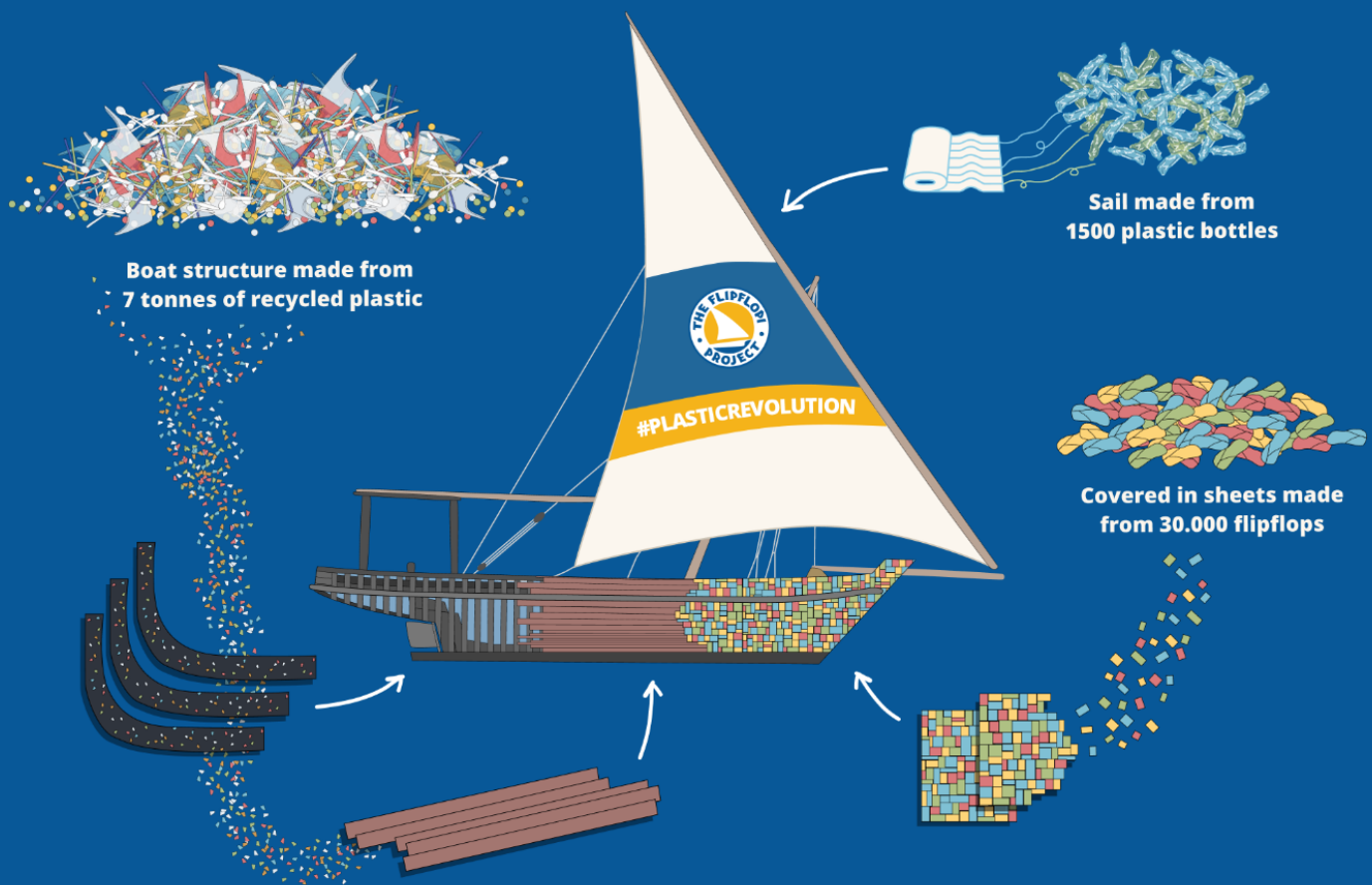




From Waste to Wonder

# BUILDING THE WORLD'S FIRST RECYCLED PLASTIC SAILING DHOW



A FLIPFLOPI TOOLKIT

Compiled and written by Katharina Elleke

# INTRODUCTION

The plastic waste problem is pervasive, with improperly discarded plastics choking our ecosystems and threatening the health and wellbeing of our communities.

**For many, plastic waste has no value, but for us, trash is treasure.**

In 2015, our project co-founder, Ben Morison, came up with an idea after he was struck by the amounts of plastic, especially flip flops (slippers), littering the beautiful beaches he deeply loved.

He decided to research alternative uses for used plastic – and quickly realised that building a boat from this waste would be an effective way to celebrate the centuries old traditional craft of dhow building that is a cornerstone of the Swahili culture of our coastal region, while also sharing a positive message about the need for change.

Shortly after, Ben joined forces with Ali Skanda, a renowned dhow builder from Lamu in Kenya and together they set about building a traditional sailing dhow entirely from waste plastic with the aim to create a positive example of how single-use plastic could have a second life.

Combining traditional boat building whilst also pioneering new techniques, Ali and his team were able to craft the various components of the dhow.

Ten tonnes of plastic waste, all collected from the coast and towns of Kenya, were melted, shaped and carved by the team exactly as they would do with wood. Clad in 30,000 flip flops, the footwear of 3 billion people (and the most common item found during our beach clean ups), the 10-metre and 7 tonne dhow, aptly named “The Flipflop” was born.

**As the first of its kind, our dhow is a prototype.** The processes we used to build it were developed through trial and error and are not perfect. But the lessons and techniques learned along the way are invaluable. **That’s why we’ve created this toolkit - to give you what we didn’t have - a foundation on which to build.** There is a lot of discarded waste in our environment which has value and there are many more boats to build. Hopefully this toolkit can inspire you to build your own recycled plastic boat - or get ideas for other exciting recycled plastic projects!

P.S. Don’t take this as a guide to copy identically but as something to learn and get inspired from :)

# CONTENT

**0 - OVERVIEW**

**1 - GATHER A TEAM**

**2 - MAKE A PLAN**

**3 - LEARN YOUR PLASTICS**

**4 - MAKE THE BIG PARTS**

**5 - MAKE THE PLANKS**

**6 - MAKE FLIPFLOP SHEETS**

**7 - BUILD THE BOAT**

**8 - SET SAIL AND INSPIRE**

**9 - FLIPFLOPI KUBWA**

# 0 - OVERVIEW

As a start, here you can see an overview of what it took us to build The Flipflop “Ndogo”.

## PEOPLE

- 3 Co-Founders with a vision and strategy
- 5 Boat builders + helpers from time to time
- 2 Design Engineers
- 2 flipflop Artists
- Dozens of waste pickers and cleanup volunteers
- Workers of recycling manufacturers

## MATERIALS

- Plastic (HDPE, PP, LDPE) ~ ca. 10 tonnes
- flipflops ~ ca. 30.000 pieces
- Metal and wood for templates and moulds
- Nuts and bolts, screws, sealing material, glue
- Sailing Accessoires (mast and boom, ropes, etc.)

## FACILITIES/EQUIPMENT

- Plastic recycling facility  
(incl. washing and drying facilities, plastic granulator, and extruders)
- Carpentry and boat building workspace  
(incl. wood working machines and hand tools like saws, drills, screwdrivers etc.)
- Grinder and welding machine for the metal moulds and post production

## MONEY

- This is really hard to sum up, it took hundreds of thousands for materials, services, trials and errors. We did a couple of fundraising campaigns, but also put in a lot of our own resources.

## TIME

- It took us 2 years to finish the boat, including designing, testing, trial and error.

**In the following chapters we will explain more about our process and what to learn from it.**



# 1 - GATHER A TEAM

**Building a boat is no easy task, and building one out of plastic waste is a bit crazy.** You need a support system of equally enthusiastic, innovative, and slightly crazy individuals to build something that is one of a kind.

The Flipflopi founder **Ben Morison** started by finding a visionary who was confident in building a boat from a totally different material than he was used to. **Ali Skanda**, from Lamu, Kenya, is our captain, and together with his core boat building team, **Hassan Shafii, Ahmed Bakari, Rashid Abubakar, Bakari Omar and Ahmed Obo** (to name the main ones), they applied their knowledge and creativity into building a dhow from plastic waste.

Also on board was our project leader and co-founder, **Dipesh Pabari**, and our engineering team made up of **Leonard Schürg** and **Katharina Elleke**. There are also countless other people, starting with our families, who showed their support throughout this process - they were vital in getting our dhow on the ocean and we can't thank them enough.

## WHAT TO TAKE AWAY

- You need a **support system** - friends, family, colleagues. Don't hesitate to approach new people, share your ideas, and form new networks. You never know what brilliance can come out of it.
- **Collaborate with experts** in boat design and building. We wanted to build a Swahili dhow, so we found a celebrated dhow builder with decades of experience. Without Ali and his team, we couldn't have built this beautiful dhow.
- **Have patience** and don't lose your motivation when things don't come together as quickly and easily as you would like - it took us two years to build this boat!

# 2 - MAKE A PLAN

## GET INSPIRED BY OTHERS

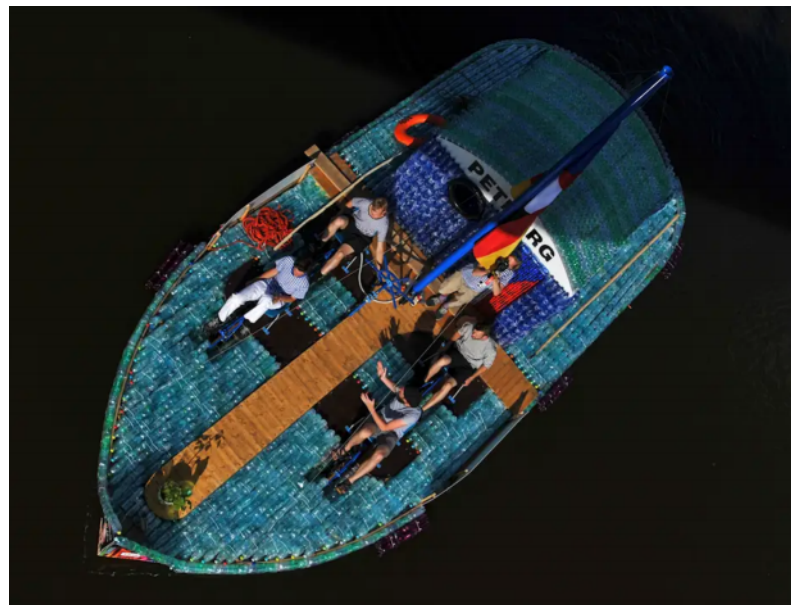


**Plastiki** - A sailing catamaran made using recycled PET bottles

**Plastic bottle boat** in Cameroon



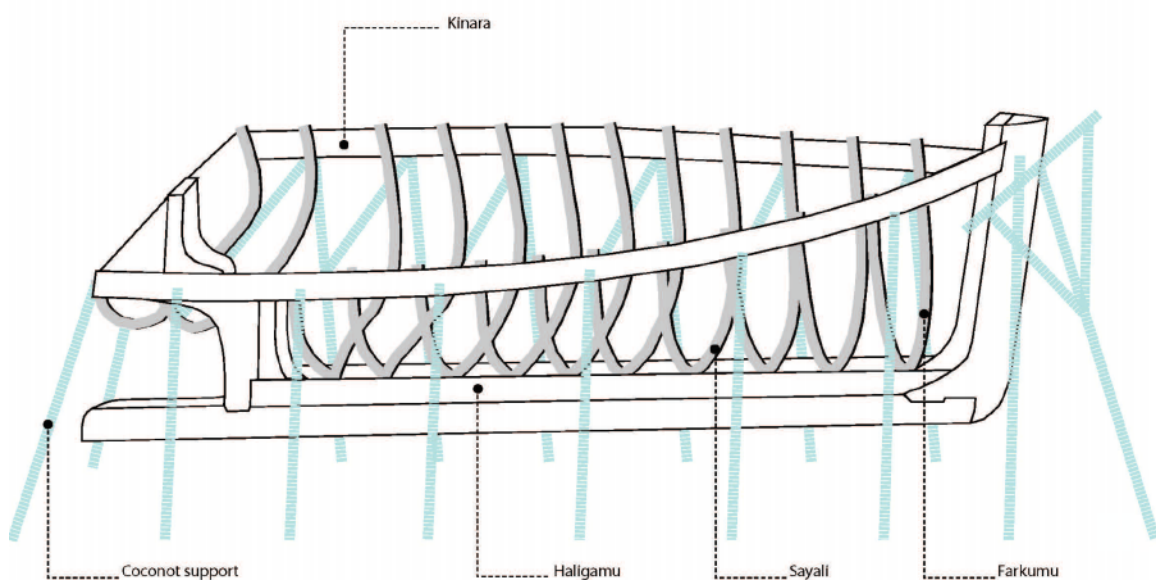
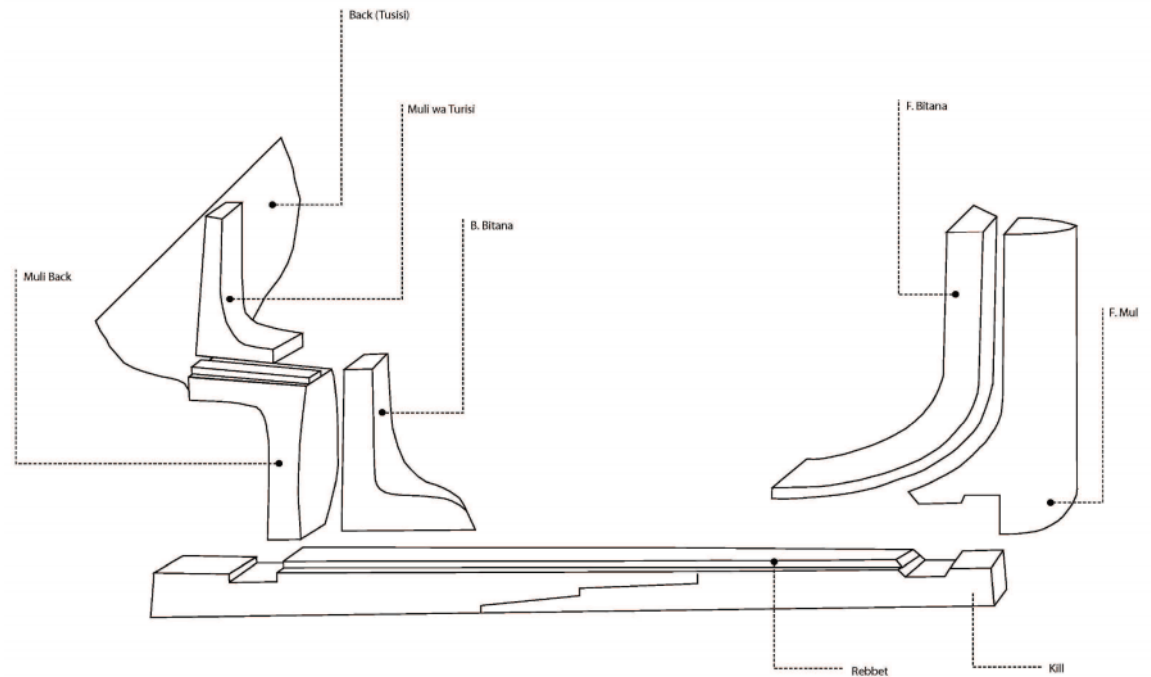
**Petburg** - A bicycle powered plastic bottle raft in Germany



## DESIGN YOUR BOAT

Together as a team we made a plan and designed the boat. The goal originally was (and still is), to build a boat which is big enough to sail around the world. But as this hasn't been done before and was going to be a big investment, we decided to start with a smaller 10-metre prototype first.

Here are some of the sketches to get an overview of the boat components (these can obviously vary, depending on the boat you want to build):



# 3 - LEARN YOUR PLASTICS

Even if you want to work with an experienced recycling manufacturer, you will most probably find that it helps a lot if you familiarise yourself with the world of plastics. This way you can get a better idea of what plastics you'll need to collect, and what machinery and processes there are to deal with this material.

Here are the main topics you'll need to know about:

## PLASTIC TYPES

There are many different types of plastics out there, each used for different purposes and therefore made to have different properties. It's very important to make sure they don't get mixed in the recycling process!

Whether you are collecting your waste from community cleanups or buying it from collectors, it is important to understand the different types of plastic and identify what you will need for your construction.

Here is an overview of the 7 existing categories of **thermoplastics** (=plastics which can be remelted and reformed into new shapes):



**For the Flipflopi dhow**, we collected over 10 tonnes of plastic waste from Kenyan beaches and streets. The keel, ribs and structural elements of the Flipflopi are all made from recycled **HDPE** (mostly found in Jerry Cans or other containers for liquids, like shampoo bottles). The reasons why we chose HDPE were its properties (buoyancy and flexibility) and its availability to be collected in sorted and relatively clean form.

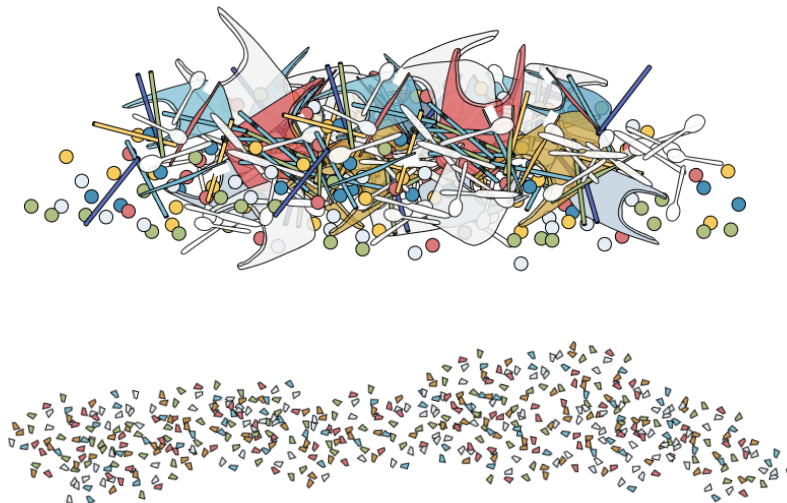
## PLASTIC RECYCLING

It's also useful to have a rough understanding of how recycling works and what machines and processes there are.

### Part 1: From plastic waste to plastic flakes

As a first step of most plastic recycling processes, all the different collected plastic waste has to be turned into a form that can be processed more easily:

- **Collect plastic:** Collection can happen through collection companies, waste pickers, clean-ups, or other activities.
- **Sort plastic:** It's very important that the plastic is sorted into the different plastic types to maintain a good material quality. If you sort by colour, this will allow you to use colours to create beautiful products!
- **Clean plastic:** Plastic has to be cleaned, as oil, dust or other dirt in the material can result in poor material quality.
- **Shred plastic:** Shredding or granulating machines are used to break plastic waste down into small flakes, so they can be transported and processed much easier.





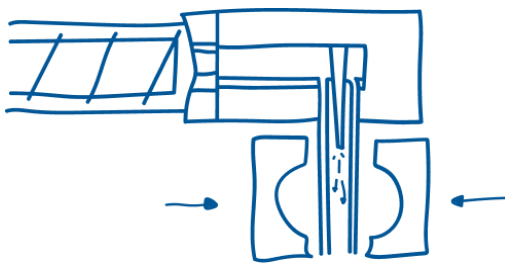
## Part 2: From plastic flakes to new product

The plastic flakes can now be used in a variety of melting machines. Generally, these machines and processes work with **heat and pressure**. Plastic gets melted, pressed into a new shape (through a die or a mould), and when it cools down, it hardens and keeps the shape it's been pressed into - just like chocolate.

Here some of the most commonly used processes:

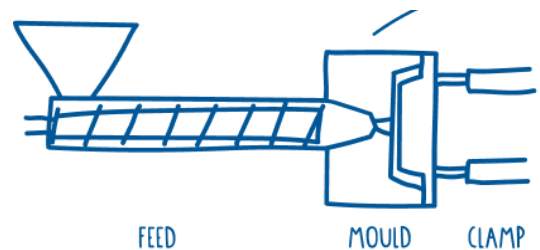
### Blow moulding

Melted plastic gets blown into a mould with the help of compressed air.



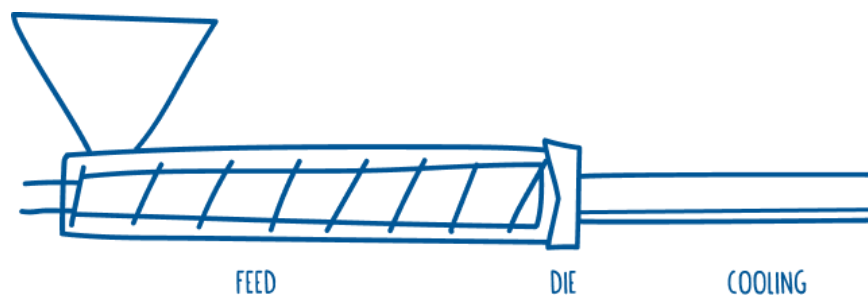
### Injection moulding

Plastic is injected into a closed mould, solidified and then cooled down.



### Extrusion

Plastic is fed into a tube where it gets heated and pushed (with a special screw) all the way to the die, which is basically a hole in the shape which defines the profile of your product.



**Extrusion (plus modifications) is the process we used for all the recycled plastic parts of the boat.** This machinery is quite commonly used in Kenya and other countries to produce recycled plastic planks, beams and other construction material.

## THE BEST PLACE TO START LEARNING ABOUT PLASTICS

A really good place to start learning the basics about plastic recycling is [Precious Plastic](#), a project developing solutions to make recycling machinery and knowledge more accessible to everyone. You can learn about plastics, machines, safety, and even what products you can create!

**Here are the most important resources we would recommend you to look at:**

- [Nerdy on plastics](#) (Overview of plastics and recycling processes in one video)
- [Precious Plastic Academy](#) (Online academy with tutorials around collecting, sorting, building machines and recycling spaces, and making products)
- [Precious Plastic Manual](#) (Printable overview document)

### WHAT TO TAKE AWAY

- **Community engagement** is key for collecting plastic and carrying out cleanups - we had hundreds of volunteers picking up trash which was eventually used for our boat.
- **Know your plastics.** What are the most common types and products in your area and what are their strengths and weaknesses? Start learning with **Precious Plastic**.
- Get an overview of the **recycling network** in your area. How and where does plastic get collected, who buys and sells it and which machines or services (like shredding or extruding) are available?
- If you are buying your plastic waste from a collector, make sure the plastic is of **good quality** (well sorted, and ideally cleaned). Even though we're using waste, quality is of utmost importance, even if it costs more.

# 4 - MAKE THE BIG PARTS



**One of the biggest challenges of making this boat was the variety of big, unique parts** which make up the skeleton: The keel, the muli, the ribs, etc.

These parts are also just very big, which alone already poses a challenge. It took us a number of trials and errors to get to a process resulting in a sufficient quality”



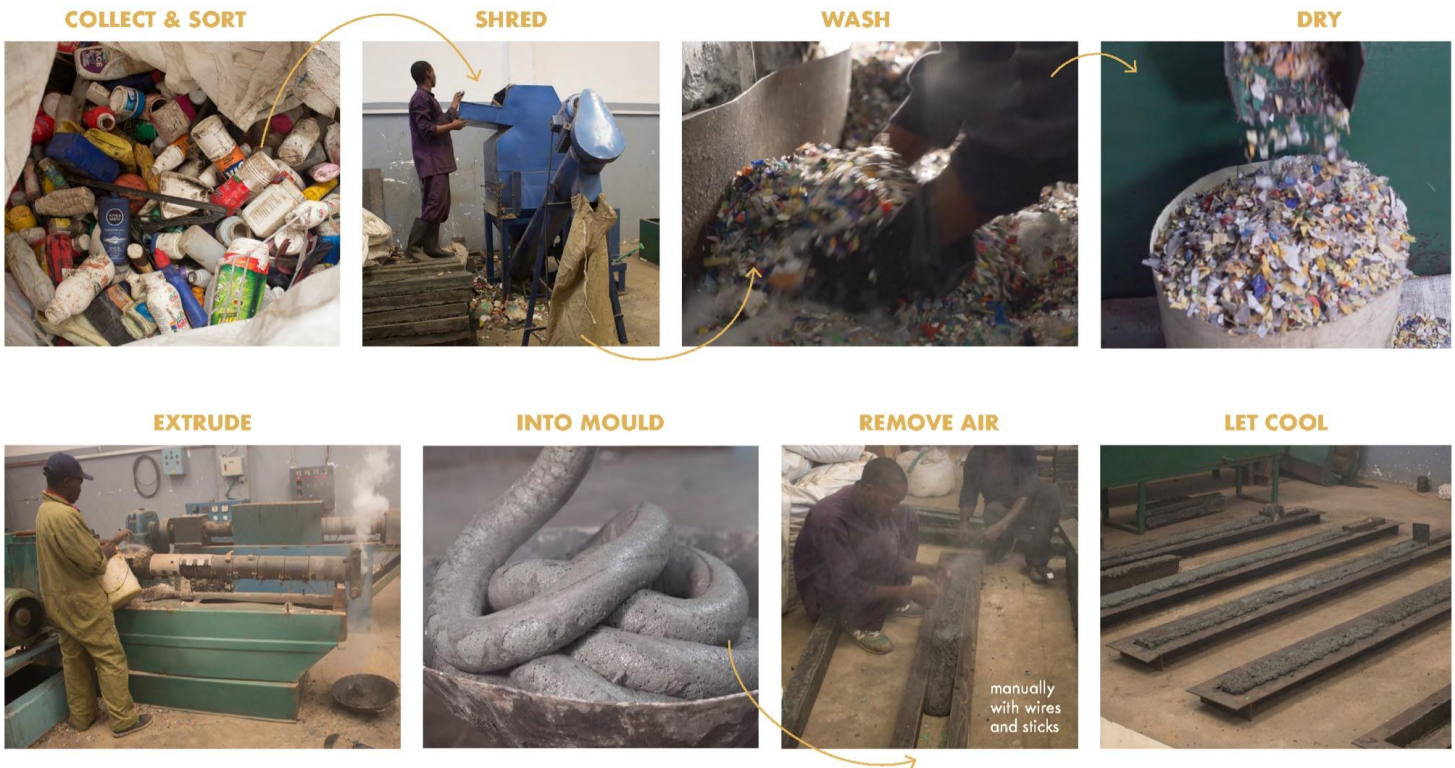


## HOW IT WAS MADE

We collaborated with [Regeneration Africa](#) in Malindi - which was the closest manufacturer to the boat building workspace in Lamu. They usually produce fencing posts and tiles.

### Process and equipment used:

- Plastic gets **collected and sorted** into types.
- Sorted plastic gets **shredded** in an industrial shredder.
- Plastic flakes get **washed** in a basin (by hand) and **dried** in a drying machine.
- Plastic flakes get **melted** in the extruder and filled into open steel **moulds**.
- Workers **remove air bubbles** with wires and sticks, and the material gets **compressed** with hand tools.
- The plastic **cools down** and hardens in the mould, and can then be taken out.



## THE MOULDS

As nearly all the parts of the boat have a unique shape, we had to make customised moulds for each shape. Ali Skanda (chief boat builder) made nearly 30 different wooden prototypes, which were then used to make the final metal moulds.





## MATERIAL TESTS

We tested these materials to help us determine what works and what doesn't. As we were building a boat, strength and flexibility was crucial. You can find the reports here:

- [Material tests](#) - An analysis of materials, including the differences between plastic, wood, and glass fibre, which can help you understand the process of testing the different samples.
- [Flipflopi Beam Bending Analysis](#) - A report of experiments conducted to determine the Flexural Strength of the Recycled Plastic Material and to test the strength and properties of an adhesive to bond the recycled plastic material.

### WHAT TO LEARN FROM IT

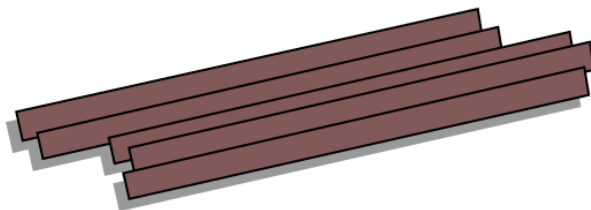
- **Quality parts are a necessity.** Your parts should be compressed and extruded properly to eliminate air bubbles. Air bubbles weaken your parts. Also, work on creating parts with a good finish, so that little post-work is needed.
- **Test, test, test different samples,** until you produce the best quality parts possible.
- Try to find a way to **use moulds efficiently for the different parts** (by adjusting them for your parts or making them modular moulds etc.).
- **Large parts are difficult to handle.** Consider producing smaller parts which can be combined.
- **Find a good recycling partner.** As the approach was to have everything made locally in Kenya, a big challenge was to find collaborations with recycling manufacturers who are open to new processes and can reliably deliver quality materials. Regeneration Africa, led by Sam Ngaruiya and his team were a huge help in exploring and figuring out different processes and materials!
- Potentially consider setting up **your own recycling facility**, so you can have the testing and production quality fully under your control.

# 5 - MAKE PLANKS



**The entire hull of the boat is made with 'plastic lumber'** - these planks are quite a common product to be made from recycled plastic in Kenya and other countries.

Each manufacturer seems to have their own recipe of material mixtures though, so the main challenge for this part was to get the parts made of 100% recycled plastic.



## HOW IT WAS MADE

For the planks we collaborated with manufacturers in Nairobi who were experienced in producing fencing posts as well as other construction material.

You can get an idea of their [machines and processes in this video](#).



### Process and equipment used:

- Workers **collect and sort** plastic into types.
- Big industrial **shredder** shreds plastic into plastic flakes.
- **Mixing machine** mixes plastic flakes (HDPE and LDPE), sawdust and additives.
- **Granulator** cuts the mixed material into even smaller pieces.
- Material gets fed into the **Extrusion machine** and **melted** into a mould.
- The freshly melted plastic gets **cooled** with water when exiting the mould.
- **Circular saw** cuts the product to the required length.

Even though our order was 100% recycled plastic parts, many recycling manufacturers **mix sawdust or sand**, as well as other additives like whiting and masterbatch into their products, to achieve stiffness and a uniform appearance (and to reduce costs, as sawdust is cheaper than recycled plastic).

The **sawdust** in the plastic parts made the quality very poor. The parts broke when trying to bend them, and it's also important to note that the sawdust (just like wood) soaks up water, resulting in an increased weakness of the material.

It took a couple of attempts, and in the end we managed to get 100% recycled plastic planks to make the hull of the boat. These planks were produced with industrial machines, but could be made with the (more accessible) [Precious Plastic Extrusion Pro](#) as well.

### WHAT TO TAKE AWAY

- **Work with reliable manufacturers**, as this will make the boat building process easier.
- **You don't necessarily need industrial machines** to produce all your parts. There are open-sourced machines like the Precious Plastic Extrusion Pro which you can build locally.
- **Avoid mixing your plastic** with other materials (including plastics of different types). While this may be cheaper to produce, the parts will be of poor quality and break much easier than pure plastic. Remember, quality is key!

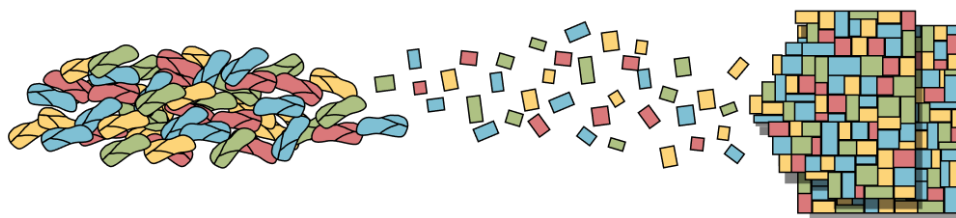


# 6 - MAKE FLIPFLOP SHEETS



Did you know that flipflops are the most common shoe worn with over 3 billion people wearing them across the world? **40% of all the waste collected on the beaches during our clean-ups for the boat were flipflops!** This is where the project got its name from and why flipflops were an obligatory element of this boat.

So we covered the boat with sheets of recycled flipflops, giving it a very colourful look and adding an extra protective layer against the water, salt, and wind - and it's also very comfortable, the whole boat feels like a big yoga mat!



## HOW IT WAS MADE

The sheets were made by James Murithi and his uncle Benson in Diani (south coast of Kenya), where they do all sorts of artworks with old flipflops.



### Process and equipment used:

- Flipflops are **collected** from beaches and streets.
  - Material is **cut** into (rectangular) pieces with a knife.
  - Pieces are **arranged** in a nice pattern
- Glue** is applied on the back and sides of the pieces (we used Tough Bond).
- Pieces are **fixed** (piece after piece) into place and pressed well.
  - Once the sheet is finished, **sand it** down to an even surface.

### WHAT TO TAKE AWAY

- **Use the materials** you have around you and give your boat personality.
- **Collaborate with artists** to give your boat a unique look.



# 7 - BUILD THE BOAT



**Once all the parts are ready, it's time to start building the boat.**

This is obviously something we won't be able to teach you here - that's what you will need your boat builders for!

The boat was built by Ali Skanda and his team of carpenters and dhow builders in Lamu, north coast of Kenya, using their traditional swahili dhow-building techniques.

# HOW IT WAS MADE

Overview of the boat build process:

**Fit and arrange the base  
(keel, muli, etc.)**



**Build a temporary wooden  
structure to shape the hull**



**Attach the planks  
to make the hull**



**Make the skeleton inside**



**Make plank decking**



**Attach flipflop layer**





The wooden material was replaced by recycled plastic, but for the rest, the boat was built in the traditional way of building swahili dhows, including a lot of manual work and craftsmanship.

### PREPARING THE PARTS

Every part was chopped to the right size and fitting.



### JOINING

Stainless steel bolts were used to lock the big parts of the skeleton. Brass screws were screwed in by hand to fix the planks onto the big parts.





## SEALING

To seal the gaps between the planks, different types of glue were tested, but in the end the decision was to use the traditional technique of filling the gaps with cotton and then sealing them with simsim oil and bondex.



## SAILING ELEMENTS

Finally, for our dhow to sail, we needed to add the mast, boom, ropes and sails. We sourced all of these parts second hand, and the rollers are also made from recycled plastic.



## IMPORTANT: TEST AND GET YOUR APPROVAL

**Once you've assembled your boat, definitely test it and check if it's seaworthy (your boatbuilders probably know how to do this). You'll be responsible for your passengers and yourself, and don't want to risk your lives!**

Also, depending on where you are based, there are inspections you will need to go through to get your boat on the water. In Kenya, you need approval from KMA (Kenya Maritime Authority), before you are officially allowed to be on the water.

We recommend that you inform yourself about the requirements you need to meet for the authorities to approve your boat's seaworthiness, while or maybe even before you start building. You can also consider getting help from Marine Engineers to support you with this.

### WHAT TO TAKE AWAY

- **Work with experienced boat builders** - their skills are vital in figuring your way around the inevitable problems that come with using a new and unexplored material.
- **You need an equipped workspace.** The workspace we used to build the Flipflopi was intended for building dhows with wood, and therefore did not have the equipment needed to protect the builders from pieces of flying plastic and did not adequately control plastic bits from flying into the environment. In the future, we will work with a fully equipped workspace suitable for processing plastic.
- Ensure that you meet the requirements to **get your boat approved** as safe for use on the water.

# 8 - SET SAIL AND INSPIRE



**“The Flipflopi Project has always been about encouraging change in a positive way, making people smile first and then sharing the very simple message that single-use plastics really don’t make sense.”**

This boat and its expeditions have already made a big impact, uniting communities to work together on better solutions, engaging decision makers to lead in the right direction and inspiring more people to get creative with how we use this precious material.

After all, if we could make a sailing dhow from discarded toothbrushes, bottles and flip flops, what else could we achieve? With all the brilliant minds, innovative thinkers, and risk takers, a lot of what we call waste can transform into something more.

**So, if you get inspired and build a boat - or another exciting thing from waste plastic, make sure you share it and use it as a positive trigger for more people to change their perspectives and join the movement towards a more circular and healthier use of plastics!**



# 9 - FLIPFLOPI KUBWA



The Flipflopi Ndogo proved the boat's potential to be a catalyst for bringing people and solutions together in East Africa. But the goal was always something bigger: **We'll be building a much bigger boat which can sail longer distances and reach millions!**

There is still a lot to improve and figure out for a boat of that size. But just imagine the moment when it's done, and the positive effect it can have! *And, as captain Ali says:*

**"Kila kitu inawezekana." - Everything is possible!**

# THE FLIPFLOPI PROJECT

**The Flipflopi Project** is a movement based in East Africa whose vision is a world without single-use plastic. We showcase alternate uses of waste plastic and the viability of a circular economy in Africa through our education programmes, our innovation hubs and our advocacy and governance programmes.

We built the world's first and only sailing dhow made entirely from waste plastic, picked up from towns and beaches in Kenya, and covered in 30,000 flipflops! We did it to prove that single-use plastic doesn't make sense.


We already took the boat on two expeditions: In 2019 it sailed its first 500 km voyage from Kenya to Tanzania and in 2021 we took the message upstream to the second largest freshwater lake in the world and the source of the Nile – Lake Victoria - spreading the message across the three countries Kenya, Tanzania, and Uganda.

**And we will keep going until we can stop imagining a world without single-use plastic and start living in one.**

**Want to learn more about us?** [www.theflipflopi.com](http://www.theflipflopi.com)

**Want to get involved?** [info@theflipflopi.com](mailto:info@theflipflopi.com)

**Want to stay updated?** [@theflipflopi](https://twitter.com/theflipflopi)

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