebouw. Doordat koeling harder nodig is dan verwarming, is een overschot opgebouwd.



CASE STUDY

Hortus Botanicus Amsterdam – Cooling pipes, Netherlands

This is a partnership between Hortus Botanicus Amsterdam and Hermitage Amsterdam. These two renowned locations in Amsterdam are connected through two pipes, 425 meters in length, which exchange hot and cold water.

As an art institution, the Hermitage Amsterdam requires more cooling than heating to safely maintain its artwork. Therefore, its chillers produce a surplus of heat. In order to restore the heat/cold balance in its thermal, underground storage system, the Hermitage Amsterdam had to find a way to lose the heat. Losing the surplus heat into the air by, for instance, a dry cooler, would be the simplest solution. Instead, an attempt was made to find a more sustainable purpose for the buffered surplus heat. While its closest neighbours were unsuitable, the Hermitage took its efforts a bit further down the street and came across the botanical garden of Amsterdam. The Hortus needs a large amount of energy to heat its monumental tropical and subtropical greenhouses. The exchange of heat and cold between the two institutions required the construction of pipelines crossing streets, bridges and even metro lines that lie between the Hermitage and the Hortus Botanicus. To be able to make the surplus heat coming from the Hermitage useful for the greenhouses, a 400 kW electric heat pump was installed in the new 'boiler room' of the Hortus Amsterdam. Eight high efficiency gas boilers were also installed (total of 850 kW) for periods of peak demand.

The Hermitage exports its buffered surplus warm water to the Hortus and, in turn, The Hermitage uses the cold water returning from the Hortus, reducing their electricity consumption for cooling.

Above: Cooling pipes (Hortus Botanicus Amsterdam)

CASE STUDY

National Botanic Garden of Wales - Biomass boiler, UK

The National Botanic Garden of Wales has installed a biomass boiler, which is helping to reduce carbon emissions from the site. An interest-free loan of £100,000 from Carbon Trust Wales in 2011 contributed towards the cost of the new biomass boiler which is rated 500 kW. This has replaced two 1,100 kW oil fired boilers – and a smaller 165 kW biomass boiler.

In common with larger biomass installations, the system has buffer tanks that smooth demand on the boiler enabling it to work more efficiently. The boiler burns woodchip, the majority of which is bought in, but it is supplemented by wood chip produced within the garden. Wood biomass can range from logs to pellets. Wood chip does not have the higher heat value or consistency of pellets, but it is available from a much wider range of suppliers and it does allow the garden to use its own wood 'waste' as fuel. As with all biomass installations, having adequate and proper fuel storage is critical.

About 80% of the heat generated is supplied to the garden's Great Glasshouse. In order to provide the right conditions for the plants the temperature in the Glasshouse is never allowed to fall below 9 degrees Celsius. This is managed by a climate control computer which also controls venting and air movement. Given that the outside temperature in winter can be minus 5 degrees Celsius or lower the heat requirement is significant.

Visit The Carbon Trust for biomass boiler resources:
<https://www.carbontrust.com/resources/biomass-decision-support-tool>



Biomass boiler (National Botanic Garden of Wales)

CASE STUDY

Dawyck Botanic Garden (RBGE) -
Micro hydro-electric scheme, UK

Dawyck House was one of the first houses in Scotland to have its own electricity supply. The early Victorian hydro-electric system used water from the Scrape Burn which runs through the garden. The old Dynamo House was situated in the middle of the garden not far from the main house. By the time Royal Botanic Garden Edinburgh (RBGE) acquired the Garden in 1978 the system had long since been replaced by a supply from the National Grid. The remaining infrastructure had fallen into disrepair and been removed.

With increasing interest in sustainability and the need to reduce carbon emissions, RBGE decided to reintroduce a hydro-electric system using new technology. Depending on the flow of the burn, it can produce enough electricity to meet the garden's demands plus surplus energy which is sold to the grid.

Visit: <https://www.rbge.org.uk/news/articles/dawycks-hydro-electric-scheme-on-full-power/>

Dawyck Botanic Garden

Actively reducing our carbon footprint and conserving our environment

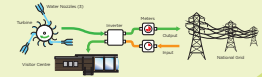
Dawyck Botanic Garden became the first carbon neutral botanic garden in 2014 with the installation of a micro hydro-electric scheme and currently holds a Gold award in Green Tourism for responsible environmental management. Since 2008 Dawyck Botanic Garden has been working to actively further reduce its carbon footprint; below are a few of the measures we have taken to positively manage our activities to reduce our impact on the environment.

Micro hydro-electric Scheme

Dawyck House was one of the first houses in Scotland to have its own electricity supply. The early Victorian hydro-electric system used water from the Scrape Burn which runs through the Garden. The old Dynamo House was situated in the middle of the garden not far from the main house. By the time RBGE acquired the Garden in 1978 the system had long since been replaced by a supply from the National Grid. The remaining infrastructure had fallen into disrepair and been removed. With increasing interest in sustainability and the need to reduce carbon emissions, we decided to reintroduce a hydro-electric system using new technology. Depending on the flow of the burn it can produce enough electricity to meet our demands plus surplus energy which we can sell to the grid.

Power output and carbon savings are displayed on the meter in the office.

Water from the dynamo post rotates the turbine, which drives a dynamo to generate electricity.



Instantaneous power
Total energy generated
Total CO₂ saving

Biomass Boiler

The Dawyck Visitor Centre is heated in an environmentally friendly way using a biomass (wood fuel) boiler designed to burn woodchip. The boiler also provides heating and hot water for the adjacent workshop, tool stores and machinery storage areas. Using woodchip for heating is beneficial as it generates heat from burning a renewable fuel. The advantages over fossil fuel is that the carbon dioxide released into the atmosphere is part of the natural cycle of carbon and the growth of replacement trees will absorb the carbon dioxide and maintain the balance of gases in the atmosphere. Our woodchip is sourced locally from waste material produced by commercial forestry.

Green Transport

The installation of an electric car charger has secured our commitment to low CO₂ travelling options and offers scope for those with electric cars to access the garden and charge their vehicle while they are here. We are also very cycle friendly and you can find information on how to hire a bike or use a bicycle. Due to our road setting many visitors will also contribute to travel by private car but we are pleased to actively support alternatives.

Reduce Reuse Recycle

We have adopted a range of other measures to reduce environmental impact such as recycling, careful water management and the purchasing of recycled office waste. In order to address concerns about single use plastics we have recently installed a bottled water refill station.

We have also created, as part of our commitment to the Green Tourism Business Scheme, our very own Green Visitor Charter and Green Policy Statement, copies of which can be viewed in the Visitor Centre.

We are also committed to reducing other emissions as time and resources allow. For the latest information on all our green initiatives visit www.dawyck.org.uk



Royal Botanic Garden Edinburgh

Dawyck

CASE STUDY

Eden Project – Generating power, UK

The Eden Project is actively investigating alternative sources of power that will enable the site to be independent of fossil fuels and be 'carbon positive' by 2023, meaning it will emit zero carbon emissions and it will in effect be capturing carbon. The garden is also keen to demonstrate to visitors, the wonder of renewable technologies, and to share with people what does – and doesn't – work. Eden sources all of its electricity from Good Energy which supplies 100% renewable energy.

Geothermal - In partnership with EGS Energy and Bestec UK, Eden has set up a new company (Eden Geothermal Ltd), to build a deep engineered geothermal plant on site, using the heat from the granite underground to derive clean energy in terms of heat (phase 1) and electricity (phase 2). Drilling the 4km into the ground below is due to begin during 2020 and will eventually supply all of Eden's heat and electricity needs and more.

Solar - In 2012, Eden launched the Solarfair project. This was the UK's first employee-owned renewables project, in partnership with Ebico. The pioneering scheme gave Eden staff the chance to invest in a new programme to provide free, renewable energy for the site, generated by solar panels, while offering them returns on their investments. Eden's combined photovoltaic panels generated some 63,000 kWh last year.

Visit: <https://www.edenproject.com/eden-story/behind-the-scenes/cutting-energy-and-carbon-at-eden>

CASE STUDY

Cheyenne Botanic Gardens –
Solar heated greenhouse, USA

The Cheyenne Botanic Gardens (CBG) has been committed to renewable energy since it created its solar heated greenhouse in 1977. The solar heating system in their greenhouses provides 100% of the heat to three separate 30' x 50' greenhouse sections. The rest of the 6,800 square foot building also receives a substantial amount of heat generated from their solar greenhouses. The solar heating is a result of the combined effects of polycarbonate glazing, insulation, thermal mass (fiberglass tubes and metal drums filled with water), and a fortified weatherized structure. CBG generates almost 50% of its electricity from a photovoltaic solar energy system.

Garden profile provided by the Sustainability Index

Visit: <https://www.publicgardens.org/sustainability-index/attributes/goals-action-energy-use-impacts>

Renewables information panel (Dawyck Botanic Garden)



CASE STUDY

VanDusen Botanical Garden – Sustainable visitor centre, Canada

In late October 2011, the Garden opened its new state-of-the-art \$22 million visitor centre. Seven years in the planning and two years in construction, the visitor centre is on target to be certified as a 'Living Building' (above LEED Platinum). Features include solar hot water, photovoltaic panels, a geothermal borehole, and a beautiful living roof.

The visitor centre uses renewable sources found on-site to achieve net-zero energy annually. The primary building material is wood which stores carbon dioxide for the life of the building. Photovoltaics on the roof create electricity for the centre, and hot water is provided by a biomass boiler fed by dry wood waste reclaimed from the surrounding area. 100% of water use comes from captured precipitation or reused water – rainwater is filtered and used for the centre's greywater requirements and 100% of blackwater is treated by the on-site bioreactor, and discharged to a new percolation field in the garden.

The design of the VanDusen Botanical Garden's visitor centre was inspired by the leaves and flowers of an orchid. The undulating green roofs are located on the "petals" and are planted with grasses and colourful bulbs. The multi-petaled structure's circular space is topped by a daylit oculus with a slope over 45 degrees which also serves as a solar chimney that exhausts hot air. The vegetated land ramp connects the greenroof to the ground plane, encouraging use by local fauna and promoting biodiversity.

Visit: <https://www.greenroofs.com/projects/vandusen-botanical-garden-visitor-centre/>

Above: VanDusen Botanical Garden visitor centre (VanDusen Botanical Garden)

CASE STUDY

North Carolina Botanic Garden - Education center, USA

The North Carolina Botanical Garden education center is the first publicly-owned building in North Carolina to earn Platinum LEED Certification. Completed in 2009, the center features a geothermal heating and cooling system, photovoltaic panels to produce electricity from sunlight, and local building materials.

The center is designed to reduce energy costs by 50% through controlled daylight, energy efficiency measures, and renewable energy technologies. Clerestory windows and controlled daylight provide natural lighting throughout the building. The window orientation and overhang allow direct light to enter the building in the winter and shade the building in the summer, limiting heat gain. Daylight sensors automatically dim lights when there is sufficient sunlight. Occupancy sensors activate lights only when people are present.

High-efficiency glazing, broad roof overhangs, and a highly-insulated thermal envelope provide indoor climate control. Geothermal wells provide efficient heating and cooling. Optimized solar orientation helps 84 photovoltaic panels covering the south-facing roof generate nearly 8% of the building's electricity from sunlight. A building management system tracks and manages energy use. The energy efficiency measures and renewable energy technologies were projected to pay for themselves within ten years.

Garden profile provided by the Sustainability Index

Visit: <https://www.publicgardens.org/sustainability-index/attributes/goals-action-energy-use-impacts>

CASE STUDY

Phipps Conservatory and Botanical Gardens - Net-positive energy with no combustion, USA

The 2,262 m² Center for Sustainable Landscapes (CSL) at Phipps Conservatory and Botanical Gardens, an education, research and administration facility is a certified net-zero energy building. It is also Living Building Challenge, LEED Platinum, WELL Platinum, SITES Platinum and 6 Star BREEAM certified. The CSL utilizes passive-first strategies and 100% renewable energy generation produced on site with no combustion to operate with net-positive energy – a strategy which has proven beneficial to both occupant comfort and building performance.

The CSL was designed with a passive first strategy that incorporates a narrow floor plan to provide maximum southern exposure for daylighting and solar gain. The orientation maximizes ventilation via southerly spring and summer winds while minimizing exposure to westerly winter winds.

The CSL uses 125 kW of on-site solar photovoltaic panels and a 10 kW wind generator to produce electricity. Fourteen geothermal wells harness the energy of the earth's consistent 13-degree Celsius temperature to efficiently heat and cool the building.

The CSL atrium is minimally conditioned; extensive use of concrete and phase change material provides thermal mass that, when managed via automatic shade cloths, window walls

and roof top vents, creates comfortable conditions. Natural ventilation, extensive insulation, triple-pane windows and a green roof further enhance energy savings. Daylighting is enhanced with internal light shelves and computer controlled overhead lights. LED task lights provide additional light if necessary. These strategies couple with renewable energy generation from photovoltaics and reuse of water through an on-site capture and treatment system to yield a total EUI (energy use intensity) of 18, 75% less than a typical office building of its size. The building also captures, cleans and reuses all storm and sanitary water on-site and is free from toxic materials.

Having three net-zero buildings powered by on-site renewable energy eliminates fossil fuel use and the greenhouse gasses associated with carbon-intensive energy production and distribution.

Visit: <https://www.phipps.conservatory.org/green-innovation/at-hippys/center-for-sustainable-landscapes-greenest-building-museum-garden-in-the-world>

Below: Center for Sustainable Landscapes green roofs at Phipps (Denmarsh Photography, Inc)



Encouraging sustainable behaviour in visitors

In the sustainable behaviour change survey, 8% of respondents reported that they assist visitors with renewable home energy either through advice or offering opportunities for visitors to switch through partnerships with energy providers. In addition, 19% of respondents have programmes out in the community where they educate/challenge community members to save energy.

Ways in which gardens are promoting energy use to visitors

- Energy saving advice workshops and courses
- Partnerships with energy companies and government agencies to offer visitors advice and free energy saving devices
- Helping visitors to switch to renewable energy
- Interpretation around the garden's energy saving practices

CASE STUDY

Royal Botanic Gardens, Kew – Promoting the Millennium Seed Bank's green energy practices, UK

The Millennium Seed Bank is committed to running solely on renewable energy by 2020 and has installed photovoltaic panels on the roof of its building which provide enough energy to refrigerate the entire seed collection contained within the vaults of the seed bank. These sustainable practices are promoted to visitors through dedicated interpretation within the Atrium. Here a display provides information about the green energy practices being used by the seed bank. This includes a real time display which indicates the amount of electricity generated and the CO₂ saved since the photovoltaic installation.



Aerial at Phipps Conservatory and Botanical Gardens (Paul g. Wiegman)

CASE STUDY

Phipps Conservatory and Botanical Gardens - Make the switch at Phipps! Green power drive, USA

Switching to renewable energy is a simple and powerful way in which individuals can contribute towards their own sustainability footprint.

Phipps' *Green Power Drive* started in January 2017 to engage visitors to take action to reduce their carbon footprint. The garden developed a partnership with Green Mountain Energy (GME). GME buys memberships from Phipps in bulk at a discount — 100 at a time at \$50 each (the regular family memberships retail for \$99 each). They then use the memberships as an incentive to get people to switch their electricity provider while they are visiting Phipps.

In the project's first two years, over 5,000 families were enrolled.

Visit: http://climatetoolkit.org/wp-content/uploads/2019/09/Converting_to_Green_Energy.pdf

Green energy green mountain tropical forest conservatory (Paul g. Wiegman)

CARBON OFFSETTING

Introduction

For botanic garden staff, travelling to conferences and meetings or on plant conservation or horticulture-related trips will impact on an organisation's carbon consumption. Similarly, local travel to and from the gardens (for staff and visitors), use of work vehicles and machinery, purchase of products associated with deforestation, and use of fossil-fuel produced fertilisers and pesticides will all have associated carbon emissions.

Conversely, as plant conservation and horticultural organisations managing green landscapes, botanic gardens are also part of the solution and can help to promote and support carbon sequestration initiatives, such as tree-planting programmes.

For visitors, botanic gardens can play a role in promoting and incentivising sustainable travel, in raising awareness of individual carbon footprints and ways to reduce them, and in delivering community based tree-planting programmes.

Links to



In-house practices

In the in-house sustainable practices survey, 34% of respondents reported that they incentivise employees to use more sustainable modes of transportation when travelling to work. The most common method is by providing incentives to cycle to work, including subsidising bicycle use or purchase.

A small number of respondents (7%) reported offsetting carbon from staff travel. Means used to offset carbon include using airlines that offset flights, tree planting, and by using a carbon footprint calculator and purchasing solar panels with the amount owed.

Almost half of respondents (47%) have removed deforestation-based products from their supply chain, with 35% also eliminating fossil-fuel-produced fertilisers and pesticides.

Ways in which gardens are reducing their carbon consumption

- Staff incentives to use sustainable modes of transport
 - Subsidised bicycle schemes
 - Implementing policies on remote meetings and video-conferencing
 - Discounts on public transport
 - Electric vehicle charging points
- Sustainable travel policies
- Carbon offsetting initiatives
- Removing deforestation-based products from supply chains
- Eliminating fossil-fuel produced fertilisers and pesticides
- Low carbon investments

CASE STUDY

Gothenburg Botanical Garden – Sustainable travel and carbon offsetting, Sweden

Sustainable travel

Gothenburg Botanical Garden encourages employees to consider sustainable travel options between work and home. The garden takes part in a project called “Bicycle friendly workplace” and fulfils criteria for the highest three-star level. The criteria include providing a dedicated space for bicycle parking that is weather protected, access to a changing room and showers, access to bicycles for work trips and a group of employees dedicated to inspiring staff to travel by bicycle more frequently. Employees can also buy a public transportation ticket valid for one year and pay through a monthly deduction on their salary. In addition, free parking for employees has been removed, to discourage driving to work.

Carbon offsetting

Gothenburg Botanical Garden belongs to the county council Region Västra Götaland. Public authorities are not allowed to pay for climate compensation. Instead, the county council adds an extra fee to the ticket price for all air travel. The money is collected on a common account and used for improvements within Region Västra Götaland to reduce greenhouse gas emissions. The goal is to reduce the impact on climate from meetings and work trips. Examples of what the money has been used for in the Gothenburg Botanical Garden include purchase of electric bikes for shorter work trips and equipment allowing for remote meeting attendance.



CASE STUDY

Jardín Botánico de Medellín “Joaquin Antonio Uribe” – Staff bike scheme, Colombia

The garden has developed a Sustainable Business Mobility Plan, which aims to reduce the generation of carbon emissions. This includes incentivising staff to travel to work by bike.

Each staff member has a unique code installed on their bicycle (similar to licence plates). By registering this code, the garden can record how many times each staff member cycles to work. As an incentive and reward, individuals who travel by bicycle are granted a day of annual leave for 40 days of bicycle use.

Likewise, to encourage use, there are 57 bike parking spaces inside for staff use. Furthermore, an annual bicycle fair is held to further promote green travel amongst staff.

In 2019, 70 staff members used the scheme and recorded 3,970 trips.

Above left: Bicycle parking area (Jardín Botánico de Medellín “Joaquin Antonio Uribe”)

CASE STUDY

Phipps Conservatory and Botanical Gardens – Carbon offsetting, USA

Phipps Conservatory and Botanical Gardens uses the Terrapass Carbon Footprint Calculator to determine the carbon offset cost. These calculated costs are then used to purchase solar panels for the garden campus to reduce the use of fossil fuels.

Visit: http://climatetoolkit.org/wp-content/uploads/2019/09/Offset_all_carbon_from_heating.pdf



Photovoltaics at Phipps Conservatory and Botanical Gardens (Paul g. Wiegman)

Encouraging sustainable behaviour in visitors

In the sustainable behaviour change survey, 40% of respondents reported incentivising visitors to use human-powered or public transportation to travel to the garden.

Some respondents (33%) educate their visitors on understanding and managing their carbon footprint. In addition, 40% of respondents report that they have programmes out in the community to educate/challenge community members to support tree planting activities and other methods to offset their carbon footprint.

Ways in which gardens are promoting carbon reduction strategies to visitors

- Visitor incentives to choose more sustainable modes of transport to visit the garden
 - Advice and recommendations
 - Discounts if travelling by public transport
 - Paid for parking
 - Electric vehicle charging points
- Managing carbon footprint
 - Educational programmes, talks and workshops
 - Interpretation and exhibitions
- Community tree planting initiatives

CASE STUDY

Incentives to travel by public transport

A number of gardens incentivise their visitors to consider how they travel to the garden, for example, **Bristol Zoo Gardens (UK)** and the **Eden Project (UK)** offer a discount on the entrance fee to anyone arriving by public transport or bike.

Chicago Botanic Garden (USA) has no admission charge to pedestrians, but there is a cost to park automobiles. The garden also runs a shuttle from a nearby train station for visitors and contains a 1.5 mile pedestrian/bicycling trail that connects to a regional trail system.

Denver Botanic Gardens (USA) offers reserved parking for shared-car services; as well as discounted admission for shared bike programme users.

Right: The cycle path (Chicago Botanic Garden)

CASE STUDY

Wollongong Botanic Garden – Theatre in a wheelbarrow (environmental theatre), Australia

Wollongong Botanic Garden's Discovery Centre has written a series of environmentally themed plays to engage younger audiences with sustainability topics. This includes *The Big Foot Detectives* – a play that deals with the concept of the ecological footprint. Dirk Stacey, Hemlock Holmes and Hercule Poirot, larger than life characters from the Big Foot Detective Agency are trying to solve their most difficult riddle - What is the Big Foot?

This play for older primary students makes a difficult concept seem easy. The Detectives and the children collect pieces of the puzzle on the way, eventually putting them together to form a giant footprint (2m long) to assemble on the lawn. Ideas on how to reduce our personal eco footprint in each of the areas is explored.

The Big Foot Detectives has toured local schools and entertained several thousand young people for World Environments Day celebrations in the Garden. The usual ingredients of larger than life characters, colour and movement, together with song, humour and audience participation are used in this garden production to help to engage the young audience in this important issue of sustainability, and how to reduce the impact of our daily living on the fragile ecosystems of earth.

Visit: <http://council.wollongong.nsw.gov.au/botanicgarden/whatson/Pages/theatreinawheelbarrow.aspx>



CASE STUDY

Royal Botanic Garden Juan Carlos I, University of Alcalá - Electric car charging points, Spain

In 2012, the Royal Botanic Garden Juan Carlos I, of the University of Alcalá installed in its parking lot, a “fotolinera”, which is a charging station for electric vehicles powered by solar panels. It provides clean electricity from a renewable source and is used to supply charge to the vehicles of the botanic garden and the university (cleaning services, mail, etc.) and it is also offered, free of charge, to visitors. Visitors are encouraged to go to the garden by electric vehicle, and are offered free access to the garden in return.

Visit: <http://botanicoalcala.es/proyectos/fotolinera/>

Right: Fotolinera in Alcalá Botanic Garden (Rosendo Elvira)



CASE STUDY

Tower Hill Botanic Garden – The Worcester Tree Initiative, USA

Worcester Tree Initiative (WTI), a program of the Outreach & Community Engagement Department of Tower Hill Botanic Garden, began in 2009 as a replanting effort in Worcester County after a devastating Asian Longhorn Beetle infestation was discovered there in 2008.

By 2014, WTI along with the Massachusetts Department of Conservation & Recreation and the Worcester Forestry Department, replanted 30,000 trees which replaced the first round of trees cut down in the quarantine zone.

After the emergency replanting was complete, Tower Hill Botanic Garden (THBG) incorporated WTI as a permanent garden program because of the tree agency's successful sustainability work in the Worcester County community. THBG recognized the value of urban trees and the importance of promoting sustainability in the community. Trees sequester carbon, mitigating the large carbon output created by dense urban settings. Trees reduce temperatures, countering the urban heat island effect that contributes to global temperature increases. Trees soak up rainwater and intercept water runoff thus reducing flooding problems.

WTI remains a robust tree program that provides tree plantings, tree establishment care, tree advocacy, and tree education for all residents in Worcester county and beyond. Providing tree stewardship and education greatly increases the viability of newly planted trees. To date, the WTI programs have planted over 6,700 trees and watered over 28,200 trees since 2011. They have pruned close to 4,000 young street trees and engaged with more than 10,000 Worcester county residents. Their work helps provide sustainable programs in Worcester.

Visit: <http://www.treeworcester.org>

Left: Worcester Tree Initiative



WASTE, RECYCLING AND COMPOSTING

Introduction

As outward facing organisations, looking after plant collections, welcoming large numbers of visitors, running shops, cafés and restaurants and hosting various events, the amount of potential waste that may be generated can be quite significant. Where possible, efforts should be made by botanic gardens to reduce, re-use and recycle and limit the amount of waste that is ultimately sent to landfill. Actions such as removing single-use plastic for food and drink, recycling and composting waste on-site are essential.

For visitors, botanic gardens are well placed to promote the importance of reducing plastic and food waste and to educate and support visitors in recycling and composting alternatives.

Links to



In-house practices

In the in-house sustainable practices survey, 79% of respondents offer recycling facilities for visitors. In addition, 95% of respondents reported recycling a proportion of their waste stream, with 31% recycling 60% or more of their annual waste stream.

When asked about food waste specifically, 42% reported composting more than 81% of their food waste.

Single-use plastics are a large contributor to global waste. The survey found that 21% of respondents have eliminated 100% of all Single-use plastic from their food waste. In addition, 14% have also eliminated bottled water and other single-use plastic beverage bottles. Finally, 71% of respondents offer water refilling services for visitors.

Ways in which gardens are reducing waste

- Recycling facilities
- Composting garden and food waste
- Water refilling stations for visitors
- Eliminating single-use plastic from shops and cafés
- Waste reduction initiatives

CASE STUDY

Royal Botanic Gardens Kew – Plastic waste reduction, UK

Kew have removed 98% of all single-use plastic from their cafés and restaurants, working with the on-site catering company to do so. In its place, the garden provides commercially compostable packaging made from PLA plastics. The garden is also trialling some serving options that cut out packaging altogether by serving food straight to the plate.

In their shops, all plastic bags have been replaced with paper bags for purchases (with the exception of bags which need to be waterproof and sealable for biosecurity). These are made from 100% recycled and recyclable plastic. Plastic has also been removed from sweets packaging which is now made from fully compostable cornstarch.

Working with suppliers, the garden is also reducing and replacing single-use plastic packaging on other items. For example, some children's toys are now to be made from recycled instead of single-use plastic.

The compostable PLA plastic packaging, along with food waste, can be placed in compost bins in the cafés. The garden is currently trialling a system on-site to turn this waste into soil improver using an aerobic waste digester, called the Garbage Guzzler. This uses heat and bacteria to convert all compostable waste into soil improver. General café waste is sorted for recycling and biofuel.

<https://www.kew.org/read-and-watch/how-kew-gardens-is-fighting-plastic-pollution>



Compostable cutlery (Paul Smith)

CASE STUDY

Shanghai Botanical Garden – Green waste processing, China

Shanghai Botanical Garden's green waste processing plant has four crushing machines and covers an area of 60,000 m². As such, it is the largest composting processing plant in Shanghai. The plant processes 40,000 tonnes of green waste annually, with the waste coming from the botanic garden as well as from the Xuhui, Changning, Minhang and Huangpu districts every day.

Since 2006, the Shanghai Botanical Garden has invested approximately RMB 20 million (USD 3 million) in green waste processing. There are 15 staff working on this project, and they can crush the waste and gather it for composting on the same day it was delivered. After crushing, they add nitrogen fertiliser and microbes to compost the material in 30-40 days. The compost is used on-site at the botanic garden with the remainder being packaged and sold.

The kind of compost produced plays an important role in soil improvement, can save energy and can reduce emissions. The project continues to develop with government support.



Green waste at Shanghai Botanical Garden (Feng Shucheng)

CASE STUDY

Eden Project – Wasteline initiative, UK

Eden's Project Wasteline initiative, aims to design out waste from the garden's products and procedures in the first instance (reduce), to close the loop on material flows (recycle) by sending as much as possible for recycling (currently 51% of total waste) and energy recovery (24%). 100% of Eden's food waste is composted and with a target of zero waste to landfill, the figure is currently at 8%.

Wasteline involves working with suppliers to reduce the amount of packaging that comes onto site, helping teams and visitors improve recycling rates through better products and signage, and involving staff and Eden Apprentices in coming up with waste reduction solutions.

Eden no longer sells water in plastic bottles or uses plastic straws and encourages the use of reusable cups and bottles through products sold in its shop, discounts for customers who bring their own cups, and provision at Eden events. Sandwiches and other food items are wrapped in paper and the majority of food and drinks are served in crockery, which is washed and reused. All food waste is either composted on-site or is sent off for composting at a local anaerobic digestion plant.

Any waste for processing is weighed and over 20 different waste streams are recorded. The data is analysed to make informed decisions about where to focus waste reduction efforts.

Visit: <https://www.edenproject.com/eden-story/behind-the-scenes/waste-and-recycling-at-eden>

Encouraging sustainable behaviour in visitors

In the behaviour change survey, 65% of respondents reported that they educate visitors on food waste and how to compost. The most common methods used for this are talks and classes, providing recycling bins and interpretation.

In addition, 19% of respondents offer recycling opportunities for plastic plant pots, 6% of respondents sell compost bins, and 12% offer free composting for visitor garden waste (for use in the garden itself or for resale).

Finally, 27% of respondents have programmes out in the community where they educate/challenge community members to recycle and compost. Programmes include workshops and education programmes, collaboration with local businesses and community composting programmes.

Ways in which gardens are promoting waste reduction to their visitors

- Workshops, interpretation and exhibitions about waste and recycling
- Compost workshops and community programmes
- Compost visitor and community waste in the garden
- Sell compost bins
- Recycle plastic plant pots



CASE STUDY

North Carolina Botanical Garden – Compost Workshops, USA

The North Carolina Botanical Garden has an on-campus garden called the Carolina Community Garden, also known as CCG. This garden is in the heart of campus at UNC-Chapel Hill and serves the community. Every day, composting is demonstrated through the collection of community food scraps and the processing of the compost on-site. In addition, there are five compost managers who are all students on campus.

They also host compost workshops where both backyard & vermicomposting methods are taught and displayed. Typically, the workshop is held at least once a year, with additional workshops ad hoc upon request. Each workshop has between 20-30 participants. Participants learn about the benefits of composting, learn how to compost, and participate in the composting at the garden so they can take their learning home. Some workshops have also included giveaways including compost bins and worms for vermicomposting. The garden partners with Orange County Solid Waste to host these workshops and they provide a great way to reach both community members and students interested in reducing their carbon footprint.

Visit: <https://ncbg.unc.edu/outreach/cccg/>

Above: Compost workshop (North Carolina Botanic)

CASE STUDY

Botanical Garden of the University of Fribourg - Community composting, Switzerland

The city of Fribourg (approx. 40,000 citizens) has practically no composting facilities available to the population, only a large collection centre outside the city.

As a result, the Botanical Garden of the University of Fribourg decided to provide and maintain a composting service, mainly for the inhabitants of the neighbourhood around the garden. Both visitors and inhabitants of the city can deposit their compost at the garden, where it is treated.

The finished (compost) product is then used for the garden's soil mixtures and soil improvers.

CASE STUDY

Chelsea Physic Garden – Shelf Life, UK

The Shelf Life project was designed to show how plants and products are relevant to people's lives.

The project involved the use of product packages (jars, boxes, bottles, wrappers and bags) as containers in which to grow the plants that make up the products' ingredients. For example, a potato plant growing in a bag of potato crisps and wheat growing in a bag of bread.

At the 2004 Royal Horticultural Society (RHS) Chelsea Flower Show, a small 'shop' was created with shelves showing 90 different 'living' products, including a top shelf alcohol selection, cleaning products and a medicine section. Cotton was growing from the cash register, since bank notes are woven with it. The garden was awarded a Silver-Gilt medal for the display. Other non-food products include cotton wool, pine cleaner and printing ink (soya and linseed) as well as many plant-based medicines (morphine, taxol, aspirin, hyoscine, and various essential oils).

Part of the purpose of Shelf Life was to encourage recycling, to collect seeds from food we eat and save relevant packaging that would otherwise be thrown away. As well as a display, the garden also produced some teaching resources to accompany it. Since its launch, schools and gardens in London, across the UK and around the world have been using the resources to develop their own displays, demonstrating that it is a useful tool for change.

Visit: <https://www.chelseaphysicgarden.co.uk/teaching-resources>



Shelf Life (Michael Holland)



CASE STUDY

Wollongong Botanic Garden - The Recycled Discovery Garden, Australia

Botanic gardens have an important role in teaching about environmental sustainability. The Recycled Discovery Garden at Wollongong Botanic Garden is a perfect vehicle for this. The very structure of the garden, the materials used and the plants that are nurtured here, support the concept of sustainability. Visitors and students gain ideas and inspiration from this garden on how to reuse old furniture or abandoned building materials to breathe new life into waste. As the garden uses food plants, composts and worm farms in the garden, it is a perfect venue, a living classroom, to run activities and workshops on backyard self-sufficiency and sustainability.

The Recycled Discovery Garden or Living Classroom was also built as a model garden for schools and community groups as inspiration, to encourage them to build one of their own. However, it has also been observed that general garden visitors especially families with children want to take these ideas to use in their gardens at home. This encourages families to spend time in their garden, growing herbs, vegetables and flowers and making it a pleasant place to spend time outdoors.

*Left: The Recycled Discovery Garden
(Wollongong Botanic Garden)*

CASE STUDY

Jerusalem Botanical Gardens – Meal from rescued food, Israel

The meal from rescued food is a highlight of the garden's Bustan summer programme for young adults. The young adults involved collect vegetable peels and scraps and invite the public to a delicious meal made out of these items. Participants are exposed to food that would have otherwise been thrown away and they can see first-hand the importance of urban sustainability.

Survey data collected from those involved with and invited to the meal, analysed the success of the event as well as individual learning. Feedback from participants was very positive, "I bloomed and became closer to the earth, my peers and this unique framework," "It opened my eyes to the city's food situation," "I saw how much food could be re-used daily."



Meal from rescued food (Jerusalem Botanical Gardens)



*Waterless toilets at University of Bristol Botanic Garden
(Paul Smith)*

SUSTAINABLE FOOD

Introduction

Many botanic gardens have cafés, shops and restaurants that serve food, and many gardens host meetings and events (internal and external) with catering requirements. It is therefore important to consider the sustainability of food provided on-site. Developing sustainability guidelines for catering, serving a high proportion of vegetarian and vegan options, sourcing local products, and using fair trade, organic and certification labels are all important considerations.

With both horticultural expertise and dedicated areas for growing fruit and vegetables, botanic gardens have an opportunity to promote sustainable food choices and food diversity to their visitors, as well as implementing best practices, and growing food to be served on-site.

For visitors, botanic gardens can also play a role in promoting healthy and sustainable diets, supporting local food and local initiatives (e.g. through culinary events and farmers' markets), and providing opportunities for visitors and local communities to grow and harvest their own food.

Links to



In-house practices

In our sustainable in-house practices survey, 75% of respondents source some of their food for catering from local farmers or producers, with 3% sourcing completely in this way.

In addition, 88% of respondents serve some vegan and vegetarian options within their food service with two gardens offering a fully vegan/vegetarian menu. Organic options are served by 67% of respondents, with 46% also offering some sustainable and/or certified seafood.

The survey found that 21% of respondents consider certification labels in the food they purchase and provide. These include Rainforest Alliance Certified and RSPO Certified Sustainable Palm Oil, Fairtrade products, EU ecolabel, FSC, Nature Planet, Better Life Label and Red Tractor certifications.

Finally, in response to whether the organisation has a sustainable food policy for any events or conferences, 80% of respondents do have a policy.

Ways in which gardens are contributing towards sustainable food systems

- Source food from local suppliers
- Ensure food service includes a high proportion of vegan and vegetarian options
- Source organic and sustainably certified food
- Sustainable food policies for internal and external catering



The Edible Academy classroom (New York Botanical Garden)

CASE STUDY

Pha Tad Ke Botanical Garden – Farm to table dining experience and slow food garden, Laos

The Pha Tad Ke Botanical Garden Café was recently listed in Forbes Magazine's World's Ten Best 'Farm to Table' Dining Experiences.

'Farm to table' is a growing social movement in the restaurant world. It generally refers to restaurants cooking with ingredients that are grown on-site or locally, bought directly from local farms or at local farmers' markets. The movement has a strong focus on education and Pha Tad Ke exemplifies this aspect with its various educational programmes. Many of the ingredients used in the dishes served by the café are grown within the gardens, in the permaculture demo and research farm, which visitors can visit while in the gardens. At the café, visitors can sit in a sala, amid the plants and flowers and enjoy a freshly made lunch using vegetables, herbs, bamboo and ginger grown in the garden and from the permaculture demonstration farm.

In early 2020, a new slow food garden was opened on site; slow food promotes local food and traditional cooking. This garden supplies fresh produce to the café and around the garden a programme of workshops and lectures will start summer 2020.

Visit: <https://www.pha-tad-ke.com/visit/slow-food/>



Dining at Pha Tad Ke café (Cyril Eberle)

CASE STUDY

Royal Botanic Gardens Kew – Seasonal, local produce and the Chef's Manifesto, UK

Seasonal, local produce that has minimal environmental impact is at the centre of food served in Kew's restaurants and cafés. A kitchen garden along with the herb garden provide seasonal vegetables and herbs for dishes.

The garden relies on the expertise of horticulturalists to know when wild herbs and plants are tasting their best, these are then foraged from across the gardens to use in the restaurants and cafés. The garden also has a focus on sourcing local and seasonal produce to celebrate the best of British produce. At the garden's Pavilion Bar and Grill, fresh vegetables come from local Surrey farms and sea bream is from Cornish day boats. Beef is sourced from specialised farms in Wales and the south-west of England, and is reared on a diet of 70% foraged food.

The garden has also thought carefully about sustainable ways to cook the produce, with a Josper grill that uses a mix of charcoal made from the woody waste at Kew and Department for Environment, Food and Rural Affairs (Defra) approved charcoal.

In addition, Kew have collaborated with the SDG2 Advocacy Hub, which has brought top chefs from all over the world together to create a Chefs' Manifesto. The manifesto, made by chefs for chefs, is a framework, which outlines how chefs can contribute to the SDGs through simple, practical actions. Set up to fight for the food-related issues that matter most to them under the SDGs, the campaign aims for a better and more sustainable food system for all. Several of the chefs involved with the Chef's Manifesto paid a visit to Kew to learn about the garden's vital science and horticultural work around food security, sustainability, biodiversity and growing food in new ways.

Visit: <https://www.kew.org/read-and-watch/kews-restaurants-sustainable>

CASE STUDY

Chester Zoo – First sustainable palm oil city, UK

In September 2017, Chester Zoo launched an ambitious, major new conservation campaign to make Chester the first city in the world to source its palm oil from entirely sustainable sources.



Conservationists from Chester Zoo developed the Sustainable Palm Oil City model based on the framework created by the Sustainable Fish Cities project, led by independent group Sustain, the alliance for better food and farming. The campaign is backed by the Orangutan Land Trust and the Sumatran Orangutan Society and is endorsed by key conservation organisations such as the British and Irish Association of Zoos and Aquariums (BIAZA).

The initiative has been supported by a host of industry advisors such as the Roundtable on Sustainable Palm Oil, as well as palm oil sustainability consultants Murdoch Associates and Efeca.

More than 50 organisations in the city have revolutionised their supply chains and committed to sourcing palm oil from entirely sustainable sources. These methods are being replicated by Paignton Zoo, and the Newquay SPO Town Initiative.

Visit: <https://www.chesterzoo.org/what-you-can-do/our-campaigns/sustainable-palm-oil/sustainable-palm-oil-city/>

CASE STUDY

Phipps Conservatory and Botanical Gardens - Sustainable practices at Café Phipps, USA

Nestled inside Phipps' LEED® Certified Welcome Center, Café Phipps was recognized in Food & Wine Magazine as a Best Museum Restaurant in the U.S. in 2014 and 2019. The café is a 3-star Green Restaurant Certified® eating establishment, a Platinum designated Sustainable Pittsburgh Restaurant, a Farm Forward Leadership Circle Member, a Live Well Allegheny Restaurant, Zero Waste Pittsburgh Platinum certified and a Hobart Center for Foodservice Sustainability award winner.

Café Phipps follows the “veg first” principle, offering plant-based meals by default for over 90% of menu options, including a variety of vegetarian and vegan salads, sandwiches and soups. For a slight up-charge, guests have the option to add tofu, salmon or chicken to any menu item. Eating meat and dairy-free at least one day a week helps reduce carbon footprints and can also be healthier. Phipps also invites guests to support the Meatless Monday campaign by offering an extra vegetarian selection at the start of each week.

In 2009, Phipps eliminated bottled water from its entire facility. Phipps provides drinking water that has been filtered on site and offers reusable water bottles for purchase. Since 2006 all china and silverware has been washable and reusable, which eliminates the energy, material and water resources necessary to produce and haul disposable serveware. Cups are made from compostable, vegetable-based starches, napkins are made of 100-percent unbleached recycled paper, and compostable containers and serveware are available for takeout orders.

The Café features local and organic foods and composts all pre- and post-consumer organic waste, and more than 90 percent of the products used in the Café are compostable.

Visit: <https://www.phipps.conservatory.org/visit-and-explore/visit/cafe-hipps>



Rooftop edible garden at Phipps Conservatory and Botanical Gardens (Paul g. Wiegman)

Encouraging sustainable behaviour in visitors

In the sustainable behaviour change survey, 37% of respondents report that they educate visitors on how food choices, like eating meat, contribute to climate change. The survey found that 19% of respondents run programmes/activities/interpretation around the catering offered at the garden. Programmes include interpretation on sustainable palm oil linked to catering/sustainable catering, healthy food choices, school education programmes, having a specialised vegan café, and promotion talks by suppliers.

To promote locally sourced food, 25% of respondents host local farmers' markets, the frequency of markets varies, with some being a regular event and others linked to specific projects or programmes.

In addition, 36% of organisations offer opportunities for growing food (on or off-site), this is in the form of education gardens for children, community gardens and community group training, demonstration gardens and urban gardening.

Around a quarter of respondents (24%) have programmes out in the community where they educate/challenge community members to use sustainable food options. Community sustainable food programmes are delivered through food growing projects and classes, collaborations with campaigns and free vegetable garden installations in homes.

Finally, 45% of respondents offer advice on garden design and planting, maximising green spaces and minimising hard landscaping. This is delivered through education activities, workshops and lectures, ad hoc advice in the garden, and specific greening programmes in the local community.



Talinn Botanic Garden growing programme (Talinn Botanic Garden)

Ways in which gardens are promoting sustainable food to their visitors

- Educate visitors on food choices through:
 - Interpretation, exhibitions and workshops
 - Vegetarian and vegan options in cafés and restaurants.
- Host farmers' markets
- Food growing projects on and off-site
- Urban greening programmes



CASE STUDY

Inverness Botanic Gardens – GROW project, UK

The GROW project is an award-winning scheme that gives people with learning difficulties the chance to learn horticultural skills. Running for 25 years, it has produced high quality and organic locally grown produce, which can be purchased by the public from Inverness Botanic Gardens.

The GROW project relies on the commitment of the project leader and a strong community group of approximately 30 trainees and volunteers. Together, they grow produce to an organic standard, which has created a high demand within the area. In 2019, the GROW project made around £3,000 from the sale of their produce including herbs, fresh fruit and vegetables, which has gone back into the project.

Above: GROW (Inverness Botanic Gardens)



CASE STUDY

New York Botanical Garden – Bronx Green-Up, USA

Bronx Green-Up helps Bronx residents transform vacant, abandoned lots into vibrant green spaces, such as community gardens, school gardens and urban farms, by contributing gardening advice, hands-on workshops, planting materials, and much more. With the help of these programs, Bronx residents learn how to select and grow many flowers, fruits, and vegetables; how to prepare planting beds, sow seeds, plant bulbs, build a compost pile, and prune trees and shrubs; and how to harvest what they've grown.

The program is the visible presence of the New York Botanical Garden beyond the garden's gates, inspiring NYC residents to get involved in improving their communities through greening and food growing projects. Since 1988, Bronx Green-Up has helped create more than 300 community and school gardens and urban farms that have served tens of thousands of Bronx residents. In 2019, Bronx Green-Up conducted 248 activities and events, reaching approximately 4,400 people representing 77 gardens, greening groups, schools, and community organizations.

Visit: <https://www.nybg.org/gardens/bronx-green-up/>

Above: Bronx Green-Up (New York Botanical Garden)



Fribourg farmers' market (Botanical Garden of the University of Fribourg)

CASE STUDY

Royal Botanic Garden Edinburgh – Food Forever global exhibition, UK

Food Forever is a campaign organised by the Crop Trust, which calls upon the global community to protect the vast, colourful spectrum of diversity within our food system. It is about investing in the future by protecting agricultural biodiversity, to ensure adequate nutritious food for all in a rapidly changing world.

The Royal Botanic Garden Edinburgh, in collaboration with BGCI, the Crop Trust, Royal Botanic Gardens Kew and The Leichtag Foundation developed and piloted a Food Forever Exhibition which was launched in Edinburgh in 2019. From this, a toolkit and series of panels have been produced that are available free of charge for botanic gardens and other key sites to use, to produce their own Food Forever exhibition. Through this project, the aim is to promote the message of Food Forever and the importance of crop diversity within our food system to a global audience.



Visit: <https://www.bgci.org/our-work/projects-and-case-studies/food-forever-global-exhibition/>

Right: Food Forever panels (Food Forever)

CASE STUDY

Botanical Garden of the University of Fribourg – Farmers' market, Switzerland

Every May, a Farmers' Market is held at the Botanical Garden of the University of Fribourg. During one day, the garden hosts around 30 exhibition and sales stands, and sells home-grown plants. Invited exhibitors sell seeds, plants, fruits and vegetables, as well as plant-related products: tools, natural soaps, sustainable bags, organic oil, honey, etc. Most sellers are local and/or organic. The market has an average of 4,000 visitors per event.

It is an occasion for the public to meet and talk to the garden's professional team, to get advice about gardening and sustainability, and to learn more about the scientific content of the garden (importance of plant conservation, endangered species, etc). The Society of Friends of the Garden holds an information stand and recruits new members, and the garden hosts a food and beverage stand. The Market is a source of income (plant sales, food stands, stand rental) and increases the visibility of the garden.

CASE STUDY

Jerusalem Botanical Gardens – Educational Garden Network, Israel

The Educational Garden Network helps to establish educational gardens in kindergartens and special needs classrooms around the city as a way to teach sustainability and food security. By tending to this garden, urban children are able to learn where food comes from and its affect on daily life. The process includes planting vegetables with the students as well as continuing education for the teachers to adapt their lessons to themes of environmental awareness and urban agriculture. So far, the garden has worked with 110 pre-schools, 11 special education classes and 38 schools. Through this programme, 21,280 children have participated in sustainable garden activities and 103 educators have received training and one-on-one professional development.

*Below: Sustainable garden education
(Jerusalem Botanical Gardens)*



CASE STUDY

Orto Botanico Di Bergamo “Lorenzo Rota” – The footprint pillar, Italy

As part of the BigPicnic project (a BGCI led project that focused on food security), the Botanical Garden of Bergamo organised an interactive exhibition about food security, the role of plants and the environmental and health impact of food. The aim was to make people aware of the link between correct nutritional choices and conservation of biodiversity and sustainability.

This exhibit, which was made up of a range of activities included a display called The Footprint Pillar.

In this display, visitors can see the footprint of different food types. For every food type, visitors can learn about the impact on the planet to produce it. The display includes three footprint indicators: 1) The carbon footprint indicator, which calculates the greenhouse gas emission during the life-cycle of the food type. 2) The water footprint indicator, which calculates the consumption and mode of use of the water resources used. 3) The ecological footprint, which calculates the Earth's capacity to regenerate resources and absorb emissions.

Through this exhibit visitors are encouraged to consider the impact of their food (and wider sustainability choices) on the planet. This exhibition has now been developed into a mobile exhibition to be able to travel to schools, museums, fairs, and other botanic gardens to reach new and different audiences.



BigPicnic exhibition (Orto Botanico Di Bergamo “Lorenzo Rota”)

SUMMARY

In this Review we have provided an overview of the ways in which botanic gardens are contributing to environmental sustainability. Every garden has a responsibility to contribute to sustainability, with that response being situation and capacity dependent.

Botanic gardens should be leaders in environmental sustainability and the case studies provided in this Review highlight the ways in which we are already doing this - reducing our use of resources and committing to sustainably responsible practices. We also have a platform to reach out to visitors, not only by leading by example and promoting our own sustainable practices but finding new and innovative ways to encourage and change sustainable behaviour and measuring the impact of

those activities and practices. Together, and by mobilising our visitors, we have an opportunity to make a significant impact, addressing key global topics such as climate change mitigation.

Key recommendations

Botanic gardens should:

- Identify and implement sustainable practices relevant to their garden and situation
- Reference the Sustainable Development Goals in key strategic or master plans
- Lead by example
- Mobilise visitors to consider their own sustainable actions
- Implement impact monitoring

Sustainable practices that can be implemented at botanic gardens

What will your garden do?

	In-house practices	Encouraging sustainable behaviour in visitors
Water management	<ul style="list-style-type: none"> • Rainwater collection and reuse • Water monitors/sensors • Efficient toilets/water aerators • Water/storm water treatment systems • Automated drought mitigation • Efficient irrigation systems • Drought tolerant planting • Gator bags on plantings • Mulching • Rain gardens • Green roofs (excess rainwater collection) • Treating and reusing sanitary water (blackwater) 	<ul style="list-style-type: none"> • Advice on low water usage plants • Selling water saving devices (e.g. cistern water displacement bags and rain gauges) • Public information programmes that promote simple water saving actions • Water saving events
Energy consumption	<ul style="list-style-type: none"> • Sustainable building construction • Energy efficient LED or other efficient lighting systems • Electric vehicles • Renewable energy systems • Condensing boilers • Atmospheric boilers • Heat pumps and programmable thermostats • Timer controlled heating and lighting • Radiant floor heat and geothermal energy • Electric equipment • Energy audits • Incorporate passive energy design in new buildings. • Upgrade to energy efficient equipment and appliances • Eliminate combustion • Use of Phase Change materials 	<ul style="list-style-type: none"> • Energy saving advice workshops and courses • Partnerships with energy companies and government agencies to offer visitors advice and free energy saving devices • Helping visitors to switch to renewable energy • Interpretation around the garden's energy saving practices

	In-house practices	Encouraging sustainable behaviour in visitors
Carbon consumption	<ul style="list-style-type: none"> • Staff incentives to use sustainable modes of transport <ul style="list-style-type: none"> - Subsidised bicycle schemes - Policies on remote meetings and video-conferencing - Discounts on public transport - Electric vehicle charging points • Sustainable travel policies • Carbon offsetting initiatives • Removing deforestation-based products from supply chains • Eliminating fossil-fuel produced fertilizers and pesticides • Low carbon investments 	<ul style="list-style-type: none"> • Visitor incentives to choose more sustainable modes of transport to visit the garden <ul style="list-style-type: none"> - Advice and recommendations - Discounts if travelling by public transport - Paid for parking - Electric vehicle charging points - Develop cycle routes • Managing carbon footprint <ul style="list-style-type: none"> - Educational programmes, talks and workshops - Interpretation and exhibitions • Community tree planting initiatives
Waste, compost and recycling	<ul style="list-style-type: none"> • Recycling facilities • Composting garden and food waste • Water refilling stations for visitors • Eliminating single-use plastic from shops and cafés • Waste reduction initiatives 	<ul style="list-style-type: none"> • Workshops, interpretation and exhibitions about waste and recycling • Compost workshops and community programmes • Compost visitor and community waste in the garden • Sell compost bins • Recycle plastic plant pots • Organise a meal from rescued food event • Exhibitions and displays about/using waste • Collaborations with local waste initiatives • Sell re-usable coffee cups and water bottles
Sustainable food	<ul style="list-style-type: none"> • Source food from local suppliers • Ensure food service includes a high proportion of vegan and vegetarian options • Source organic and sustainably certified food • Sustainable food policies for internal and external catering 	<ul style="list-style-type: none"> • Educate visitors on food choices through: <ul style="list-style-type: none"> - Interpretation, exhibitions and workshops - Vegetarian and vegan options in cafés and restaurants. • Host famers' markets • Food growing projects on and off-site • Urban greening programmes • Food festivals • Pop-up kitchens in the garden • Collaborations with celebrity chefs

Sign up to BGCI's Sustainability Challenge

BGCI and Phipps Conservatory and Botanical Gardens are creating a Sustainability Challenge for gardens wanting to scale up their sustainability practices, which will include the establishment of mentor gardens, provision of ideas and methodologies, and making funding available to gardens wanting to develop new sustainability actions. For more details see <https://www.bgci.org/our-work/projects-and-case-studies/bgci-sustainability-challenge/>.

If your garden is interested in incorporating sustainability actions, such as those listed above, into its business or the way it influences visitors, please get in touch with Helen Miller at BGCI helen.miller@bgci.org

FURTHER INFORMATION

Sustainability standards and schemes

- ISO 14001 Environmental Management Standard: <https://www.iso.org/iso-14001-environmental-management.html>
- Living Building Challenge: <https://living-future.org/lbc/>
- Leadership in Energy and Environmental Design (LEED): <https://www.usgbc.org/leed>
- Public Gardens Sustainability Index: <https://www.publicgardens.org/sustainability-index>
- Sustainable SITES Initiative: <http://www.sustainablesites.org/>
- WELL Building Standard: <https://www.wellcertified.com/certification/v2/>
- The Planet Mark: <https://theplanetmark.com/>
- The Climate Toolkit: <https://climatetoolkit.org/>
- The BGCi Accreditation Scheme: <https://www.bgci.org/our-work/services-for-botanic-gardens/bgci-accreditation-scheme/>
- Building Research Establishment Environmental Assessment (BREEAM) <https://www.breem.com/>

Case studies

Water consumption

- Brooklyn Botanic Garden – The Water Conservation Project: https://www.bbg.org/collections/gardens/water_conservation_project
- Auckland Botanic Gardens – Sustainable rainwater management: <http://www.aucklandbotanicgardens.co.nz/science/sustainability/sustainable-water-management/>
- Royal Botanic Gardens Victoria - Melbourne – Working Wetlands: <https://www.rbv.vic.gov.au/sustainable-landscapes/sustainability>
- Naples Botanical Garden – Water quality: <https://www.naplesgarden.org/education/sustainability/>
- Eden Project – Make the change: <https://www.edenproject.com/make-the-change>
- Denver Botanic Gardens – One World One Water Center: <https://www.msudenver.edu/owow/>

Energy consumption

- Gardens by the Bay – Cooling conservatories: <https://www.gardensbythebay.com.sg/en/the-gardens/sustainability-efforts.html>
- National Botanic Garden of Wales - biomass boiler - The Carbon Trust guidance on biomass heating: <https://www.carbontrust.com/resources/biomass-decision-support-tool>
- Dawyck Botanic Garden (RBGE) - Micro hydro-electric scheme: <https://www.rbge.org.uk/news/articles/dawycks-hydro-electric-scheme-on-full-power/>
- Eden Project – Generating power: <https://www.edenproject.com/eden-story/behind-the-scenes/cutting-energy-and-carbon-at-eden>
- Cheyenne Botanic Gardens – Solar heated greenhouse: <https://www.botanic.org/about/sustainability/>
- VanDusen Botanical Garden - Sustainable Visitor Centre: <https://www.greenroofs.com/projects/vandusen-botanical-garden-visitor-centre/>
- North Carolina Botanical Garden Education Center: <https://ncbg.unc.edu/visit/ncbg/aec/green-features/>
- Phipps Conservatory and Botanical Gardens - Net-Positive Energy with No Combustion: <https://www.phipps.conservatory.org/green-innovation/at-hippys/center-for-sustainable-landscapes-greenest-building-museum-garden-in-the-world>

- Phipps Conservatory and Botanical Gardens - Make the Switch at Phipps! Green Power Drive: http://climatetoolkit.org/wp-content/uploads/2019/09/Converting_to_Green_Energy.pdf

Carbon consumption

- Phipps Conservatory and Botanical Gardens – Carbon offsetting: http://climatetoolkit.org/wp-content/uploads/2019/09/Offset_all_carbon_from_heating.pdf
- Royal Botanic Garden Juan Carlos I, University of Alcalá - Electric car charging points: <http://botanicoalcala.es/proyectos/fotolinera/>
- Wollongong Botanic Garden – Theatre in a wheelbarrow (environmental theatre): <http://council.wollongong.nsw.gov.au/botanicgarden/whatson/Pages/theatreinawheelbarrow.aspx>
- Tower Hill Botanic Garden – Worcester Tree Initiative <http://www.treeworcester.org>

Waste, recycling and composting

- Royal Botanic Gardens Kew – Plastic waste reduction: <https://www.kew.org/read-and-watch/how-kew-gardens-is-fighting-plastic-pollution>
- Eden Project – Wasteline Initiative: <https://www.edenproject.com/eden-story/behind-the-scenes/waste-and-recycling-at-eden>
- North Carolina Botanical Garden – Compost workshops: <https://ncbg.unc.edu/outreach/cccg/>
- Chelsea Physic Garden – Shelf life: <https://www.chelseaphysicgarden.co.uk/teaching-resources>

Sustainable food

- Pha Tad Ke Botanical Garden – Farm to table dining experience: <https://www.pha-tad-ke.com/visit/slow-food/>
- Royal Botanic Gardens Kew – Seasonal and local produce: <https://www.kew.org/read-and-watch/kews-restaurants-sustainable>
- SDG2 Advocacy Hub - Chef's manifesto: <http://www.sdg2advocacyhub.org/chefmanifesto>
- Chester Zoo – First Sustainable Palm Oil City: <https://www.chesterzoo.org/what-you-can-do/our-campaigns/sustainable-palm-oil/sustainable-palm-oil-city/>
- Phipps Conservatory and Botanical Gardens - Sustainable practices at Cafe Phipps: <https://www.phipps.conservatory.org/visit-and-explore/visit/cafe-hippys>
- New York Botanical Garden – Bronx Green-Up: <https://www.nybg.org/gardens/bronx-green-up/>
- Royal Botanic Garden Edinburgh – Food Forever global exhibition: <https://www.bgci.org/our-work/projects-and-case-studies/food-forever-global-exhibition/>

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(Barney Wilczak)

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Front cover images:

Top left and bottom right, Paul Smith. Top centre, VanDusen Botanical Garden. Top right, Chicago Botanic Garden
Middle left, Rosendo Elvira. Middle right, Allie Caulfield
Bottom left, New York Botanic Garden

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