Royal Academy of Engineering

# THIS IS ENGINEERING



# ENGINEERING A BETTER WORLD

**Majik Water** – Beth Koigi, Kenya

A STEM resource inspired by the AFRICA PRIZE FOR ENGINEERING INNOVATION

# ABOUT MAJIK WATER

**Beth Koigi is a mechatronics engineer and project planner from Kenya.**

She has developed an innovation that harvests water from the atmosphere in especially arid areas. She then sells affordable and clean water to communities through unmanned water 'ATMs'.

**Using a smartphone, laptop or tablet, visit www.majikwater.co and watch the video (scroll down to find it) to answer the questions below.**

- What proportion of people in Kenya do not have access to clean water?
- What problem were the engineers trying to solve?
- What was their design criteria?
- What science inspired their innovation?
- What materials are they using for their innovation?
- How did they test if their innovation worked?
- How could their ideas help people and the environment?

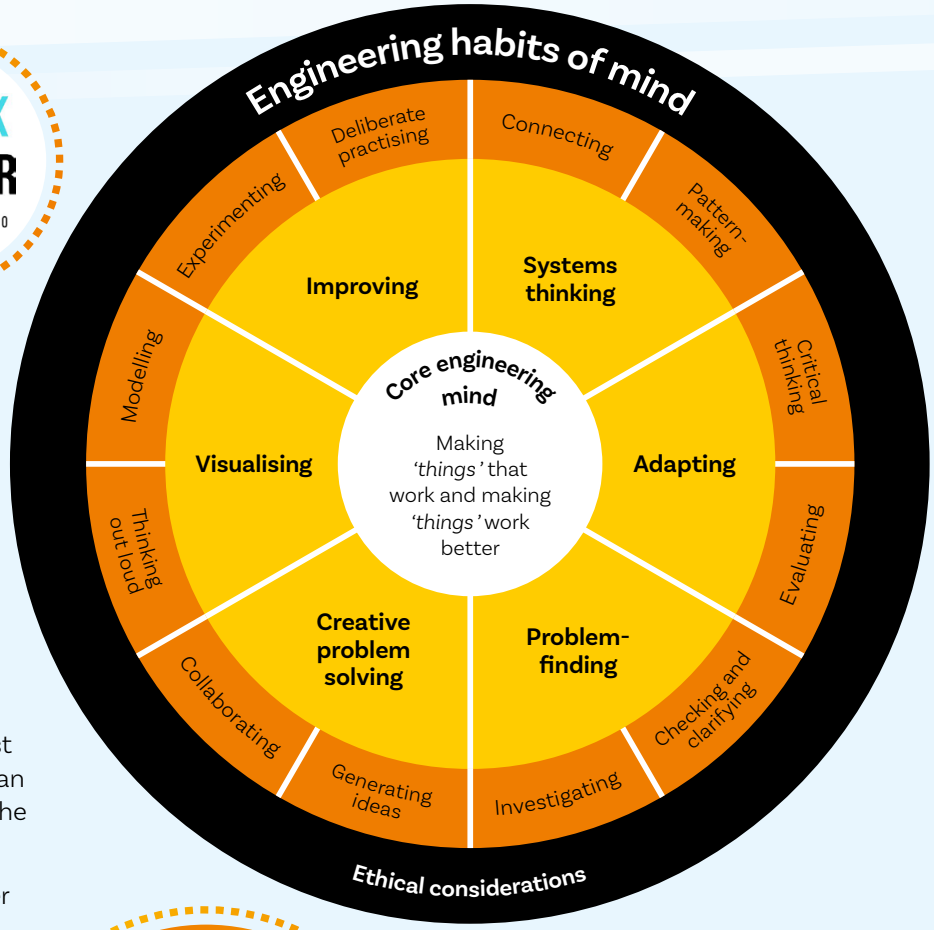
Kenya has three types of climate. Hot and **humid** along the coast, **arid** or semi-arid in the north and east and temperate in the mountainous areas in the west and south-west (see map on the next page). This creates a huge problem for many people accessing clean water. Rather than feeling defeated by this, Beth looked for opportunities to work with the heat in her country to tackle the problem of limited drinking water.

She has been developing a system in which her and her team can harvest drinking water from the atmosphere, especially in particularly dry areas. She wants to increase access to clean drinking water among low-income households in these regions.

At first, it sounds like Beth has achieved the impossible – producing water from air – but she has been experimenting with lots of creative solutions.

## Time to reflect

What engineering habits of mind do Beth and her team demonstrate?

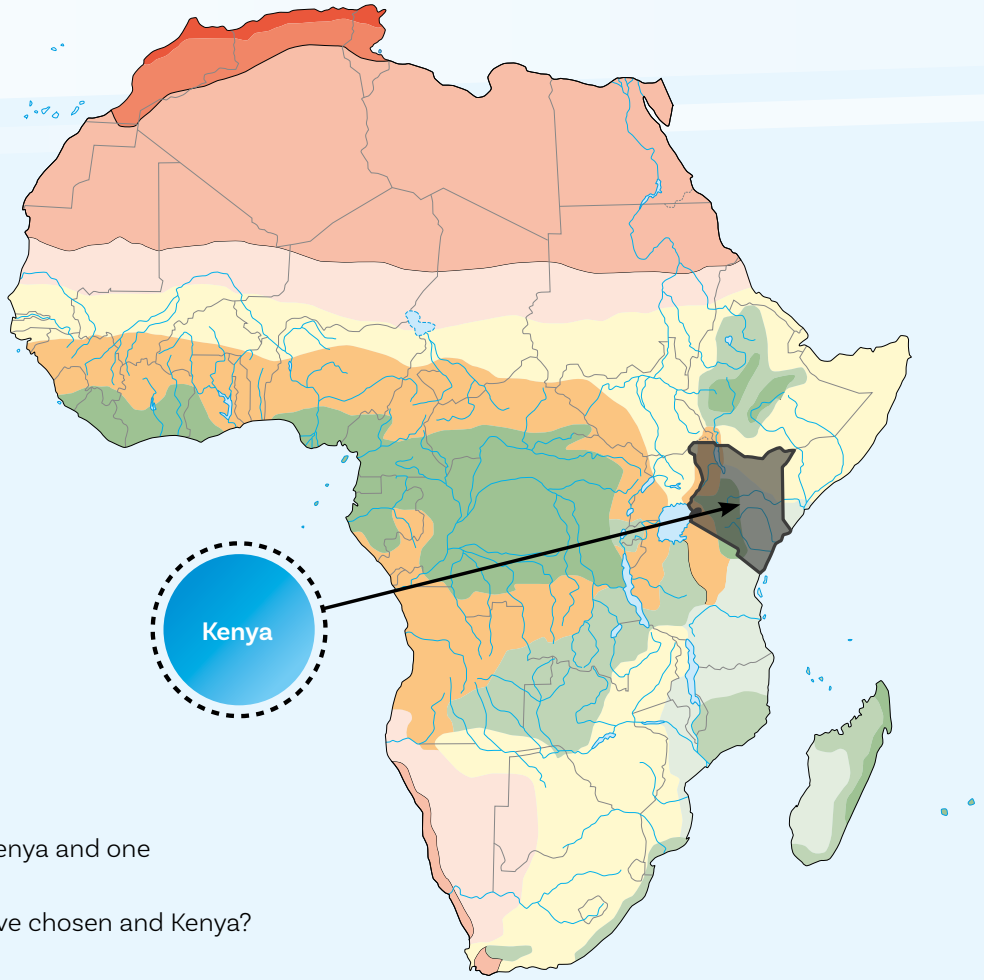



**Arid:** having little or no rain.

**Humid:** high level of water in the atmosphere.

**Mechatronics:** technology combining electronics and mechanical engineering.

# COUNTRY PROFILE




## Time to research

**You are an engineer working with a team in Kenya. 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 Kenya?
- What is the general climate?
- What natural resources does Kenya have?
- What is the population of Kenya?
- 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 could be useful to know?

## Stretch and challenge

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

## SUSTAINABLE DEVELOPMENT GOALS

- Ensure availability and sustainable management of water and sanitation for all.


## Time to reflect

After you have completed this challenge, reflect on how Majik Water works towards the SDG mentioned above.

# THE WATER CYCLE

## Time to experiment

You may notice that when you drink a cold drink from a can on a **humid** day, water forms on the outside of a can. Another example is when the grass is wet in the morning after a cold night, even though it hasn't rained.

This is called **condensation** and it is a change of matter from water vapour to liquid water.

This happens when water vapour comes into contact with a surface that is cooler than the air.

*How do you think this relates to Majik Water's innovation?*

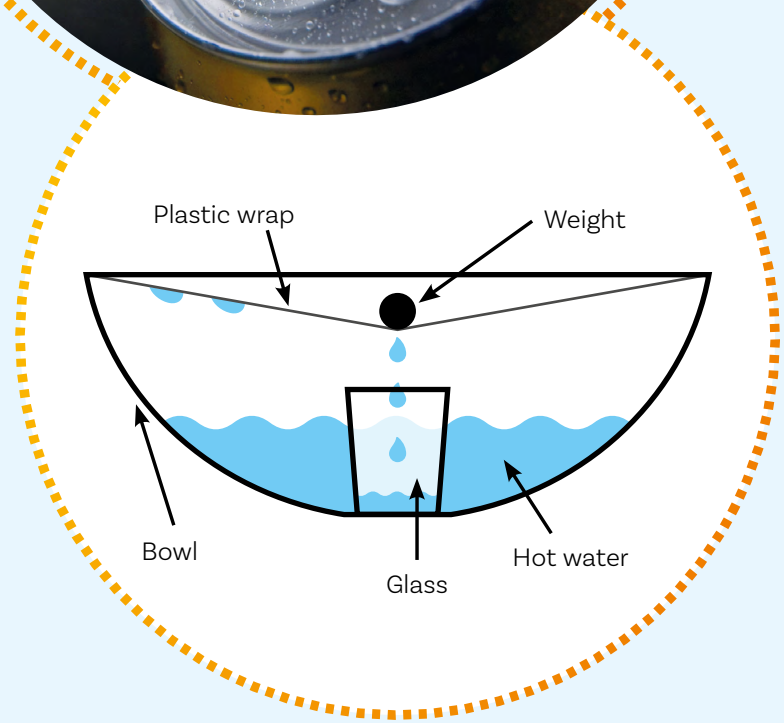
Beth and the team have applied knowledge about the water cycle and adapted it to develop a simple innovation that will have a big impact in Kenya.

## Create your own water cycle

**What you need**

- Large plastic bowl
- A mug
- Cling film
- String
- Water
- Small weight (for example, a few coins)

1. Place the mug in the bottom of the bowl
2. Add water around the mug so that it rises to approximately ⅔ of the height of the mug
3. Cover the bowl tightly in cling film and secure with the string
4. Place the weight on top of the cling film over the mug
5. Mark the water level on the bowl
6. Leave overnight and somewhere where the sun will hit it if possible.




What do you notice? What do you think the water droplets on the cling film represent? What could the mug represent?

Try different variations of this experiment and compare your results. What happens if you use hot water? Cold water? Try putting small pieces of ice on top of the cling film.

## Time to think

What do we know about the climate in Kenya and how do you think this affects the water cycle?

You are trying to capture as much water as possible in the mug. How could you improve the water cycle system from this experiment?

## Stretch and challenge

**How much does a cloud weigh?** This will depend on how **dense** the cloud is. Density tells us how compact a substance is.

Scientists have calculated the **water density** of a typical cumulus cloud (one of ten main groups of cloud) as being ⅔g per cubic metre. This would be the same as a small marble's worth of water in a space that you could comfortably sit in.

A typical cumulus cloud is a kilometre tall and a kilometre long. What is the mass of the cloud?

*One cloud is approximately the same mass as 100 African elephants!*

## Listen and learn

Beth talks about how she sources Majik Water from the air.

Listen to her short BBC radio interview **'How to source Majik Water from the air'** and answer the questions below:

1. What method does Beth use to 'extract water from the air'?
2. What problems does she identify?
3. How does she resolve these problems?
4. How much water is the prototype capturing per day?
5. What engineering habits of minds is Beth demonstrating?

# HARVESTING DRINKING WATER FROM AIR

**In any good design process, it's important to develop, improve and build on your ideas. Beth and the team are continuing to review and improve their innovation so it best meets their design needs.**

The diagram shows how the Majik Water system works.

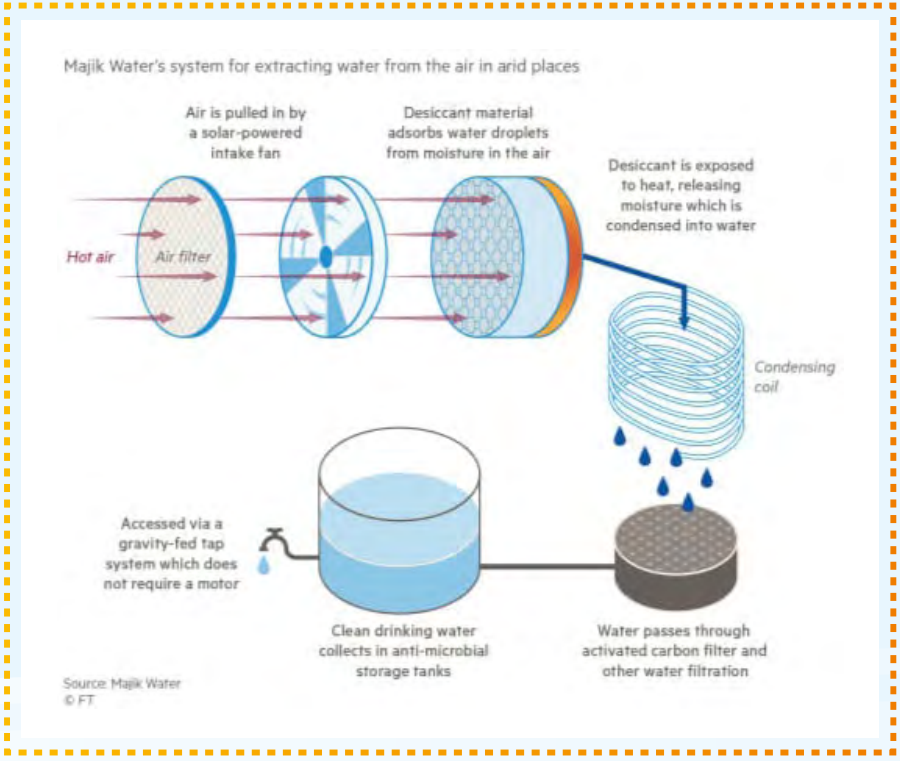
Write up a step-by-step information sheet to show the process.

**Desiccant** is a substance that absorbs water. An example of a desiccant material is silica gel. You may have seen this in sachets in packages you buy.

## Process

1. .....
2. .....
3. .....
4. .....
5. .....
6. .....
7. .....

*This space is just used as a guide. You may wish to add more or less steps.



## Time to calculate

Majik Water still needs to generate income to continue running and to have the greatest impact and reach.

### Customer 1: Rural areas

**Business model - pay as you go**

Smart-taps will be installed where customers can bring their own containers to fill up with water.

Water will cost $0.01 per litre.

### Customer 2: Semi-urban areas

**Business model – monthly membership**

Stores set up a scheme where customers pay a monthly membership fee of $2.00 per adult and $0.80 per child. On top of this, they will also pay a one-off charge of $1.50 to purchase a reusable 5-\litre branded Majik Water bottle.

Let's assume the average adult needs 3 litres of water per day for eating and drinking and the average child needs 1.5 litres of water per day for eating and drinking.

A family living in a rural part of Kenya consists of two adults and three children, how much would they pay per day for their water? How much would they pay for a month's water in September?

A family living in a semi-urban part of Kenya consists of two adults and three children, how much would they pay for their first month membership? How much would they pay for the following months?

Majik Water is currently harvesting 1000 litres per day. With the current model, approximately how many adults / children / families consisting of two adults and three children can Majik Water reach?

## Stretch and challenge

As the project expands, the team at Majik Water will be developing different ways to quickly calculate revenue. **Revenue** is the income that a business makes from sales before deducting any costs.

Based on the information provided, write formulas to calculate revenue for each business model.

## RISKS

**Like any innovation, it is important to consider potential risks.**

In your groups identify two possible risks of the project and explain your reasoning.

## Prototyping

**Beth and the team built a prototype of their design.**

- Why do you think this is important?
- What did they learn?

# SOLUTIONS

## Answers – time to calculate

- If a family living in a rural part of Kenya consists of two adults and three children, how much would they pay per day for their water?

  *(2 x 3 litres x 0.01) + (3 x 1.5 litres x 0.01) = $0.105* however they would pay $0.11.

- How much would they pay for their water in September?

  *$0.105 x 30 = $3.15*

- If a family living in a semi-urban part of Kenya consists of two adults and three children, how much would they pay for their first month of membership?

  *(2 x $2.00) + (3 x $0.80) + ($1.50) = $7.90*

- How much would they pay for the following months?

  *(2 x $2.00) + (3 x $0.80) = $6.40*

- Majik Water is currently harvesting 1000L/per day. With the current model, approximately how many ..... can Majik Water reach?

  *Adults = 1000 ÷ 3 ≈ 333*

  *Children = 1000 ÷ 1.5 ≈ 666*

  *Families consisting of two adults and three children = 1000 ÷ 10.5 ≈ 95*

## Stretch and challenge

- There are several ways we can write these formulas.

  This is one example:

  *Pay as you go: Revenue = Adults x 0.03 + Child x 0.015 x Days*

  *Monthly plan: Revenue = Adults x 2.00 + Child x 0.80 x Months*

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