Royal Academy of Engineering

# THIS IS ENGINEERING




# ENGINEERING A BETTER WORLD

**The Vertical Farm** – Paul Matovu, Uganda

A STEM resource inspired by the AFRICA PRIZE FOR ENGINEERING INNOVATION

# ABOUT THE VERTICAL FARM

**Paul Matovu, is a forester and environmental scientist from Uganda.**

He has developed The Vertical Farm, a farm-in-a-box vertical garden to grow leafy greens in urban settings. Each farm is custom built for users with little space for gardening.

## Time to research

Using a smartphone, laptop or tablet, search for **'Vertical and Micro Gardening' by Paul Motovu** and watch the video to answer the questions below.

- What is the five-pillar benchmark that The Vertical Farm operates on?
- How does Paul describe vertical farming?
- How many plants can a person grow in one farm?
- Where will The Vertical Farm be used?
- Why will it be most useful there?
- How will they ensure that plants grow all year?
- What tests were carried out for The Vertical Farm?

## How does it work?

The Vertical Farm is a vertical gardening and composting system built into a box. It makes the most of limited space by building upwards, allowing for several levels to grow plants.

Paul Matovu developed his innovation for Kampala, the capital city of Uganda, which is growing at a fast rate.

## Time to calculate

The land area of Kampala is 189 square kilometres. The approximate population is 1,700,000.

- What is the population density?

*Why might vertical farms be useful in cities which have a high **population density**?*

Each level of the vertical farm is **one square metre**. The height of each level is **30 centimetres**. The farms are currently built up to four levels high.

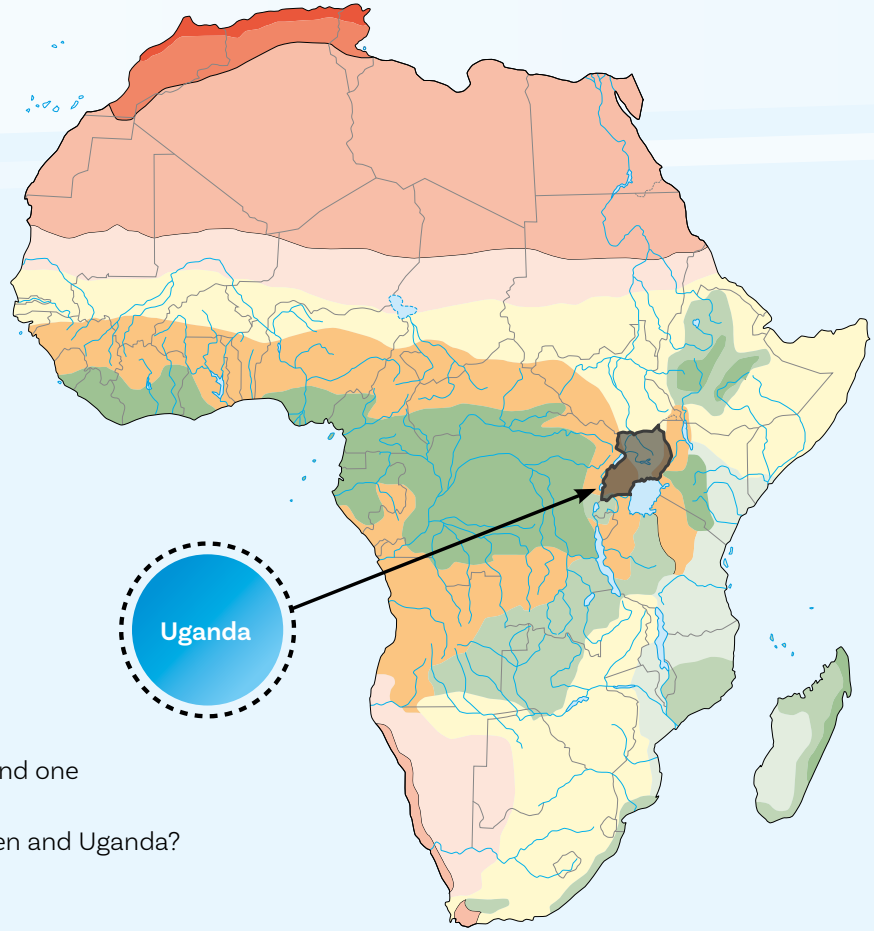
- If the farm in the picture can contain up to 200 plants, how many plants could be grown on each level?
- Approximately how many cubic metres of soil will be needed for each level? How much soil will be needed for the whole farm?
- Approximately how much wood will be needed to build each level?

## Stretch and challenge

As you can see from the picture, the vertical farm needs to be built on a foundation layer and needs to have holes cut out for the plants to grow.

Based on the measurements that you have for the vertical farm, sketch a plan with dimensions to show the size of the foundation layer and where the holes will be drilled.

# COUNTRY PROFILE




## Time to research

You are an engineer working with a team in Uganda. In small groups, use a computer, tablet or smart phone and visit Ducksters.com and answer the questions below.

You will create a country profile with this information.

- What is the land area of Uganda?
- What is the general climate?
- What natural resources does Uganda have?
- What is the population of Uganda?
- What is the terrain?
- What is the main industry?

Why do you think the information you have gathered will be useful?
What other information do you think would be useful to know?

## Stretch and challenge

- Use the online tool – The True Size – and find one country that is smaller than Uganda and one country that is larger.
- What is the difference in square kilometres between the other countries you have chosen and Uganda?
- How many times smaller or larger are the countries that you have chosen?

## SUSTAINABLE DEVELOPMENT GOALS

- End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- Make cities and human settlements inclusive, resilient and sustainable.
- Ensure sustainable consumption and production patterns.


## Time to reflect

After you have completed this challenge, reflect on how The Vertical Farm works towards the Sustainable Development Goals mentioned right.

What ideas can you use for your own project in the World's Largest Lesson?

# COMPOSTING

**A key feature of the vertical farm is that the central column (vermicomposting chamber) converts biodegradable urban waste into compost.**

Compost is decayed **organic matter**. When you mix organic matter in a compost pile, it breaks down naturally into a nutrient-rich fertiliser that helps plants grow.

## Time to research

Research which organic matter is suitable for composting. Create an information sheet that will clearly show someone what they can and cannot compost.

## Why compost?

Composting is important for many reasons!

When food waste goes into landfill it emits **methane** and **carbon dioxide**, together creating a biogas that goes straight into the atmosphere.

The methane in the biogas is extremely harmful to the environment.

But composting is an excellent way to benefit from food wastage. It increases the water retention of soil so it needs less irrigation (watering). It also produces soil that is high in **nutrients** so a greater number of healthy plants can grow.

**Nutrients** are substances used by any organism (that also means plants) to survive, grow and reproduce.

## Over to you!

Are you composting at school?
Are you composting at home?

Coming up with an effective solution for composting is an excellent way to reduce waste and to encourage responsible consumption. We have provided the basics to get your own compost bin started but it's up to you to experiment to find out what works and what doesn't work, encourage people to use the bin and decide what you will do with your compost.

### 1. Getting started

You will need a plastic container with a lid (is there anything you have at home that can be recycled?) Place holes in the lid, around the container and at the bottom as drainage holes.

### 2. What to prepare

You will need a mixture of 'green' materials that are rich in **nitrogen** and 'brown' materials that are rich in **carbon**, all shredded into small pieces.

**Carbon-rich** materials include dry leaves, twigs, plant trimmings, shredded cardboard and newspaper.

**Nitrogen-rich** materials are mostly your left-over food scraps. These include egg-shells, fruit and vegetables, mouldy bread and cut flowers.

Refer to the research you did around what organic matter can and cannot be composted!

You will also need some soil (ideally taken from another active compost).

### 3. Layering your compost

Build up alternate layers of carbon-rich ingredients, soil and nitrogen-rich ingredients. Add water so that everything is damp (but not soaking). If doing this indoors, put your compost on a plate or dish.

This ratio (see image) is a useful guide for layering your compost.

Cover with fleece, mesh or muslin.

Place in a warm place outside of direct sunlight.


## Rotting away

A healthy compost needs looking after.

As the composting process takes place, materials will start sinking and you will need to continue adding additional material.

After approximately four to six weeks, the materials should look like a dark, rich soil. You can start planting seeds at this stage (for example chives or green beans). Just add another layer of soil, place in a well-lit area and water.

This is a long-term project, so make sure you are tracking progress overtime. A photo diary is a great way to do this!

## Worm composting

A process called **vermicomposting** is used in the vertical farm where different species of worms are used to feed on the biodegradable food waste to produce high quality fertiliser.

The unit has a vermicomposting core that supplies highly nutritious soil to all levels of the farm where different crops are grown.

The vermicomposting core has been designed so that worms can travel through the column contributing to aeration and infiltration while also depositing their nutrient-rich waste (**vermicast**).

## Stretch and challenge

Testing and evaluating different compost compositions is a great way to find the process that works best for your environment.

Set up more than one bottle so you can compare results (make sure you label them so you can track what is happening). You might want to set up a 'control sample', comparing any variations you make to the control sample.

## Teachers note

Try **vermicomposting with your class** as one variation. Red worms (sometimes known as red wigglers) are considered best for compost and can be purchased online. Worms need to be in the dark so you will need to adapt your container.

Visit shareitscience.com and search for worm composting for more tips on building a worm bin.

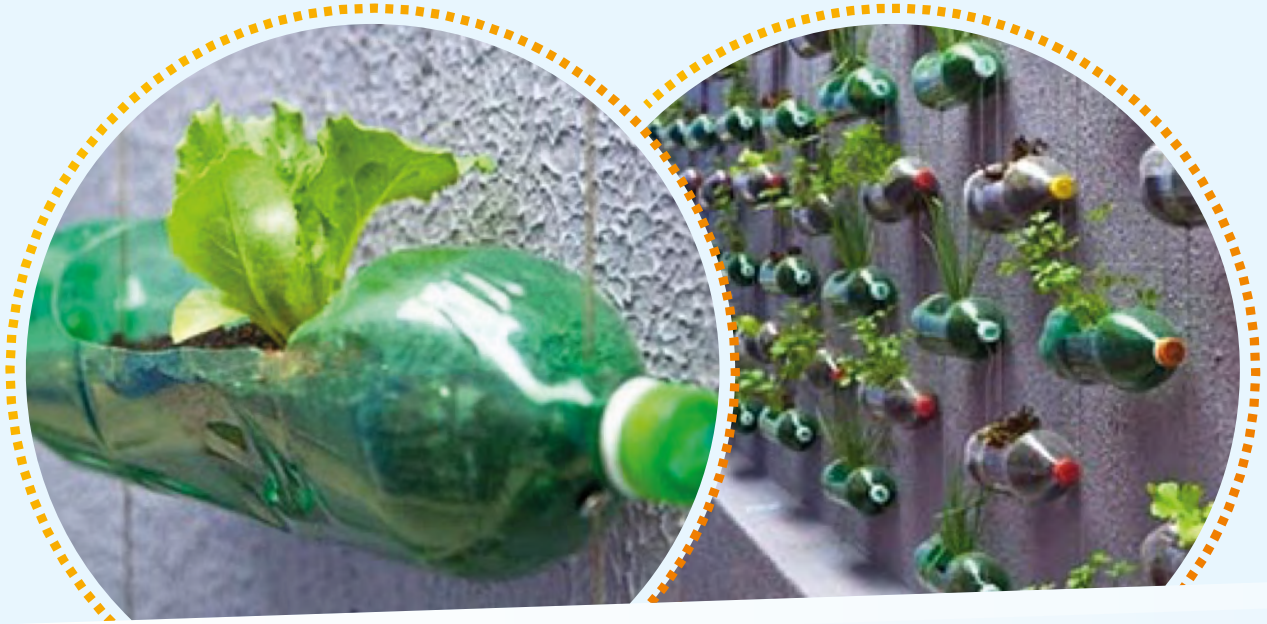
Investigate with your class how this might affect their compost mix.

## Time to build

Vertical farms are becoming more popular in cities all around the world.

Depending on whether your school or home is in a town, city or village, design and build a farming unit that would be suitable for your home or school environment.

Engineer a **window farm** that will support at least four plants using as little horizontal space as possible. You will also design and build a **lighting system** that will direct light to all levels of your window farm.



- You will work in groups to engineer your garden.
- Your garden must support four plants.
- You can either hang your garden or it can be a single free-standing unit.
- You must use recycled material and/or material provided in the box.

## Stretch and challenge

Engineer a water system that delivers water to all levels.

### Handy hint!

Use the water irrigation system you created in the SolarKoodo resource to help you build your own watering system.

### Design, model, test, repeat...

Use your engineering habits of mind when designing and testing your vertical farm, lighting system and watering system.

Experiment by creating different models, test your design and continue adapting and improving.

Use the sentence starters and the sub-habits below to show how you have been thinking like an engineer.

- We **visualised** when designing and building our window farm by...
  Sub-habits: thinking out loud / modelling
- We **adapted** our window farm by...
  Sub-habits: evaluating / critical thinking
- We have **improved** our window farm by...
  Sub-habits: experimenting / deliberate practicing

**Engineering habits of mind**

- Visualising
- Improving
- Adapting

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