



Simple,
Market based,
Affordable,
Repairable
Technologies

Mzuzu drilling

Training Manual



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Mzuzu drilling has details which can be best learned with practical training. Therefore, it is highly recommended to use this manual in combination with practical hands-on training that can be provided by a SMART Centre in Tanzania, Malawi, Mozambique, Zambia and in the future in other countries.

Please feel free to contact us via www.smartcentregroup.com

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3 Introduction

Techniques for drilling wells can be divided into (a) Machine drilling and (b) Manual drilling. In general, the term 'Tube well' is used for the shallower wells that are drilled with manual drilling techniques. The term 'borehole' is used for deeper wells drilled with mechanical drilling techniques. A tube well can be considered to be similar to a hand dug well but with a smaller diameter and using other tools. In general, manual drilling is less complex than machine drilling but the drilling is slower, is limited to softer ground layers and to shallow aquifers. Mechanical drilling rigs are imported in Africa, but drill sets for manual drilling like Rota sludge, SHIPO drill and Mzuzu drill can be made with materials that are locally available. They can be produced (after proper training) by local welders and in metal shops with basic tools like a welding machine and an angle grinder. Compared to hand dug wells, the hand drilling of a well is less dangerous and can penetrate deeper into the aquifer so there is less risk of dry wells. Making a hygienic seal for a tube well is also easier and cheaper than a hand dug wells. With improved drilling options like SHIPO and Mzuzu drilling, tube wells can also become cheaper than hand dug wells.

The Mzuzu drilling combines tools like Augers, a Soil punch and a Tube bailer. The Tube bailer uses a tube (polypipe) whereas conventional bailers use a rope. A Mzuzu drilling set is affordable with a cost of 50 to 150 US\$ depending on the depth, and drilling is relatively easy. In general, the Mzuzu drilling will only reach shallow water layers (aquifer) and can penetrate 3 to 6 meters into an aquifer. Depths of tube wells drilled with a Mzuzu drill have reached 20 meters, but it can possibly go deeper. The Mzuzu method can drill in non-consolidated ground layers of sand, clay and gravel. It can crush stones with the soil punch but will not drill through hard stone layers. This manual is part of a range of SMART Centre manuals.

The complete range includes:

Wells and Drilling:

- Geology and site selection
- Well digging
- SHIPO drilling
- Mzuzu drilling

Pumps:

- Rope pump model 1 Standard model
- Rope pump model 2 Economy model
- Rope pump model 3 2 Pole model
- Rope pump model 4 1 Pole model
- Pump care taker training

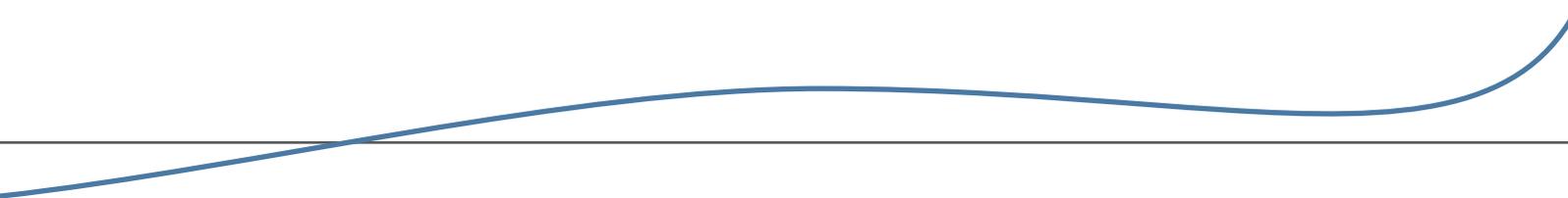
Water storage/groundwater recharge

Irrigation

Water treatment

Workshop skills

Business skills:

- Training of drilling companies
 - Business, financial and marketing planning
- 

4 What you need



The Mzuzu drilling set can be made with local materials. The table of materials can be found on the next page

Item	Number	
Soil punch with extension pipes	1	
Auger set (2 to 3 augers) with extension pipes	1	
Fishing tool (optional)	1	
1.5" Bailers. Open /closed (for 2 inch casing)	2	
2" Bailers. Open / closed (for 3 , 4 inch casing)	2	
Long chisel with 1" socket (optional)	1	
1" Poly pipe with 1" nipple	15	metres and more
Hacksaw	1	
Fine clay (or polymer) to make drilling mud	5	bags 25 kg Polymer 5 kg
Half round file	1	
Spade and hoe	1	Each
Pipe wrench	2	12" or bigger
Steel or strong plastic buckets	4	
Rubber strips	10	
Jig to mark filter screen	1	
Drill log form and pen	1	
Marker pens (permanent)	3	
Safety helmets	2	
First aid kit	1	
For the tube well, casing 2", 3", 4". End cap	Number depends on well depth	

5 Site selection

To select the best site for a tube well see the manual, “Geology and site selection”

In short, criteria to select the drill site include:

1. Where does the client want the well. This may **NOT** be the best location to find shallow water layers!
2. Find drilling logs of boreholes that have been drilled in the area. (Maybe available at a SMART Centre, local authorities or NGOs).
3. Look at existing drilled and hand dug wells in the area and see soil structure, depth of aquifer.
4. Look at landscape, vegetation, anthills, divining. In general water flows from high to low.
5. In flat areas, a good indicator can be a gully, a stream or a river.

Install the well where possible, in a sunny place. Sunlight with its UV rays will disinfect the apron. Rivers flow through the lowest-lying area and groundwater generally flows to rivers. Be careful: this only counts for natural rivers, not for manmade channels. Groundwater in general does not stand still but flows (very slowly) through sand layers or pores and cracks in the underground. It is not always easy to determine the flow direction of groundwater.

As professionals, all drillers are responsible to inform clients about sanitation and hygiene and the preferred distance between a well and a latrine or other sources of contamination.

5.1 Sources of pollution

When a latrine is located on the slope of a hill, and there is a shallow groundwater aquifer, this aquifer maybe contaminated with bacteria or other contaminants. It is likely that the flow of the groundwater is in the same as the slope of the hill, so it is preferable to construct a well up-stream of a latrine.

Most national guidelines indicate that a well should be at least 30 metres away from a latrine or other source of contamination such as waste pits, fuel or oil spills, pesticides or animal waste on farms. In practice bacteria in groundwater will be eliminated in distances between 3 and 10 metres. In general bacteria cannot survive if they are 3 days or more without oxygen.

To be sure that the water is potable, always **recommend that water for drinking should be treated at the household level** by boiling, chlorine or a good quality household water filter.

6 Drilling

Mzuzu drilling starts with an Auger in softer layers or a soil punch in hard or stony layers. Once you reach the water bearing ground layer (aquifer) and the Auger or Soil punch does not lift soil anymore, should you start using a bailer.

6.1 Auger

The diameter of the auger to be used depends on the desired size of the casing. In general, the diameter of the auger is ca 20 mm more than the diameter of the casing. Therefore:

- For a 2-inch casing (60 mm) use an auger of 80 mm.
- For a 3-inch casing (90 mm) use an auger of 110 mm.
- For a 4-inch casing (110 mm) use an auger of 130 mm.

If soil layers are hard, start with a small auger.

Augers can also be used inside a casing pipe. When augering in casing, use an auger with a diameter that is 10 mm smaller than the inside diameter of the casing pipe.

Steps to drill with an auger:

1. Rotate the auger and push it down at the same time.
2. Make the soil as wet as possible without making it liquid.
3. Each time you extract the Auger for cleaning, add 1 or more cups of water in the hole.

In case of very hard soils use a foot step (**see photo below**)

4. Lift the auger, keep it vertical, place it on a piece of wood and rotate.
5. Clean it with a cleaning tool and repeat the steps.

If lifting is too heavy turn the auger back 1 turn.

The auger can be extended with extension pipes.

Deeper than 6 meters? Take off the top extension pipes when extracting the Auger each time the auger is cleaned.

Use a key ring or curtain ring through the pin for the security when pinning the extension pipes onto the Auger

Use an auger until you are in the aquifer and the auger is not lifting material anymore



Set of augers for casings of 2,3 and 4 inch



2-inch auger (60 mm) that fits in a 3-inch casing of (75 mm)



Start drilling. Adjust the handle on the right height with the rubber strips. Slowly turn around the auger 3 to 5 times. Lift, it.



If lifting is too heavy turn the auger back so there is less material. To empty the auger, keep it vertical, turn it around, clean with a cleaning tool. Do not use a hammer to avoid damaging the auger.



Cleaning tool



When soils are tough, mount the foot step and use weight of a person to drill deeper. Keep drill pipe straight to avoid bending of the pipe.



Use Key rings or curtain rings as security for the pins



If the well is deeper than 6 metres, take off the extension pipe

6.2 Soil punch

1. In layers where an auger cannot drill (boulders, stone layers) use the soil punch. The 4 steps are;
 - Down (push the punch down in the hole)
 - Swing (make 2 large circles with the top end of the tool to keep the punch loose)
 - Lift (bend knees while lifting to avoid back problems)
 - Turn (turn about 90 degrees to keep the hole round)

In hard soils repeat these 8 times.

In soft soils repeat these 4 times.

2. If the soil is dry, put 2 cups of water in the borehole.

If the soil is too loose (sandy) add water mixed with fine clay in the well. The sand or stones will mix with the clay and stick in the punch.

3. After 4 to 8 times punching, empty the punch by hammering on the sides with a stick or small hammer. Keep the soil punch straight up so that the weight helps the soil to fall out. With clay, use a pin to push out the clay

The soil punch can be made longer with extension pipes. Go as deep as needed with the soil punch until you can use the auger again or until the punch will not hold soil anymore because of the water in the soil. Than install the filter screen and start using a bailer.

Empty the punch by hammering on the protection plates



Using the soil punch with the 4 steps 1 Down, 2 Swing, 3 Lift, 4 Turn



Empty the punch by hammering on the protection plates

6.3 Bailer

When you reach a water layer and the soil punch or auger does not lift material anymore, install a casing (PVC pipe with a filter screen of 3 to 6 metres long). The filter screen can be prepared before or during the use of the auger. Start cutting slots 30cm from the bottom end of the filter screen

The length of the filter should be 3 to 6 metres, depending on the water layer

Start bailing inside the casing. Start with a closed bailer and if that does not function anymore go on with the open bailer that has an opening on top. Steps for bailing are;

1. Install the filter screen with the socket facing downward (at the bottom)
2. In case of a sandy soil pour a few buckets of drill fluid (water and clay) in and around the casing
3. Start with a closed bailer. There should be at least 10 mm clearance between bailer and casing.
4. Mark with a marker pen the total length of the casing at the top of the casing
5. Mark with a rubber strip the polypipe level at the top of the casing when the bailer is at the bottom
6. Start bailing. By moving the bailer up and down you can pump out sand, clay, small stones
7. With bailing you create caving underneath the filter screen
8. Push down the PVC casing every now and then (do not hammer on the PVC casing!!!)
9. When it is not possible to pump out material with the closed bailer, start with the open bailer.
10. Closed bailer; make long strokes, 1 per second (ca 0.5 m)
11. Open bailer; make short strokes 4 per second (ca 0.1 m)
12. Open bailer, lift the bailer after 10 pump movements, clean it in a bucket with water.
13. With both bailers, a person holds the poly pipe outlet, walks half circles (180 degrees) to keep the hole round.
14. Go down as far as possible until you hit a thick clay layer or stone layer.

**Never try to hammer the casing pipe down!
This will compact the sand and prevent the PVC casing from going down.**

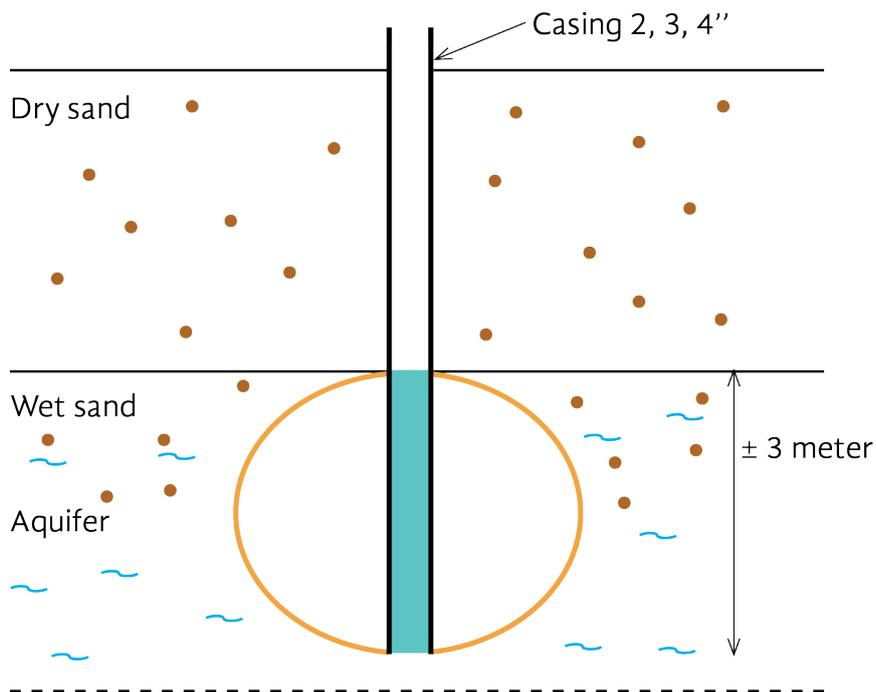


A closed bailer. Move it up and down with long strokes (0.5 m)



Open bailer. Move it up and down with short strokes. Clean in a bucket with water with short strokes. Make sure there is no sand or stones left in the bailer.

You can create a hollow space around and under the casing which can function as an underground storage



7 Casing

7.1 Type/diameter, length of casing

The casing is necessary to prevent the tube well from collapsing. The lower end of the casing is a filter screen to let water in and keep particles larger than 1 mm from entering in the casing. For wells drilled with a Mzuzu drill the length of a filter screen is 3 to 6 meters. The length depends on expected dimension of the water layer. Sometimes it is possible to buy a pre-fabricated filter screen which in general are pipes of 4 inch (110mm). The diameter of the PVC-casing depends on the type of pump your customer wants:

- For most submersible pumps the casing should be 110 mm (4").
- For an engine suction pump or an EMAS pump the casing can be as small as 50 mm (1 ½").
- For a Rope pump the diameter of the casing pipe depends on the pump pipe diameter which depends on the depth of the well:
 1. Well depth 0-10 metres: pump pipe 1 inch, casing = 110 mm (4"), wall thickness 3 mm or more.
 2. Well depth 10-20 metres: pump pipe ¾ inch, casing = 75 mm (2.5"), wall thickness 2.5 mm.
 3. Well depth 20- 40 metres: pump pipe ½ inch, casing = 60 mm (2"), wall thickness 2 mm or more, inside diameter of 55 mm).

Some thick-walled PVC-casings have a thread; others have a socket that fit around the next pipe. If it doesn't fit exactly or if the casing pipe does not have a socket, a socket should be made with a socket tool.

7.2 Making the filter screen (see photo below (right))

You can make a filter screen by:

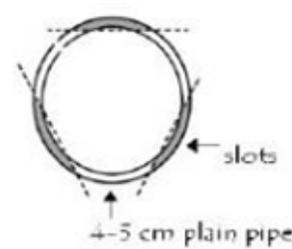
- Cut slots every 12 mm. Angle of 45 degrees. On 3 sides of the casing pipe, marked with a tool
- Watch out not to cut the slots too long (60 mm for a 4 inch casing), this will weaken the casing.
- Make slots as narrow as possible, using a used hacksaw blade.



A pre-fabricated filter screen



Making slots with a hack saw, 45 degrees.



7.3 Finishing the well

There are many details in the making and the finishing of a tube well so we recommend to get trained by a SMART Centre to avoid errors. Training is essential for a hygienic, user friendly and proper working tube well. When you have drilled as far as possible with the Auger and or soil punch, and the PVC casing with filter screen is installed there are the following steps

1. Cut the casing pipe 15 cm above ground level.
2. Pour a small plastic bag with cement in the casing to close the Filter screen at the bottom.
3. Pour gravel or coarse sand around the casing until 3 metres from the top
4. Fill up the top 3 metres around the casing with clay

7.4 Gravel pack

With the Mzuzu drilling it is not possible to place a gravel pack around the filter screen as with other drill methods. The logic is that with swabbing and pumping, the gravel pack will develop itself.



*Installing the filter screen, the socket side down.
Length of the screen 3 - 6 metres*



Push down the casing pipe during bailing

7.5 How deep should we drill?

Drill as deep as possible in the water layer(s). You can stop when the soil changes from sandy or loam into a thick heavy clay or stone layer. With the Mzuzu drill method the sand or loam in the aquifer will collapse directly around the filter screen and after 3 to 6 metres in the aquifer, there may be so much friction that it is not possible to push down the casing anymore. In general, some 3 metres into a good aquifer is enough to get a good well capacity but always try to go as deep as possible.

7.6 Swabbing and testing

When drilling is finished, the filter screen can be cleaned, and the tube well can be developed using a 'swabbing tool' to unclog the pores. The swabbing tool consists of a plastic disc and a rubber flap connected to a rod or pipe or the tool can be connected underneath the guide block of a Rope pump.

The rubber flap fits with a small clearance in the casing and acts like a plunger. When it is moved up it closes and when moved down it opens. The most efficient swabbing is to pull up quickly and push down slowly. If combined with a Rope pump, the advantage is that dirty water can directly be pumped out. To do this, install the pipe and rope and pump, loosen the rope on the wheel, move the pump pipe up and down, connect the rope and pump again and pump out the dirty water. Repeat this as often as needed to get a good and clean water flow. When the well is developed you can test the well capacity.

An average indicator is that the yield should be 360 litres per hour (6 litres per minute) although it depends on the expected use and purpose. For instance, if the well is only used for 1 family and only for domestic use 100 litre per hour can be enough. It is important to test if the well meets the demand of the owner before finishing the well with a concrete slab and soak pit. Testing the yield can be estimated by a Rope pump model 1 or 2 on a prefabricated slab or rope pump model 4 with a pole in the ground or with an electric submersible pump.



A swabbing tool attached to a guide box



After the casing is placed a pump can be installed to develop the well. It can be a Rope pump model 1 or 2 on a prefabricated well cover or a Rope pump model 4 with one pole directly installed in concrete

8 Problem solving

How do I know where to start drilling?

- See above and the manual "Site selection".
- Talk to the people in the village, look for open wells. specific vegetation and slopes of the land.

The Bailer is not going down, No water/mud is coming out of the poly pipe

- If on a sand layer add Clay, make a thick drill mud. Make sure the sand comes in suspension.
- If the foot valve or poly pipe is clogged. Try hand sludging by closing the outlet of the poly pipe with the up going stroke. If this does not work take out the pipe and clean the bailer.
- Flush (wash) frequently during drilling.
- Maybe the bottom valve in the bailer is not closing. Repair or mount another bailer.

The PVC casing is not going down

- Hard soil such as volcanic tuff , sandstone.
- A gravel layer. Use a bailer with a flap valve instead of a metal ring valve, see also above
- Stone in hole. Crush with long chisel or soil punch. If that does not work start another hole

Avoid problems!

Prepare, keep the equipment in shape, have the drilling site organized and know what you are doing

Breaking of Soil punch or bailer

- If this happens, use the fishing tool immediately and lift the pipe. Waiting will give the sediments time to settle on top of the bailer and it will be difficult to remove the parts.

"How do I know I have reached water?"

- This is experience. In general water is found in sandy layers and indications of a water layer are that soil does not come up anymore with the soil punch.
- If the sand layer is short (1 -2 metres) in general the aquifer is not enough so continue drilling until you hit a next water layer.

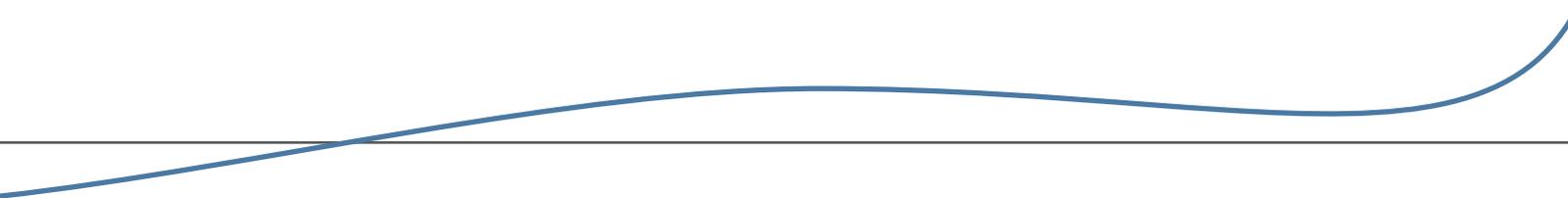
What should the length of the filter screen be?

- Make it as long as possible, in general up to 6 metres.

No water is coming from the well

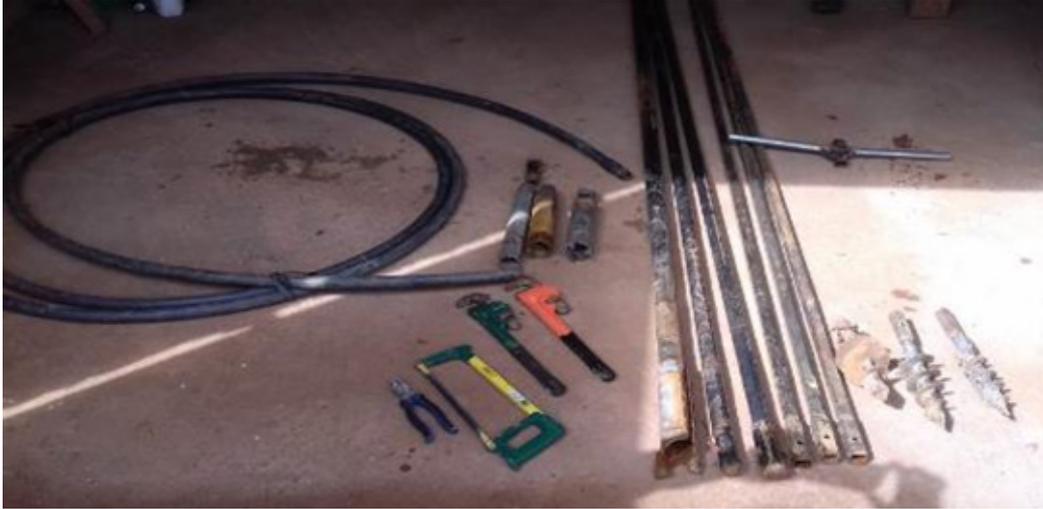
- If after a pump test there is no or not enough water coming out, try to drill deeper
- It depends on the type of soil if water will enter in the tube well. In clay layers there is no water. Normally sand or gravel is the best soil type for water
- A long term solution can be, make a Groundwater recharge system like a Tube recharge (See Tube Recharge manual)
- For water- and ground layers see also manual on site selection
- If you think the well will not have water and want to take out the casing, lift the casing with a lever, or a tripod with a pully and a car. Hammer the casing while lifting as the vibration loosens the grip of the soil surrounding the casing

How to maintain the drilling equipment?

- Clean the Augers, with a spray bottle (PET bottle with a small hole in the cap)
 - Mount a protection socket on nipples
 - If you store the drill set for a long time put oil on steel sockets and metal threads
 - Sharpen the drill bits after each drilling
 - Inspect fish tools, wrenches and other tools
- 

9 How to make a Mzuzu drilling set

Materials	Unit	Number	Observations
Square Black pipe. 25mm. Thickness 1.6mm (Event.1.2 mm)	Pipe of 6 metres	2 or 3 pipes	So 12 metres in total For auger
Square Black pipe 32 mm. Thickness. 1.6 mm	metres	1	For connections of auger and pipes and extension pipes
Round Black pipe 40 mm. Thickness 2mm Event 1.6 mm	Pipe of 6 metres	1	For soil punch and long chisel
Round black pipe 32 mm Thickness 1.2mm	Pipe of 6 metres	1 pipe	For soil punch and handle
Gi pipe ½". Thickn.1.8 mm	metres	1 metre	For augers
Gi or black pipe 2" Thickness. ca 2.5 mm	metres	1 metre	For augers, bailers
Poly pipe, 1"	metres	15 metres	For bailers
Sockets 1"		4 pcs	For bailers
Nipples 1"		4 pcs	For bailers
Round bar 8 mm	metres	2	For bailer valves
Curtain rings , Or GI wire 2 mm	kg	1	To secure the pins
Rubber strips	kg	1	To fix handle
Tungsten drill tiips	4 pcs		Or bike crank axles
Bike axles front wheel	pcs	3	For bailers
Tools for the field			
Safety helmet	pcs	2	Depending # people
Hacksaw, half round file	pcs	1	
Pipe wrenches, 12 or 14 Inch	pcs	2	Or similar
Buckets 20 ltrs	pcs	3	
Clay	Bags 25 kg	1-3	depends diam. casing and soil type.
Tools for production			Vice,Anglegrinder,Welder and rods. Hand drill wirh drills 5,6,10 mm. Hacksaw, round file



Complete set Mzuzu drill

9.1 Making the Augers



The Mzuzu drill has augers with different diameters. The plates of the augers can be made of a 2 inch GI pipe made flat. The hole in the plate should be 6 mm more than the diameter of the Centre pipe so for a $\frac{1}{2}$ " pipe (20 mm) the hole should be ca 26 mm.



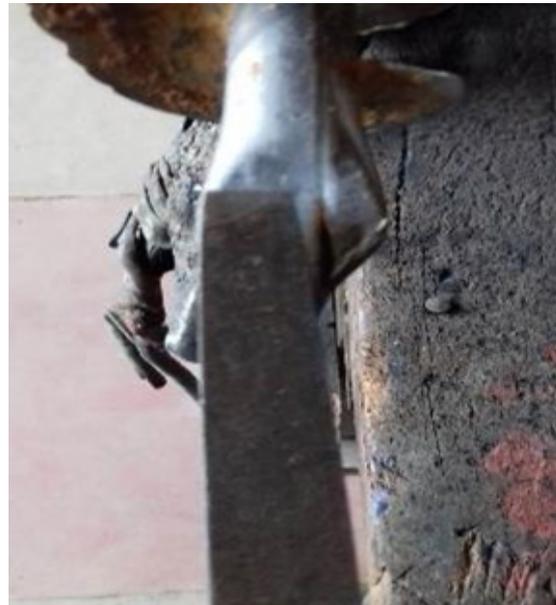
Basic drawing of an auger with diameter of 90 mm



The diameter of the plates can be anything from 50 to 250 mm



Bend the plates in a vice until opening is 40 mm or more. Weld the plates on a 1/2" GI pipe



Make the point flat. Weld a piece of an old flat file on the point. Sharpen with and angle grinder, make a cutting edge.



Eventually make teeth on edge of the plates



Weld a spot and grind. Note the cutting edge of the point.



Cleaning tool. To clean the plate auger



Made of strip 25 mm



The extension pipes. Made of square black pipe of 25 mm, 1.2 mm wall thickness. The number of pipes depend on depth. In general 4 to 6 pipes of 3 metres length



The connections. made of square pipe 32 mm with 1.6 mm wall thickness



Handle. The pipes on the handle should be large diameter for instance 1 1/4"inch



Foot step. Both handle and foot step are reinforced with strip to avoid cutting of the rubber strip



Foot step and handle fixed with rubber strips

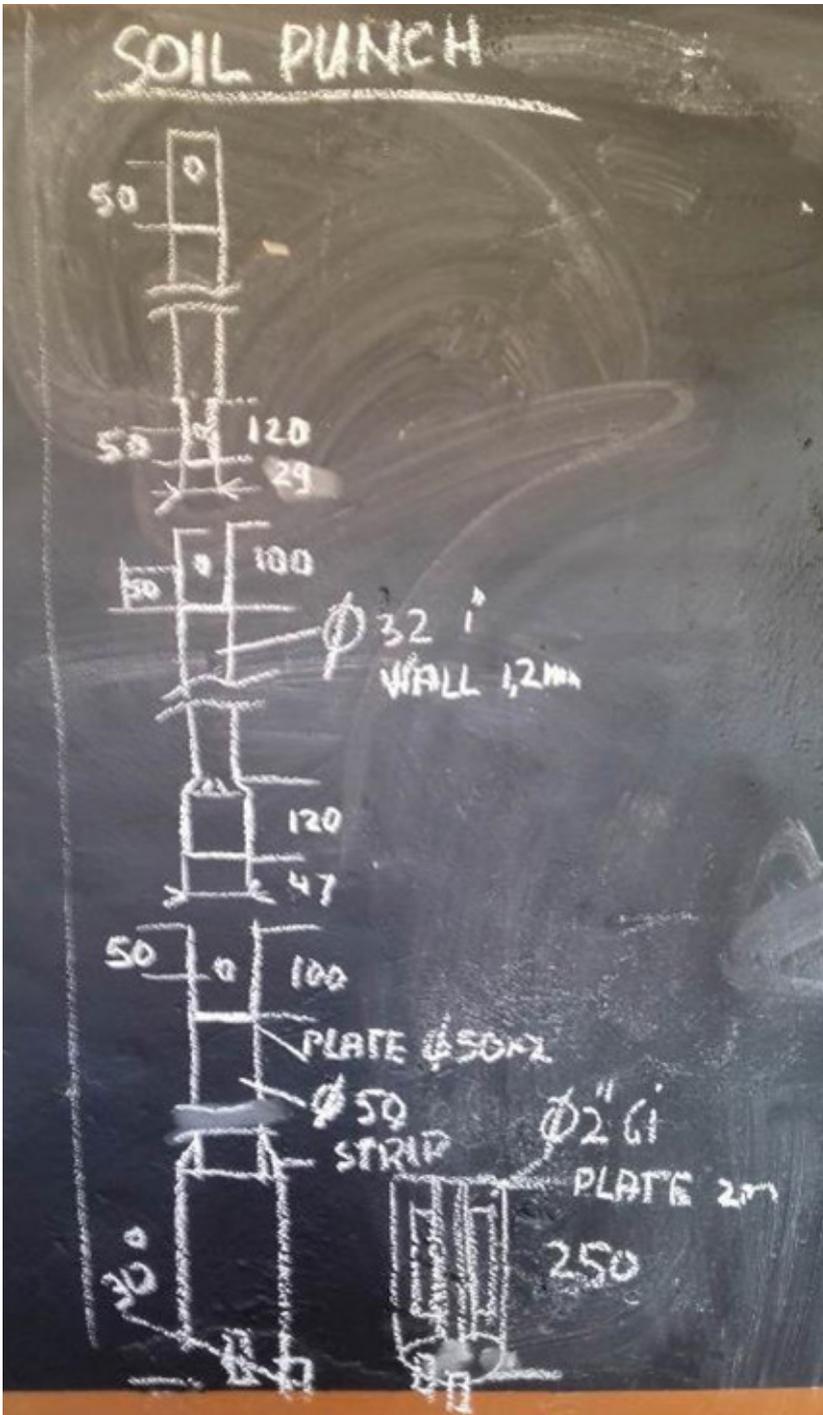


Mark each extension pipe to make sure that the holes fit



Secure the pins with a key ring or curtain ring

9.2 Making a Soil punch



Basic drawing of the Soil punch



Good and strong material for the teeth is an axle (crank shaft) of a bicycle . Also tungsten tips can be used



Weld 2 teeth. The middle teeth should be longer than the side teeth. The sharp point on outside of the pipe



Weld a strong end plate

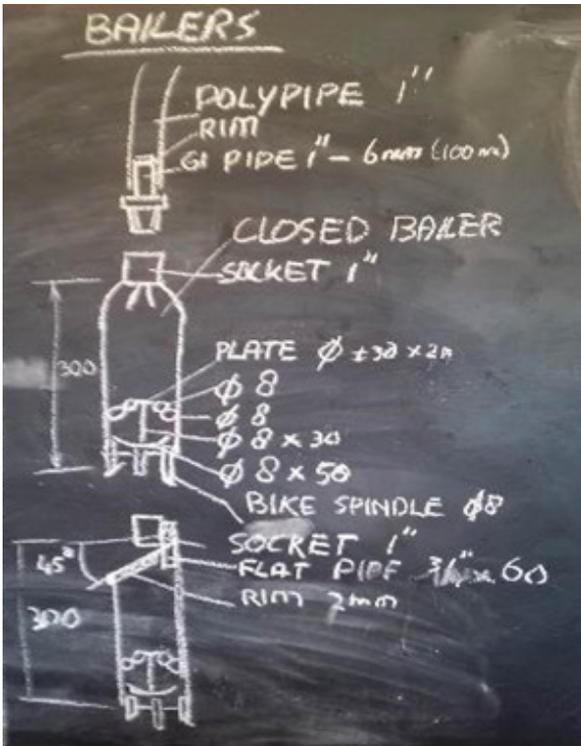


Make a strong connection to the pipe. Weld a strips on the side to protect it from deforming.



The first pipe on the soil punch is 40 mm diameter and wall thickness 2 mm or more, length. 3 meters. Extensions 32 mm diameter. To make it heavy , the lowest 2 metres of the 40 mm pipe is filled with sand and closed with some clay or cement.

9.3 Making a Tube bailer



Basic drawing of the bailer



To fix the valve inside the 2 inch pipe, make 2 cuts and weld pieces of welding rod.



Note the bar with a round shape on the valve. This to maximise the flow.



The outside ring of the valve is made of round bar 10 mm. Rings made with a strong pipe 32 mm



Then weld at the bottom.



Weld 3 pins, (for example shaft of bike front wheels axles) Make sure the diameter of the bailer first well in the casing.



Video on the Mzuzu drill <https://youtu.be/PxySOopYwKI>