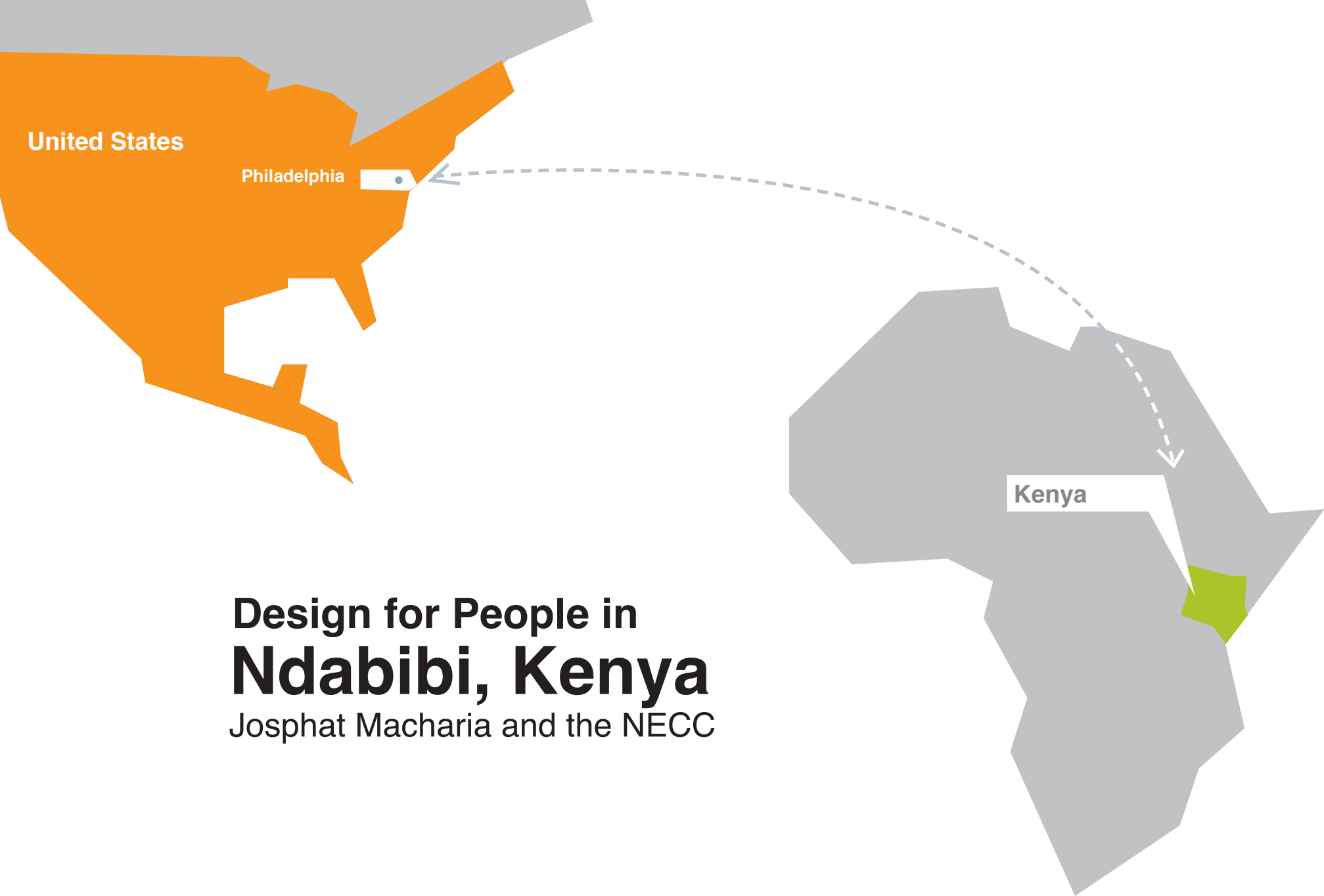




The Easy Breezy Solar Dryer



Design for People in **Ndabibi, Kenya**

Josphat Macharia and the NECC

* NECC (ndabibi environmental conservation centre)





CONTENTS



-  Background
-  Conceptualize
-  Research
-  Prototype
-  1st Test & Analysis
-  Final Model
-  2nd Test & Analysis
-  Further Plan



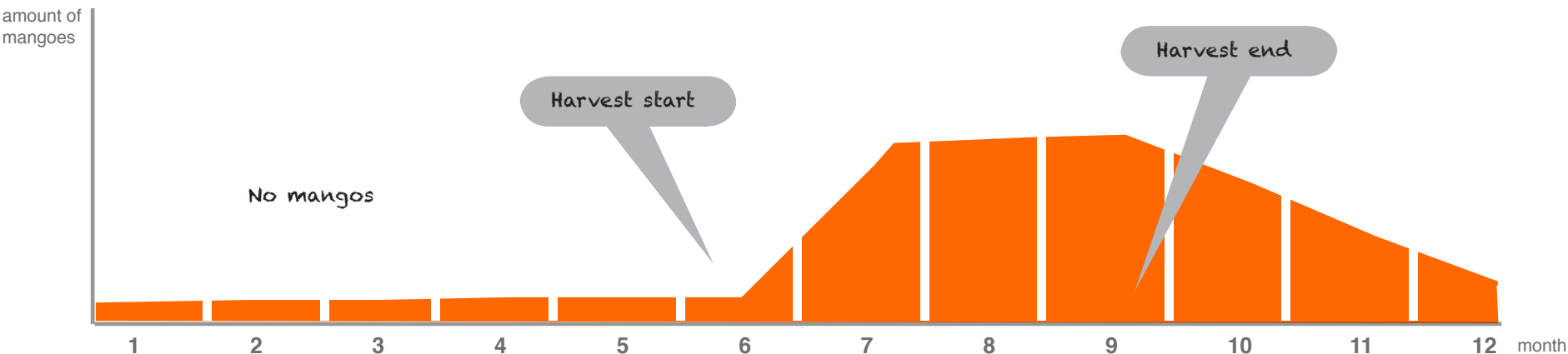
 **Background**

90% of people from Ndabibi, Kenya are **farmers**, but only 34% of them have **electricity** and 46% have access to **running water**.

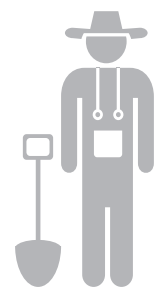
<https://opendata.go.ke/Energy/Availability-of-Energy-Sources-by-County-2009/g9hi-bs9n>



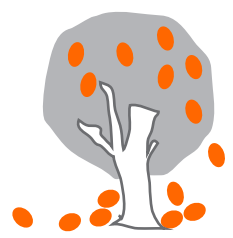
Without storage system in Kenya



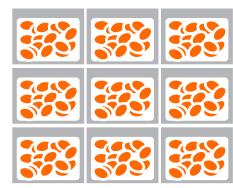
ONE OF MANGO FARMER IN KENYA



HARVEST



AFTER THE HARVEST HE HAS BUNCH OF MANGOS



THEY WILL ALL PERISH AT THE SAME TIME



IF HE CANNOT SELL THEM IN TIME, HE HAS TO THROW OUT ALL OF HIS MANGOS





Conceptualizing

Requirment list from NECC



“ We don’t have proper storage to put fruits so that can stay longer. We get vegetables for that day.”

Josphat, from Ndabibi in Kenya



Josphat gave us a list of things that he, his community, and his program (the NECC) would like to improve upon. Solar cooking, food storage and preservation, and solar driers were on his list, giving us a jumping off point.

NECC DESIRED PROGRAMMES

- | | |
|-------------------------------------|--------------------------------------|
| 1. Animal Care | 22. Organic Farming |
| 2. Horticulture | 23. Bio gas. |
| 3. Beekeeping | 24. Tree pruning |
| 4. Soil Conservation /cut of drains | 25. Hay harvesting “fodder” |
| 5. Water Harvesting | 26. Tree planting |
| 6. Farming Techniques | 27. How to make zero grazing units |
| 7. Tree nursery | 28. Pesticide making using weeds. |
| 8. Farming God’s way | 29. Home made foliar feed |
| 9. Compost Making | 30. Solar driers |
| 10. Bolea Chai | 31. Introduction to mushroom growing |
| 11. Grafting | 32. Tools storage and cleaning |
| 12. Crop rotation | 33. Farm record keeping |
| 14. Seed harvesting | 34. Mud Jikos |
| 15. Solar Cooking | 35. HIV/Aids programme |
| 16. Fireless Cookers | 36. General farm machines |
| 17. Food storage and Preservation | Maintenance – bicycles |
| 18. Cooking methods and Nutrition | Wheelbarrows etc |
| 19. Hygiene – Latrine management | 37. Deflouridation filter |
| 20. Bio sand filter | 38. NECC fuel project |
| 21. Sack garden | 39. Zai holes |
| | 40. Terraces / cover crops |



Research



In Kenya, **30-45%** of fruits and vegetables are lost due to poor post-harvest handling.

<http://www.businessdailyafrica.com/Unique-mango-drier-offers-rich-pickings-for-small-producers/-/1248928/1239068/-/item/1/-/c0u7o5/-/index.html>

Because of this we decided to research...

- Salting meats**
- Low-tech cooling systems**
- Solar and air drying**

Initial Research

HOW IT WORKS

- 1. Fridge is made up of two cylinders - one inside the other - and is not connected to any power source. Outer cylinder made of any solid material (eg wood or plastic) with holes drilled in the side.**
- 2. Inner cylinder is made of metal and has no holes to ensure contents remain dry.**
- 3. The gap between the inner and outer cylinder is filled with a material such as sand, wool or soil, that can be soaked with water.**
- 4. In hot weather the sun's rays heats this wet material and the water evaporates off. As the material is held against the inner cylinder wall, heat is removed from the inner chamber by the evaporation process, keeping it at a temperature of a cool 6c.**
- 5. Resoaking material with fresh water will keep the 'fridge' working.**

Graphic by John Lawson

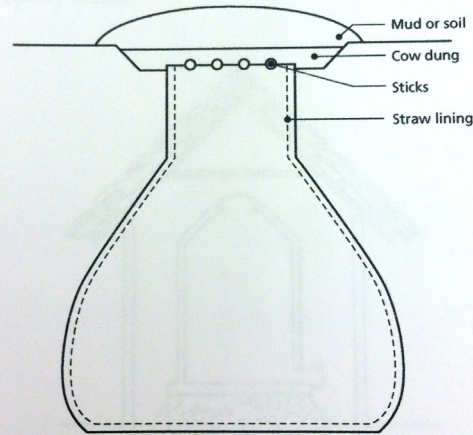
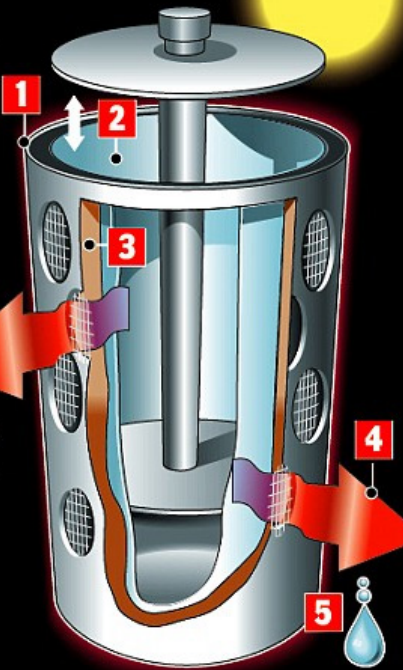
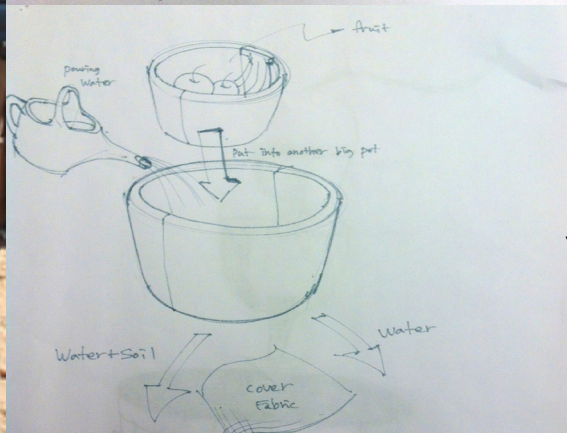
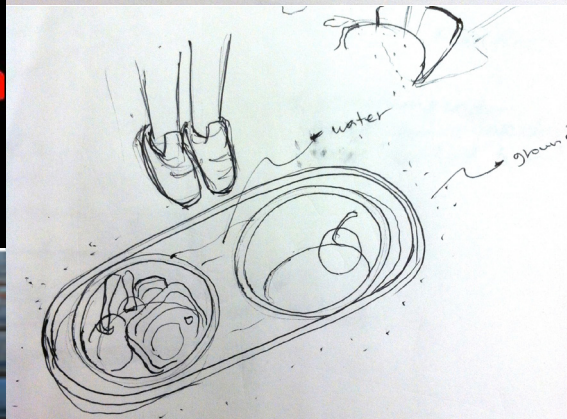


Figure 16.20 Underground pit



There are hundreds of ways to preserve food. We decided to do most of our research around refrigeration and underground cooling, as well as salting and air drying.



**But we decided to stick to solar
drying because...**



Kelsey and Somina,

It was a pleasure for me too meeting you. I appreciate your interest in the Ethiopian food culture and will try to answer your questions as best as I can

When we talk about food or anything else with regards to Ethiopia, it is important to understand that there exist two very different life styles. One is the modern, city lifestyle that resembles any other modern city in the world using modern methods and equipment for cooking, preserving food and every other human activity.

The other lifestyle exists in the country side and areas far from cities and towns where **more primitive methods** are used. Since Ethiopia is a vast land with close to a hundred different tribes and ethnicities, you will find many different ways of cooking and preserving food.

Talking about the non-modern ways, it is important to know that since **there are no refrigerators, very little prepared food is stored for long**. Mostly, what is prepared today is **consumed today as it will get spoiled** if left in unrefrigerated environment.

Fruits and vegetables are picked, prepared and consumed the same day but if some are left they are stored in clay containers until the next day or the day after.

Milk is stored in clay containers or gourds for a couple of days. Portions not consumed after that are left in the clay container to be turned into yogurt which will also be similarly stored for a few days. Butter and cheese are stored for much longer. Butter can stay stored for months.

Beef and mutton are cut in strips, salted and hung on strings to air dry for long storage.

Food preservation is very different between traditional Ethiopia and America. In America, people use modern refrigeration equipment to store and transport food, but in remote and undeveloped traditional parts of Ethiopia, people prepare **food that will be consumed the same day and very little is kept to store and consume at a later date**. This is because there are **no refrigerators** to keep food from being spoiled.

Yes I have known that modern methods are always better for preserving food than traditional methods as food spoilage could be minimized and more food can be stored for far longer periods if these methods are made available.

I hope this helps answer your questions, and I hope you will one day be able to visit Ethiopia.



From our interview and e-mails with Genet, we learned that...

- Refrigeration is not relevant
- Food is always picked and prepared for the same day
- If we were to focus on refrigeration, we would not be changing *how they eat, we would changing their lifestyle.*

A family in Kenya
can have mangos
every month for the off-
seasons



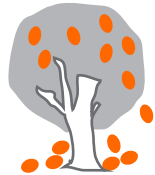
Individual family



One dryer



Store mangos for later to
support family in the dry
seasons



Mango

* Harvest at June to August

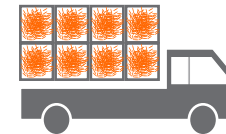
Further plan in the family and the community



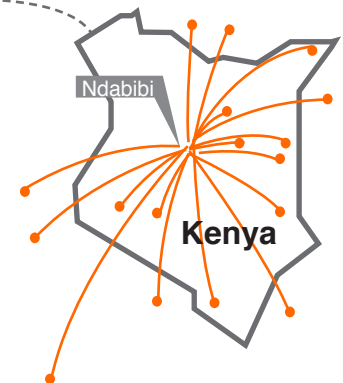
Community



Multiple dryers to dry
mango in bulk



Package dried mangos,
deliver to other cities,
eventually maybe other
countries



Sell dried mangos as
a business, **Make
a profit for the
community.**

Solar Drying History



For centuries people have dried fruit and vegetables using the sun to preserve the length of food perishability. Now a days, there have been new techniques, but also a higher demand for a healthier, cheaper and natural food. Everyone seems to be on some sort of budget, so by bringing solar drying in to the picture, it proves as an alternative for surplus food as well as extending the life of perishables.

"Temple of Nahkt, Egypt. Harvesting grapes, many of which would be dried into raisins."

15th century, BC
[http://en.wikipedia.org/wiki/File:Tomb_of_Nakht_\(12\).jpg](http://en.wikipedia.org/wiki/File:Tomb_of_Nakht_(12).jpg)



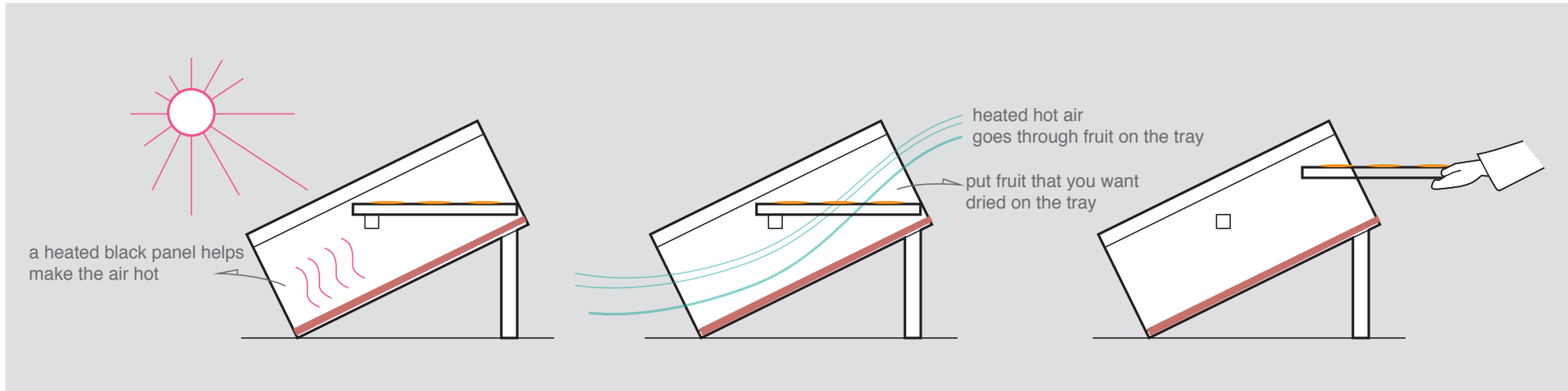
Native-american women drying meat in 1910.

<http://www.old-picture.com/indians/Indians-Drying-Meat.htm>



Solar drying in Peru.2002
https://energypedia.info/wiki/Solar_Drying

Dryer principle



- ☒ Hot air flow
- ☒ Reflective surface
- ☒ Clear surface for sun to enter
- ☒ Trays
- ☒ Dries fruit
- ☒ Made from recycled materials
- ☐ No machinery used





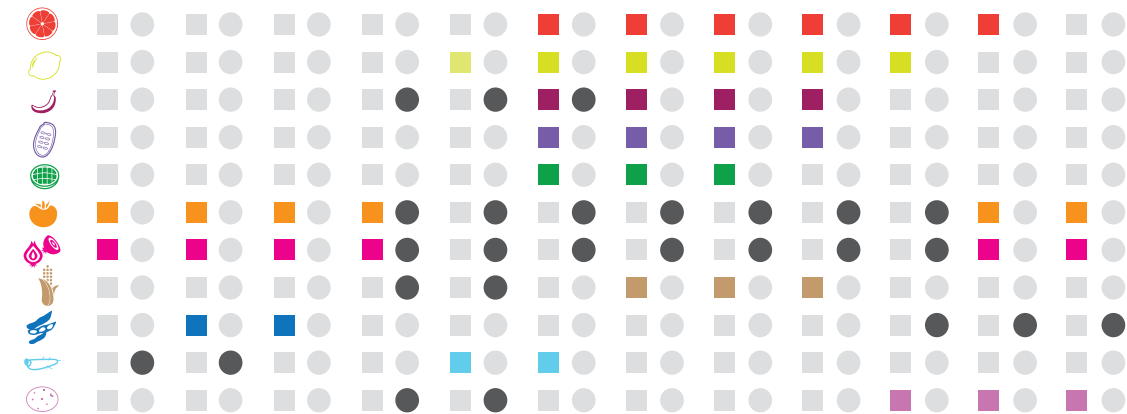
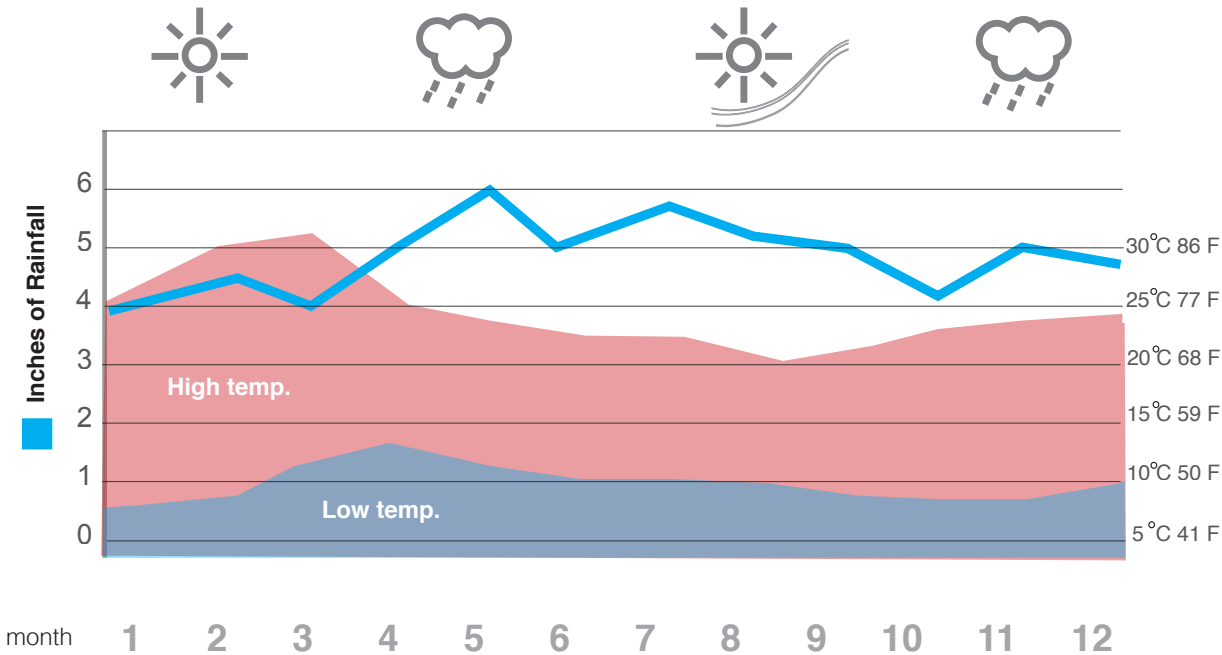
BEST CONDITION FOR DRYING FRUITS & VEGITABLE

- ☐ Sun rays
- ☐ Little moisture
- ☐ Air flow
- ☐ Hot air

 86 °F 
 60 % 
Best condition for drying fruit

Weather / Harvest season_Kenya

This chart represents the various sunny and rainy seasons in Kenya and when to plant and harvest fruits and vegetables that can be dried depending on the seasons.



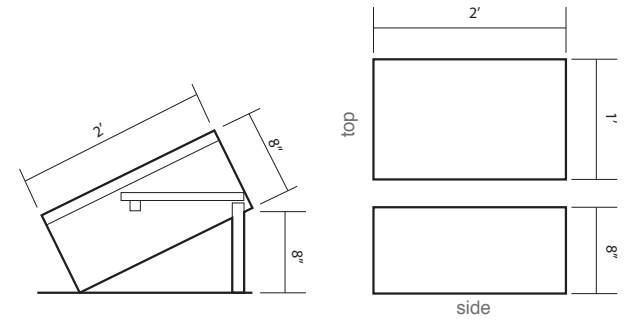
HARVEST PLANT



 **Prototype**



- ✓ Hot air flow
- ✓ Reflective surface
- ✓ Clear surface for sun to enter
- ✓ Trays
- ✓ Dries fruit

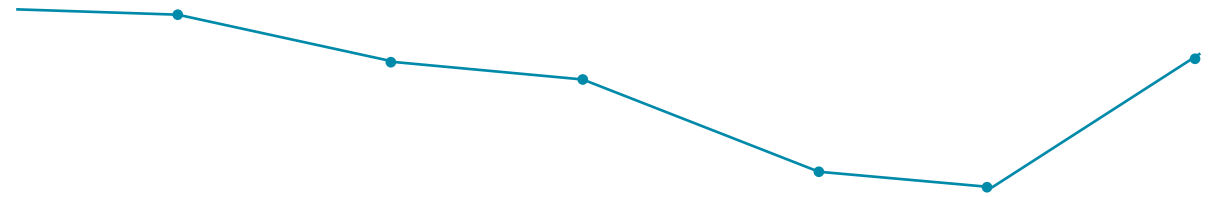




1st Test & Analysis



Test_1st prototype



Moisture rate on Fruits



62° Lo 42°

4/12 10:00



62° Lo 42°

4/12 12:00



63° Lo 45°

4/13 08:00



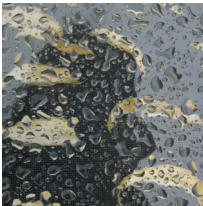
61° Lo 47°

4/14 08:00



61° Lo 47°

4/15 08:00*



Next step



- ☒ Hot air flow
- ☒ Reflective surface
- ☒ Clear surface for sun to enter
- ☒ Trays
- ☒ Dries fruit
- ☒ Made from recycled materials
- ☒ No machinery used
- ☒ Larger scale

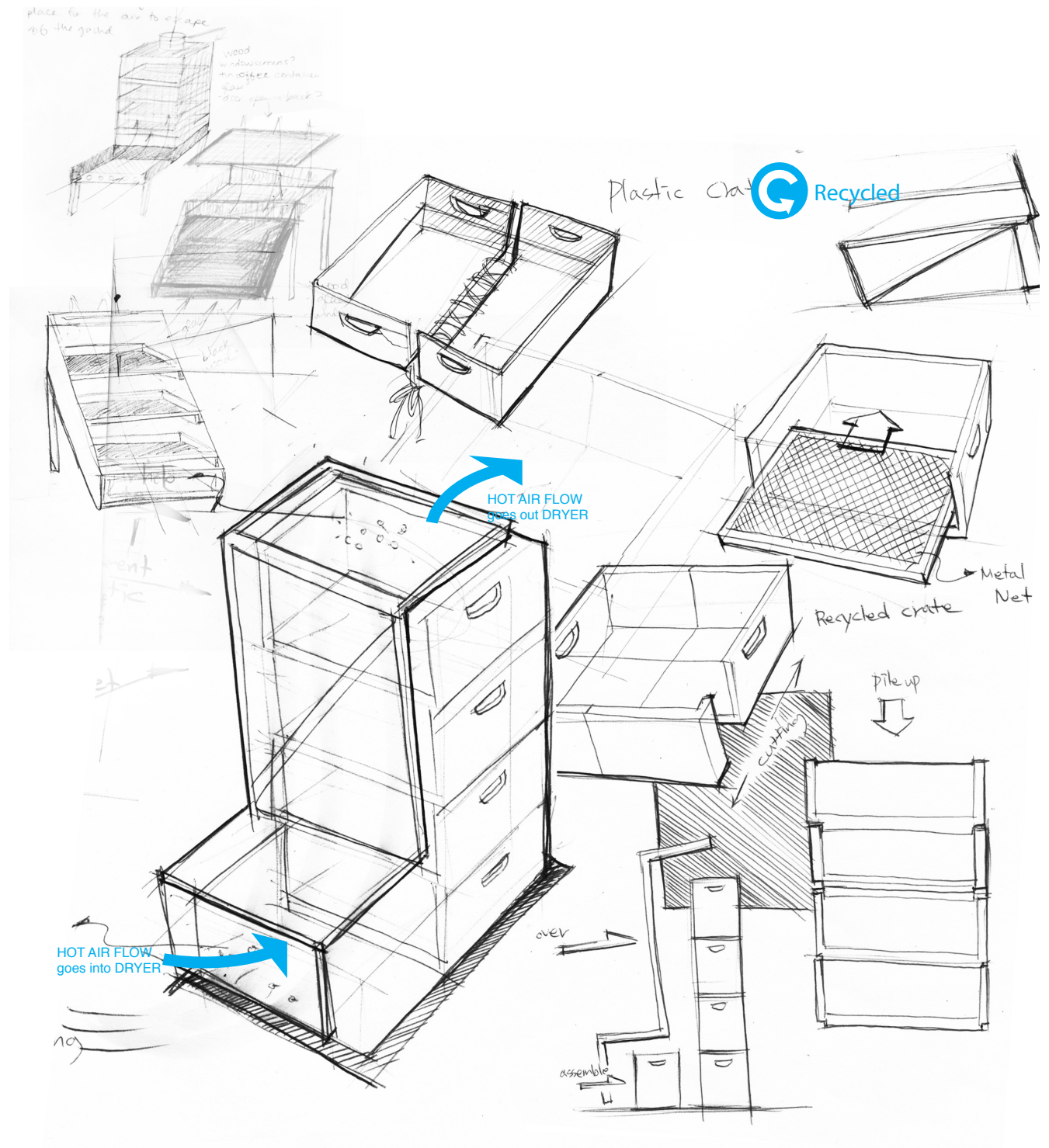
Our next step was to check off our last bullet point. We knew our previous test had worked, but by using machinery, we limited being able to implement in Kenya. Also, larger scale is needed for kenyan family.

 **Final Model**

Sketches

Many countries use the solar drying technique. However, more modern techniques use enclosed drying racks to expose the food to the hot air flow.

It is crucial for a solar food dryer to have **hot air flow**, using a **reflective surface** for the sun's rays, a **clear sheet** on top for the sun to get through, and **trays** for the food to be on.





-  Recycled
-  By hand

Material

** To empathize with Joshpat and his community, we didn't use any electrical machinery, instead we resorted to hand sawing, sewing my hand, and using knives to cut.

"We have a lot of plastic crates; we carry bananas in them. We have clear plastic as well, it's not expensive since we reuse it. Metal wire and wire mesh are easy to find too."
-Joshpat

W

2x Rail

• Plastic Film

• Wood

• Crates

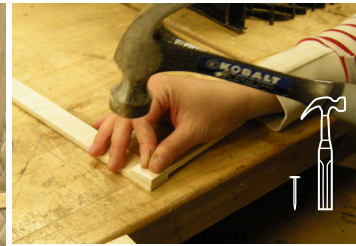
• Metal Net

• Nails

• Metal Wire



Building



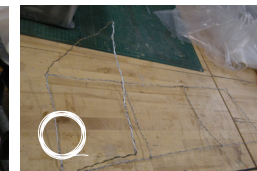
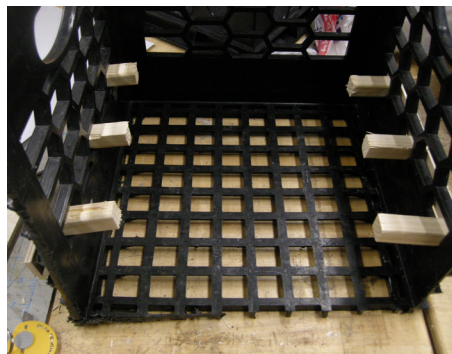
SAWING CRATE / MAKE TRAY / CONNECT TRAY TO NET

- Sawing by hand was hard because the saw was going to wrong direction



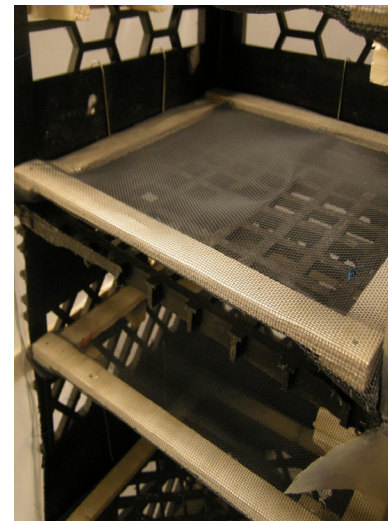
CREATING TRAYS FOR CRATE / PLACE METAL SHEET / MAKE DOOR USING METAL WIRE / COVER USING PLASTIC FILM

- metal wire was useful to connect each part.



Final Model





Our low-tech solar food dryer can be made from all **recycled materials**. It took us about **5 hours** to make, and about **10 dollars** to get the materials which is about **840 Kenya Shillings**.



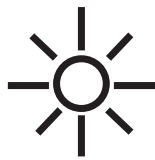
This dryer can dry **three and a half mangos** within **two days**. The mango once dried can last anywhere from **3-6 months** in a pantry or in a closed area.



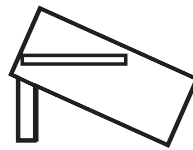
2nd Test & Analysis

Comparing Test

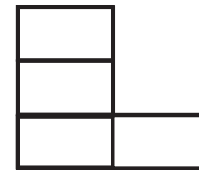
Sun drying & first & second model



DRYING BY SUN

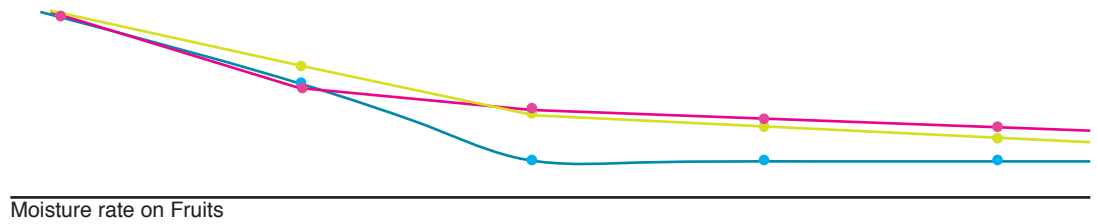


1ST MODEL

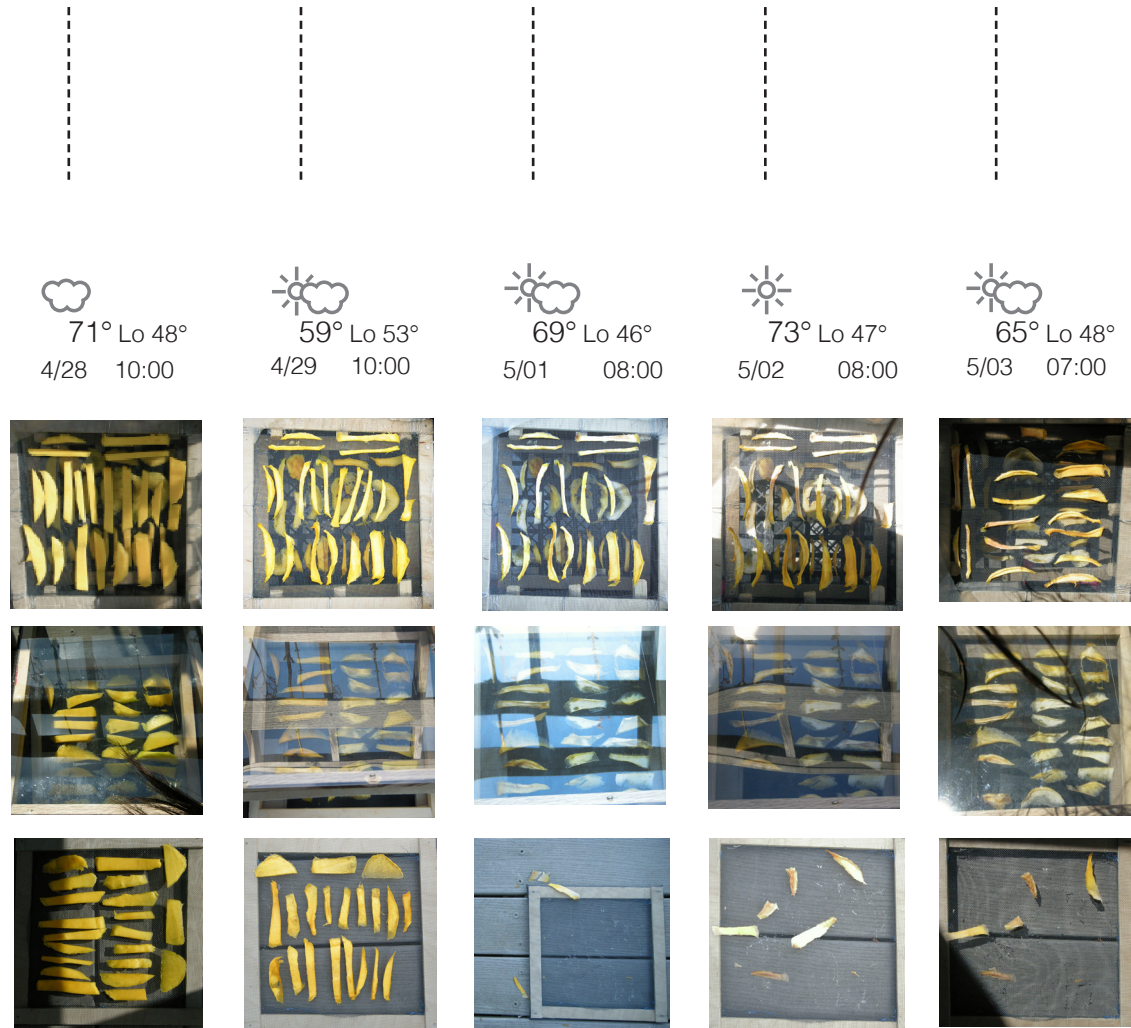


FINAL MODEL

Comparing Test



Moisture rate on Fruits



	4/28 10:00	4/29 10:00	5/1 08:00	5/02 08:00	5/03 07:00
	Test start	Mango's surface is slightly dried	a little bit thinner, and dried enough	well dried. when I touched it , it seems hard stick. not bended.	Too much dried. Too thinner * third day was enough to dry fruit.
	Test start	Mango's surface is slightly dried	outside of man-goes dried and get hard	dried, but it bend-ed easily.	dried well.
	Test start	Stil moistured	After strong wind, all mangoes blew out.	dried, but it bend-ed easily.	color is a littled bit changed as dark color. but well dried.

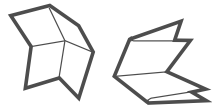


Further Plan

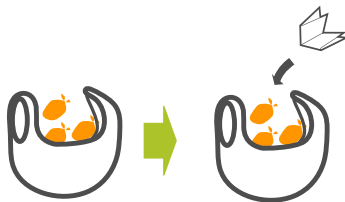
Fruit Seller



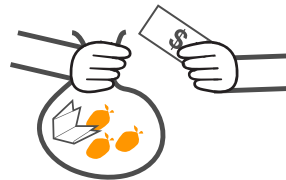
Instruction Paper



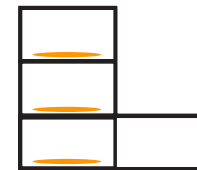
**Pack Fruit with
instruction Paper**



**Sell fruit with
instructions**



**Dry fruit
themselves**



keep for later



Ultimately, everyone can have dried fruits and make a profit

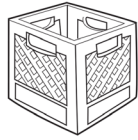


How to Build Your Own Solar Dryer

(jinsi ya kujenga nishati ya jua yako mwenyewe dryer)

What You Will Need:

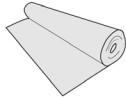
(nini unahitaji:)



Milk crates
(Maziwa makreti)



Metal sheet
(Karatasi ya chuma)



Plastic sheet
(karatasi ya plastiki)



Wire mesh
(kwaya wenye matundu)



Sticks (4 per tray)
(limbo (vijiti vinne kwa tray))



Wire or string
(waya au kamba)



Hammer
(nyundo)

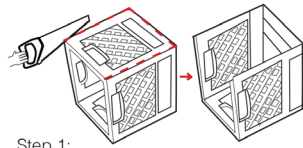


Nails
(misumari)

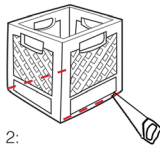


Saw
(aliona)

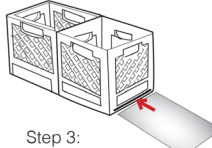
Knife
(kisu)



Step 1:
Saw the crate along with red lines (do this for each crate except for one)
Aliona crate pamoja na mistari nyekundu (kufanya hivyo kwa ajili ya kila aina crate isipokuwa kwa moja)



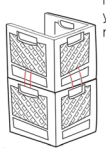
Step 2:
On the crate you did not cut, using the saw, make 2 slits on the bottom of part of it; making them parallel to each other
Juu ya crate hakuwa kukata, kwa kutumia msumeno, kufanya mpasuo 2 juu ya chini ya sehemu yake; maamuzi yao sambamba na kila mmoja



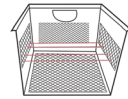
Step 3:
Place that crate next to one of the other ones. Slide the metal sheet through both so it's on the bottom
Kuweka kwamba crate karibu na mmoja wa wale wengine. Slide karatasi ya chuma kwa njia zote mbili hivyo ni juu ya chini



Step 4:
Stack the other 2 crates on top of the other one. The open side of the crates should be facing opposite of the one on the bottom.
Stack nyingine makreti 2 juu ya mtu mwingine. Upande wa wazi wa makreti lazima yanayowakabili kinyume cha mmoja juu ya chini.



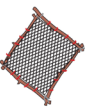
Step 5:
Tie the crates to each other with wire or string.
Kufunga makreti ya kila mmoja na waya au kamba.



Step 6:
Tie about 3 pieces string from one side of the crate to the other. Try to make them straight. Do this for every stacked crate
Funga kamba kuhusu 3 vipande kutoka upande mmoja wa crate kwa nyingine. Kujaribu kufanya nao moja kwa moja. Kufanya hivyo kwa crate kila sifa



Step 7:
Make a square that will fit inside your milk crate using your sticks. Tie the ends together with string or wire.
Kufanya mraba ambayo inafaa ndani crate maziwa yako kwa kutumia vijiti yako. Funga mwisho pamoja na kamba au waya.



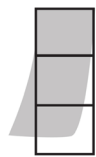
Step 8:
Wrap the wire mesh around the frame and secure with string or wire; 2 trays per crate.
Wrap waya kuzunguka frame na salama kwa kamba au waya; 2 sania kwa crate.



Step 9:
Place trays on the strings and on the bottom of each crate.
Nafasi sania juu ya waya na juu ya chini ya crate ya kila aina.



Step 10:
Wrap your dryer in plastic, except for noted and secure with wire or string.
Wrap dryer yako katika plastiki, isipokuwa kwa alibainisha na salama na waya au kamba.



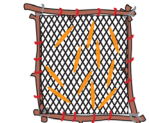
Step 11:
On the back of your solar dryer, place a sheet of plastic over it, but do not secure, this will be your door.
Nyuma ya dryer wako, mahali karatasi ya plastiki juu yake, lakini si tie, hii itakuwa mlango yako.



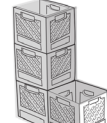
Step 12:
Get a piece of fruit.
Kupata kipande ya matunda.



Step 13:
Cut the fruit into strips or slices. Cubes will take longer to dry. Kukatwa katika vipande au matunda vipande. Cubes itachukua muda mrefu kukauka.



Step 14:
Place the strips of fruit on the trays.
Weka vipande vya matunda kwenye tray



Step 15:
Check everyday to see if your fruit has dried. It should take 2-3 days. Make sure it will not rain.
Angalia kila siku ili kuona kama matunda yako umekauka. Ni lazima kuchukua siku 2-3. Kuhakikisha itakuwa si mvua.

Instruction



References

“The Solar Boat” Pat Rand Rose

<http://www.rootsimple.com/2012/08/how-to-dry-food-with-the-sun/>

http://solarcooking.wikia.com/wiki/Solar_food_drying

<http://www.fao.org/giews/countrybrief/country.jsp?code=KEN>

<http://www.businessdailyafrica.com/Unique-mango-drier-offers-rich-pickings-for-small-producers/-/1248928/1239068/-/item/1/-/c0u7o5/-/index.html>

<http://www.weather.com/weather/wxclimatology/monthly/graph/KEXX0009>

<https://opendata.go.ke/Energy/Availability-of-Energy-Sources-by-County-2009/g9hi-bs9n>

http://nchfp.uga.edu/publications/uga/uga_dry_fruit.pdf

http://farm8.staticflickr.com/7261/7124659059_5fa5e9d10d_c.jpg

Images

Kelsey Hageman and Somina Baek
Will McHale and Michael McAllister

Illustrations

Kelsey Hageman and Somina Baek