Soil Moisture Sensor

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Co Guide:
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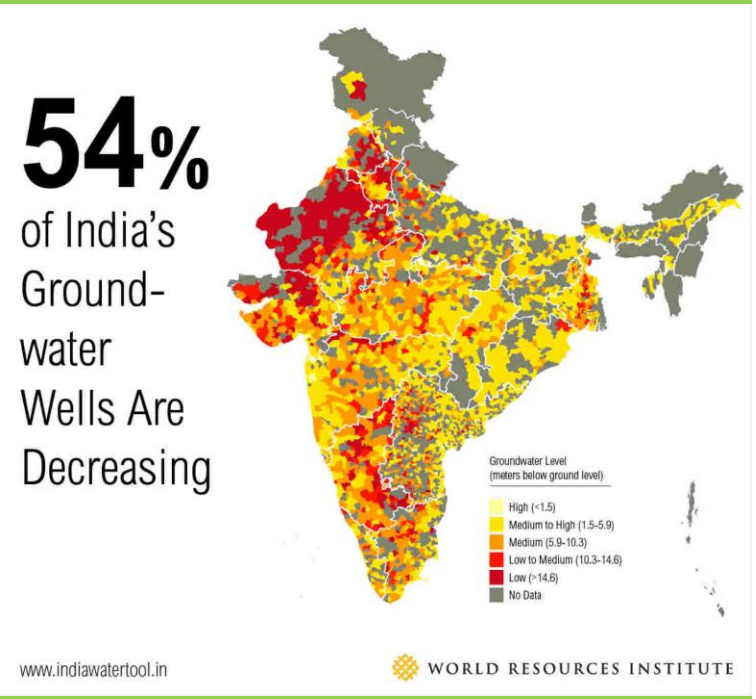


Relevance of project

54 percentage of India's ground water wells have dropped over past 7 years ,with 16 percent decreasing at the rate of 1 meter per year

Soil moisture sensor device can determine optimum amount of water required for a specific crop which helps farmers to irrigate accordingly and thereby reducing water wastage

Understanding existing interventions

Visited Krishi Vighyan Kendra at Tuljapur and had a fruitful discussion with the agricultural scientists. We had the opportunity to study and examine some of the frugal innovations in agricultural sector.

Insect catcher

Water wheel and weed remover

Centrifugal grain seperator

Understanding farmer behavior

Visited Mahabaleshwar and had the opportunity to study irrigation patters adopted for strawberry cultivation.

Mostly women are involved in cultivating, harvesting and even selling of the strawberries

Farmers adopt mixed farming by cultivating onions along with strawberries. Drip irrigation is followed and fields are covered with polythene sheets to prevent moisture loss

Methods of irrigation

Traditional
-Check basin
-Furrow
-Strip

Modern
-sprinkler
-drip


Check basin


Furrow


Strip

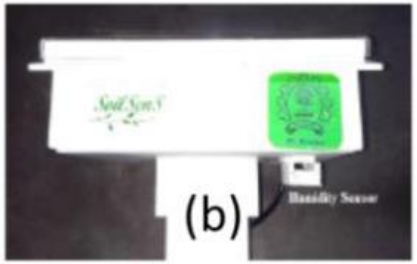

drip


sprinkler

Background

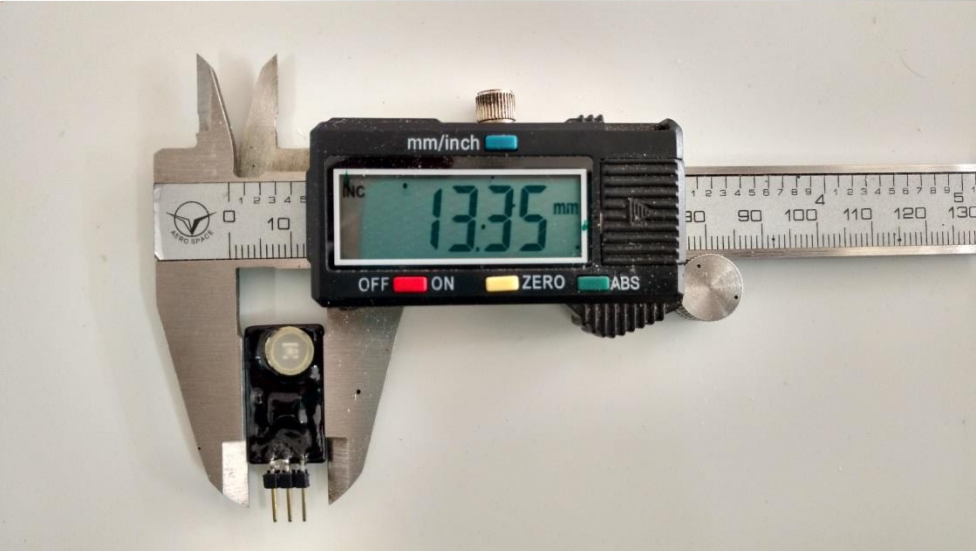
-Compact moisture sensor device developed by electrical department IIT Bombay.

-Great potential in measuring soil moisture that aids small scale farmers of India.



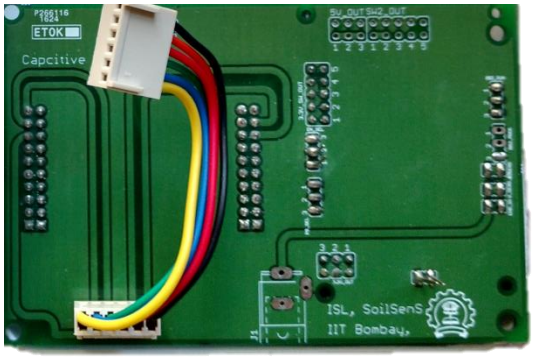
(a) Soil moisture system prototype ver(2),
(b)humidity sensor
(c)sensor module (soil moisture and soil and soil temperature)
(d)Packaged soil moisture sensor

Rajul S Patkar, (2016). “Low cost piezoresistive cantilever platforms for agricultural applications”, Ph.D.Thesis, IIT Bombay.
Prof. V. Ramgopal Rao
Prof. M.S Bagini



Sensor Dimensions -13.35x33cm

PCB board Dimensions -10.6x2x4cm



Methods of soil moisture measurement

Direct

-Gravimetric method

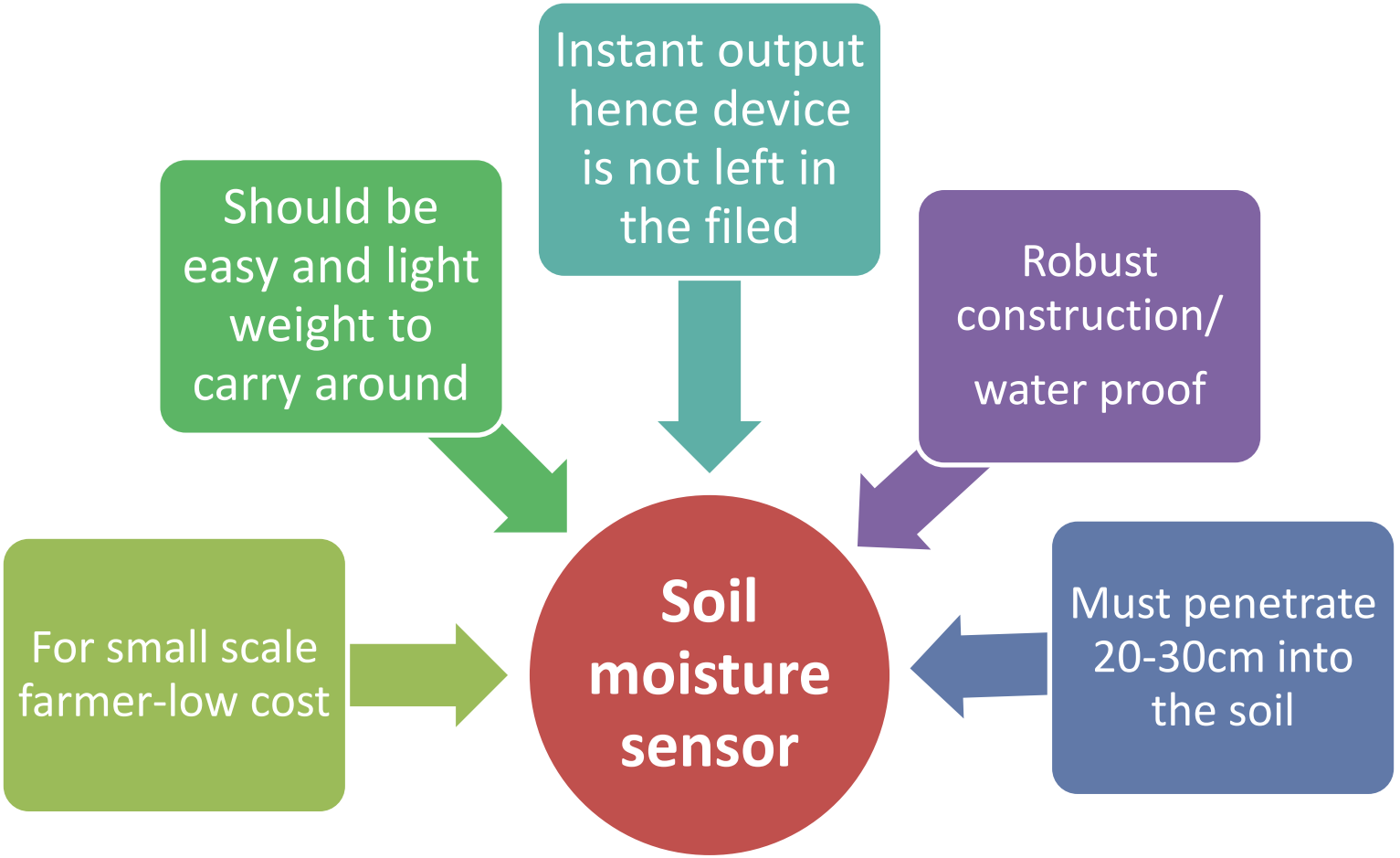
Indirect

-Tensiometer
-Gypsum block
-Neutron meter
-Dielectric sensor
-Dual needle heat pulse

Scenario in India

Feel and appearance method. A practical estimate of moisture content is obtained by the feel and appearance of soil samples taken from the desired depths.

Priorities


Instant output hence device is not left in the filed
Should be easy and light weight to carry around
Robust construction/
water proof
Soil moisture sensor
For small scale farmer-low cost
Must penetrate 20-30cm into the soil

Light weight and easy use

Cost

Robust construction/waterproof

Penetration into soil

No direct contact with sensor

Modular

Objective

The objective of the project is to design a soil moisture measuring equipment based on the proposed sensor technology developed at electrical department of IIT Bombay. The project is aimed to benefit small scale farmers and will prevent excessive wastage of water as the equipment helps determine moisture content of soil and thereby suggests farmers to irrigate conservatively.

Design Brief

To design and develop an equipment which detects the moisture content in the soil. The product will typically benefit a small scale farmer such that it helps him/her determine the water requirement for various crops cultivated in different soil types. While keeping the following constraints in mind

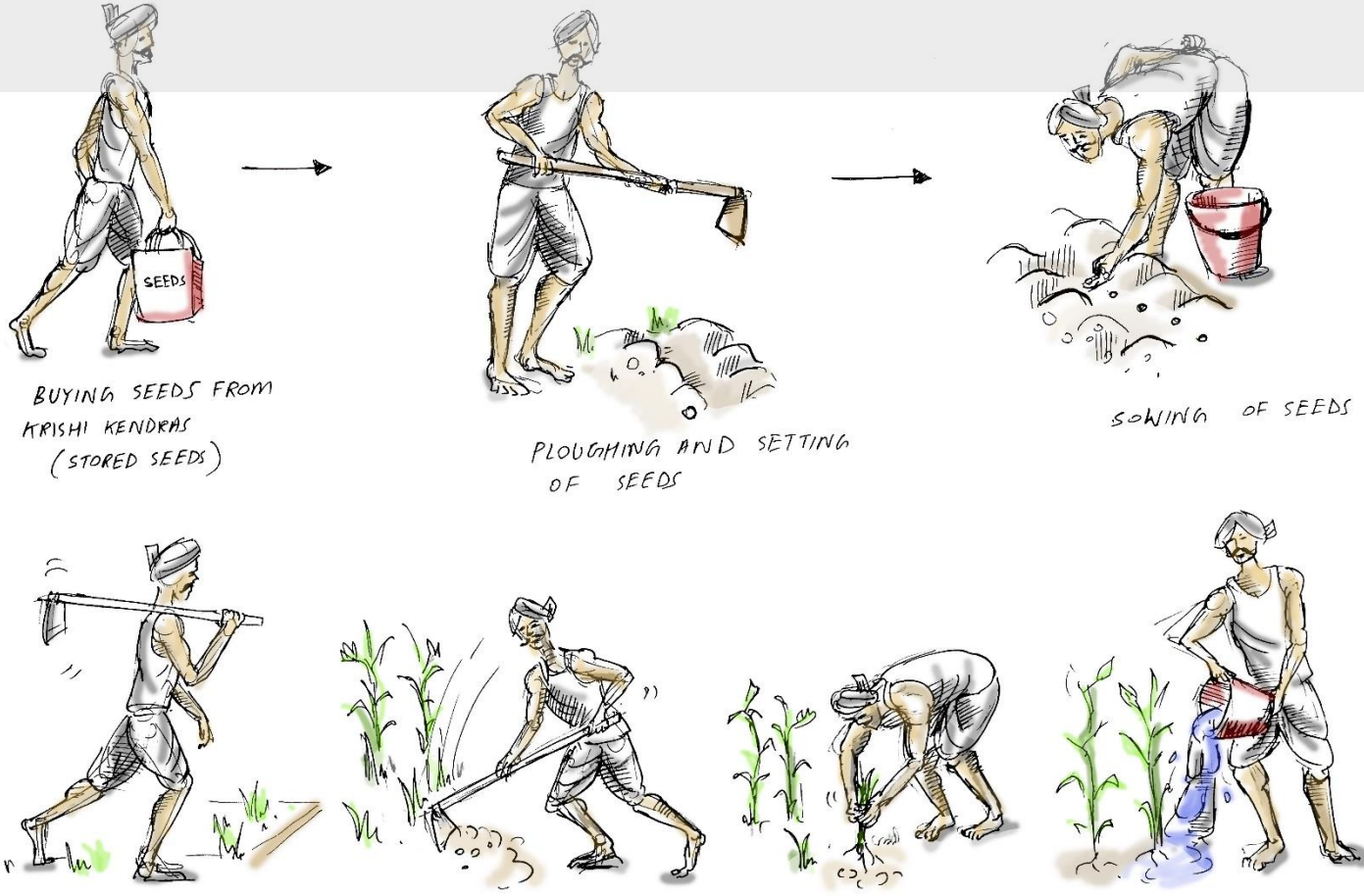
-Cost : The estimated cost of product should not exceed 1000/Rs(selling price)

-Portable unit : The unit should be portable and easy to handle that indicates moisture levels at different locations in the field randomly

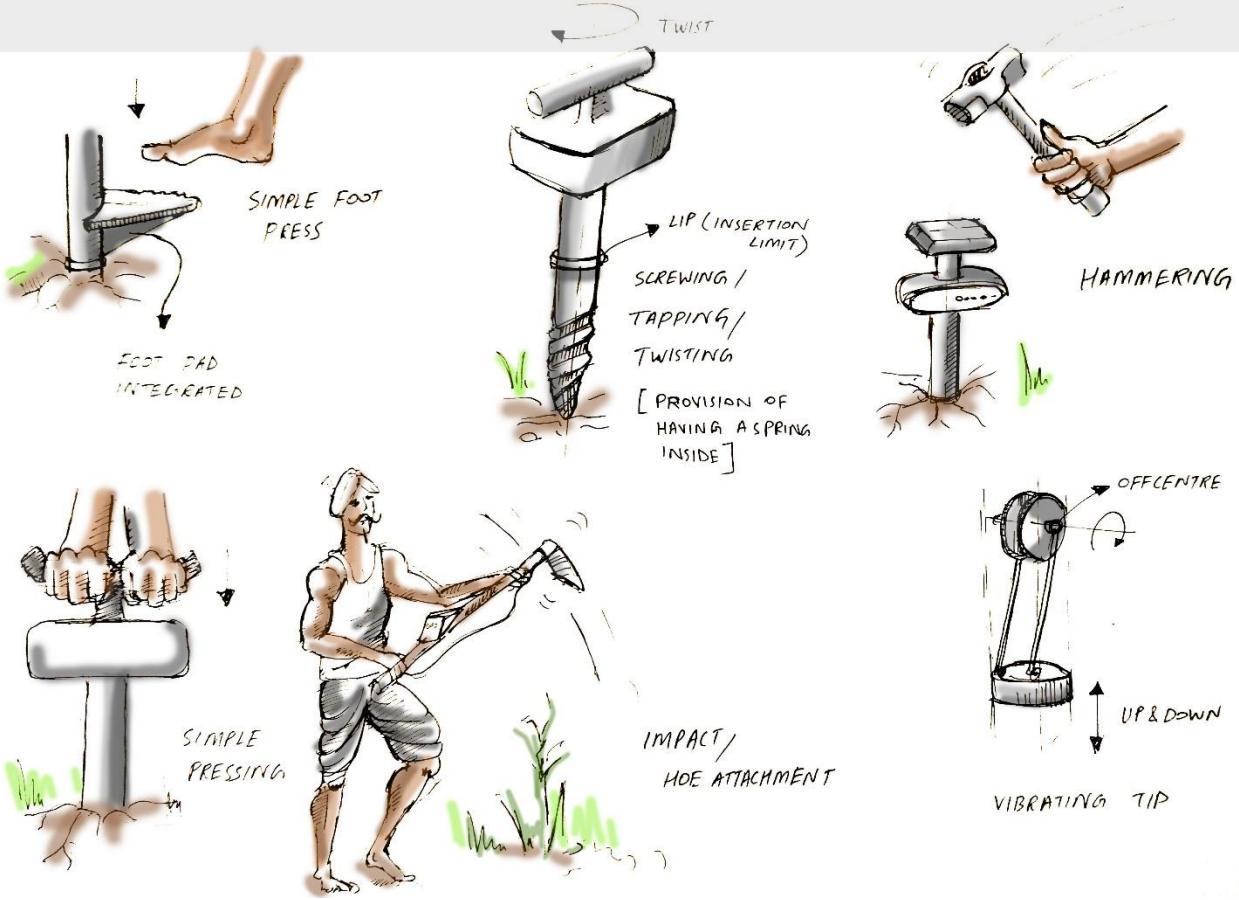
-Feedback : The unit indicates five levels of moisture content that can be customized depending on type of soil and crop

-Deployment : The deployment should be such that the sensor is well protected and does not come in direct contact with soil

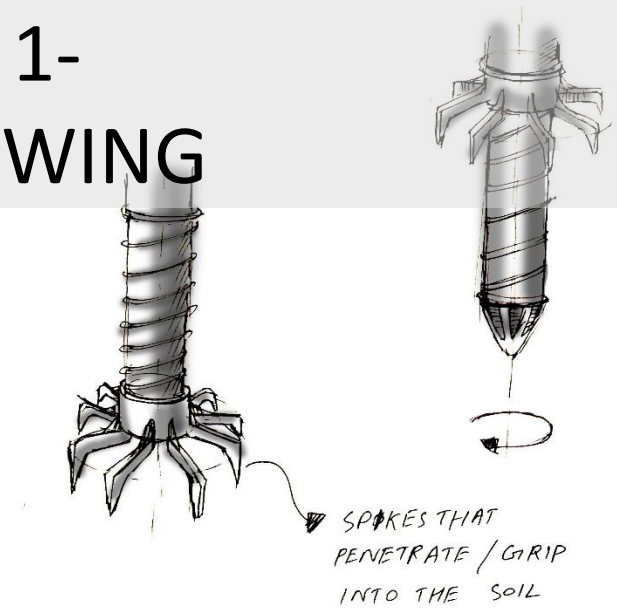
ACTIVITY ANALYSIS-FARMING

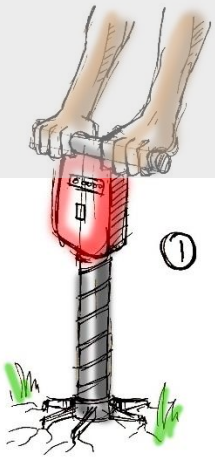


METHODS OF PENETRATION INTO THE SOIL

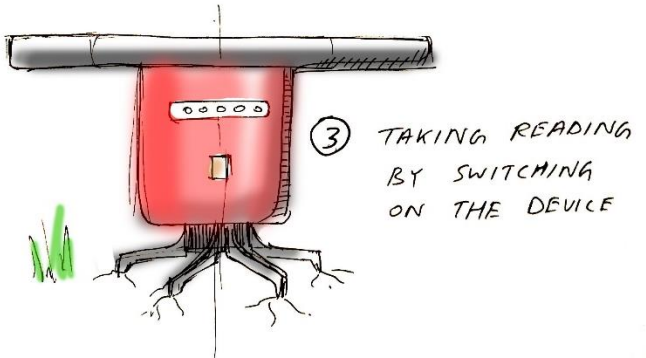


IDEA 1- SCREWING

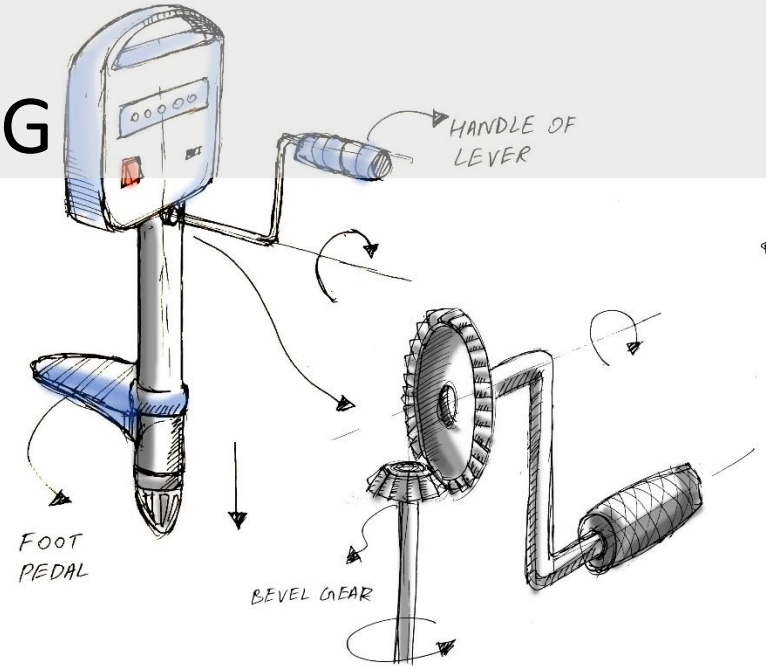


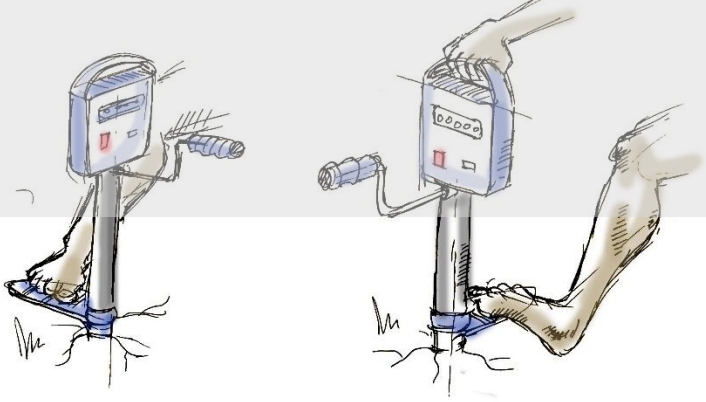


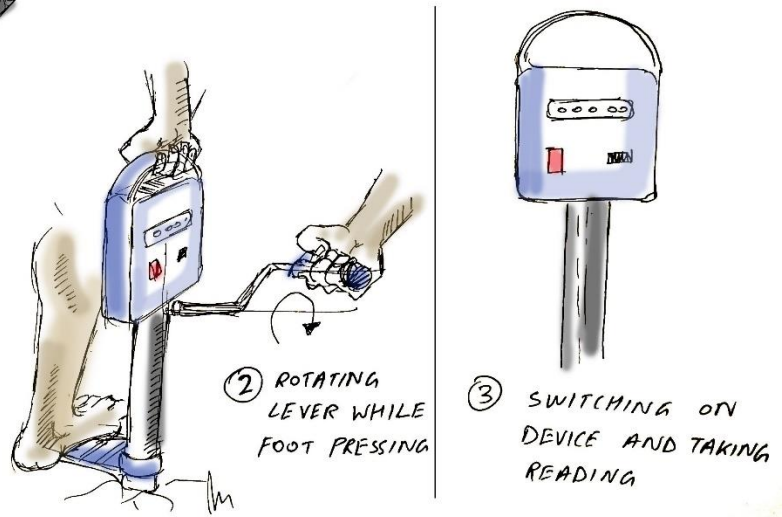
Claws resembling spider legs grip the unit which is then screwed down by twisting the handle in clockwise direction.



IDEA 2- SCREWING

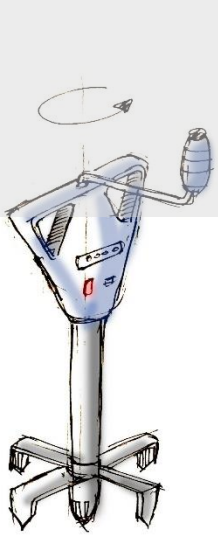


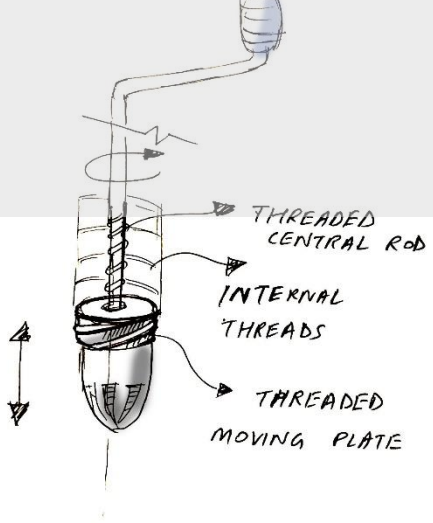




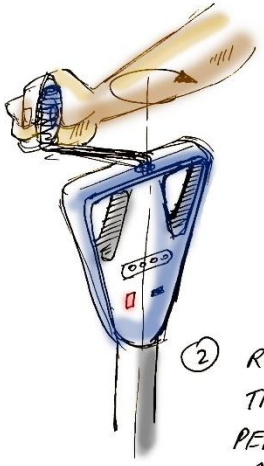
The bevel gear assembly helps in achieving twist motion of the pointed tip. Force is applied at the top handle as well as the foot pedal which makes it easy to achieve the desired depth

IDEA 3- SCREWING

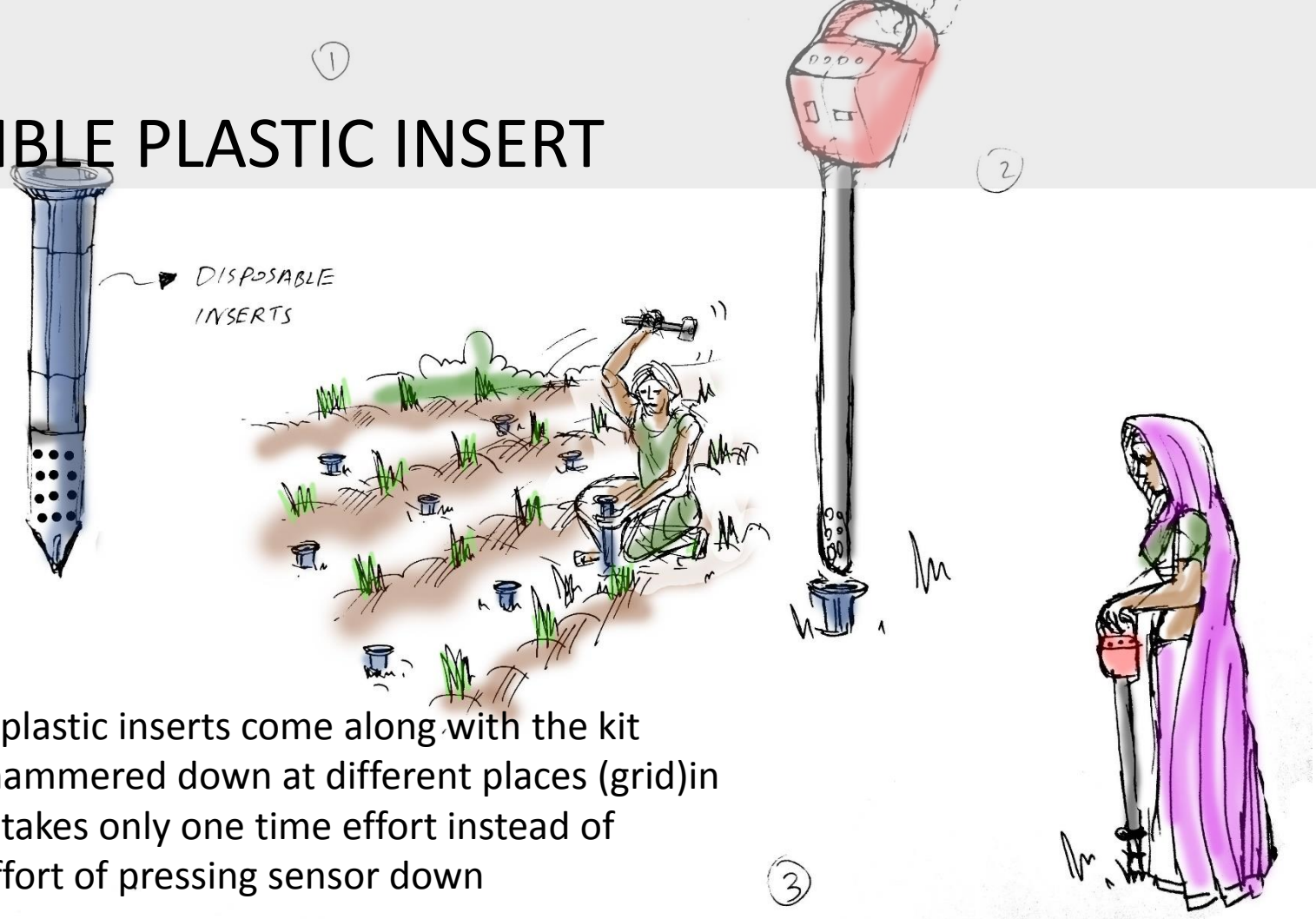




The unit has a fixed claw that grips the soil. Once fixed, the user steps over the claws and the lever is rotated. The plunger as well as the tube is threaded internally which allows the tip the extend while keeping the unit in place.

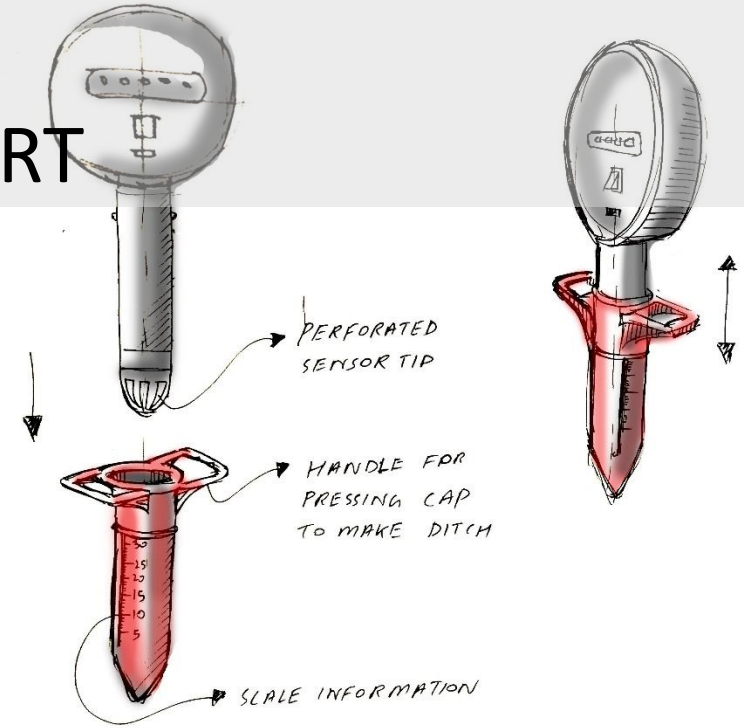


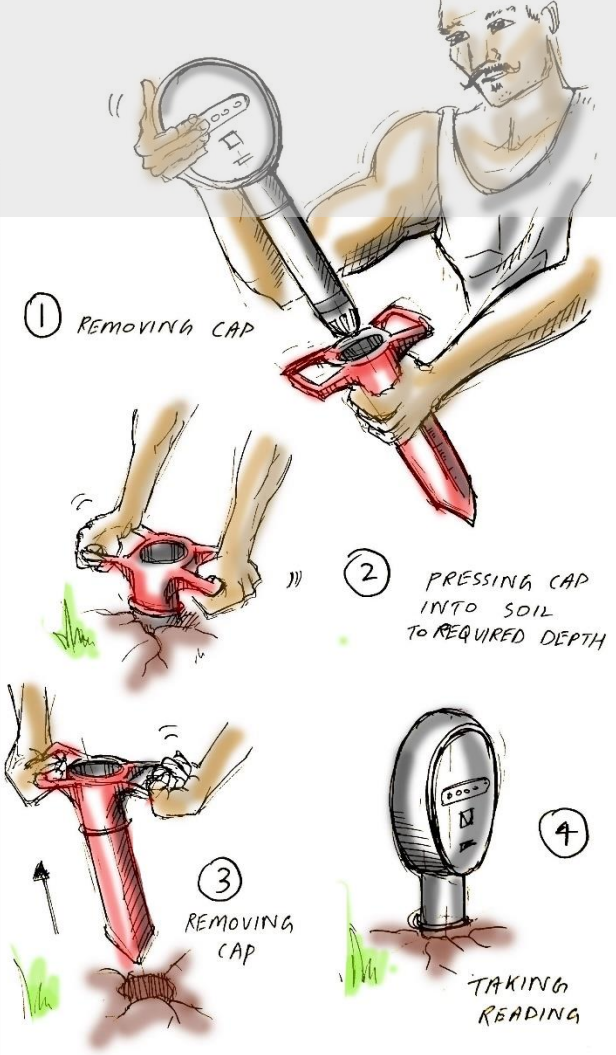
IDEA 4-
DISPOSIBLE PLASTIC INSERT



Disposable plastic inserts come along with the kit which are hammered down at different places (grid)in the field. It takes only one time effort instead of everyday effort of pressing sensor down

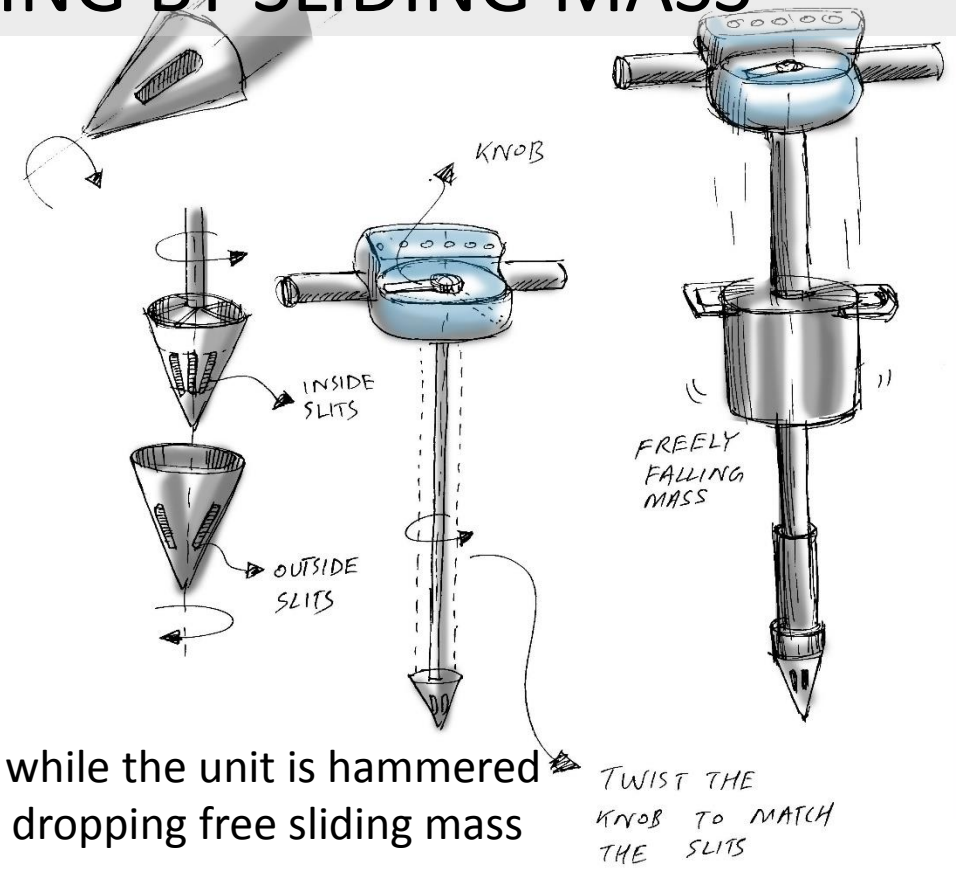
IDEA 5-
PRE- INSERT





The unit comes with hollow metal cap that is removed and pressed down the soil to achieve the desired depth. The cap is then removed and the unit with sensor tip is inserted into the dug hole.

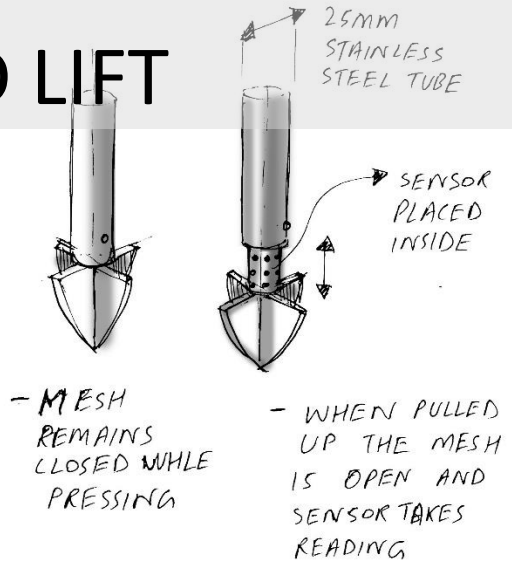
IDEA 6-
HAMMERING BY SLIDING MASS

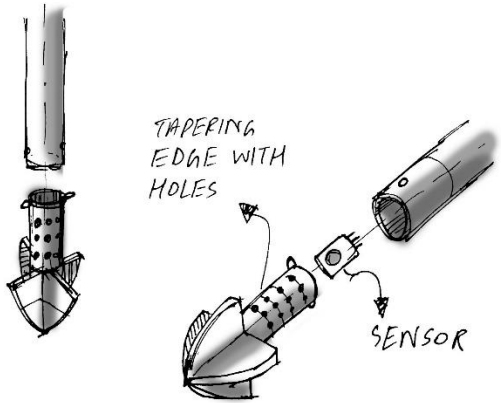


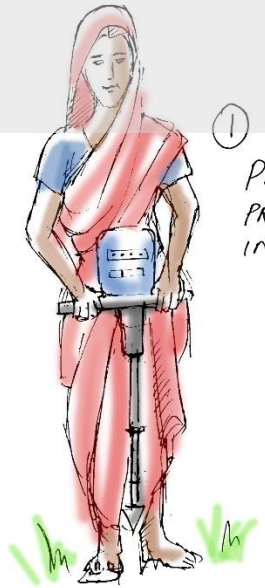
The slits are closed while the unit is hammered down by lifting and dropping free sliding mass

IDEA 7-
PRESS AND LIFT

Once the depth is achieved, the handle is lifted which slides open the sensor module by friction caused.





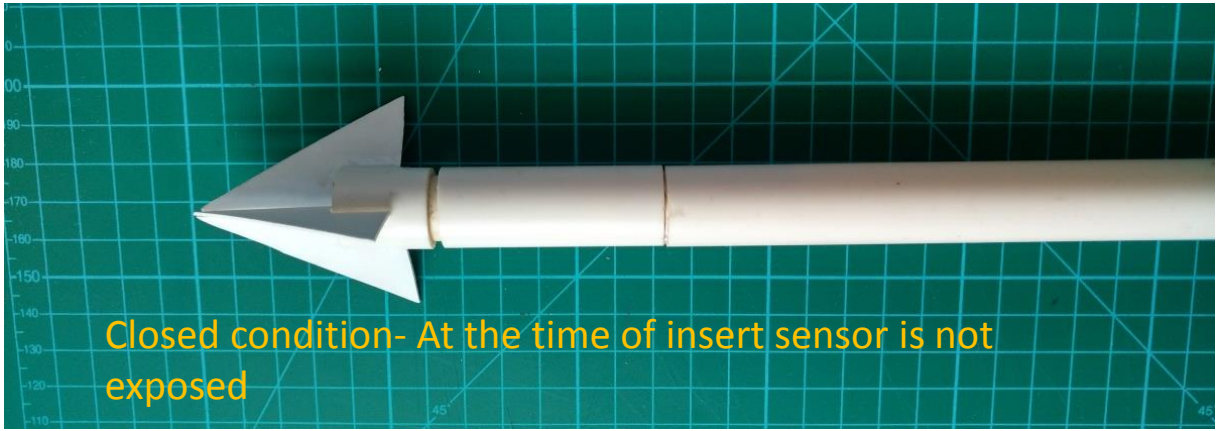


The unit pressed from the top handle while foot pressed at the same time to achieve the desired depth.

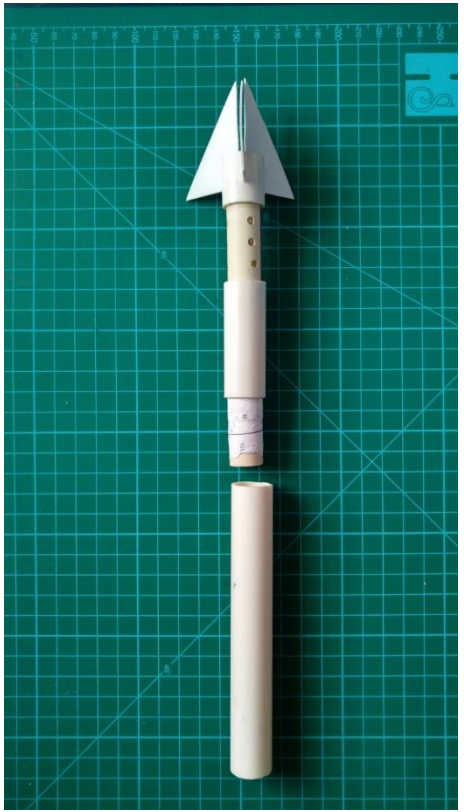
Concept	Merits	Demerits	Champion property
Idea 1	-Spikes offer better grip for twist -Easy to manufacture	-Multiple twisting required to reach desired depth	Easy penetration by screwing action
Idea 2	-Easy handling -Direct implication of usage	-Foot pedal need to be pressed continuously -Moving parts	Foot press
Idea 3	-Faster penetration because of screwing action at tip	-Moving parts -Needs more effective fixing mechanism as reaction force tends to lift the unit	Screwing Action at the sensor tip
Idea 4	-Requires only one time effort to dig and insert all the disposable inserts	-Cost of disposable insert will add -Limits flexibility -Requires maintenance as pores gets blocked and need washing	One time effort
Idea 5	-Compact unit (small) -Cap is inserted first and main module is placed in the hole made which result in longer life of sensor	-Multiple parts -User need to bend every time of usage	Cap makes the hole
Idea 6	-Desired depth is attained easily by 2-3 repeated lifting and releasing of sliding mass -Slits are closed while insert	-Sliding mass makes the unit heavy and significantly increase cost	Slits are kept closed while insert and opened only to take reading which keeps sensor safe
Idea 7	-No complex mechanisms or moving parts -Robust design	-Uses pure human effort to reach the required depth -Fin extensions cause more resistance to pull out	Robust design with no moving parts

MOCK UPS & TEST RIGS

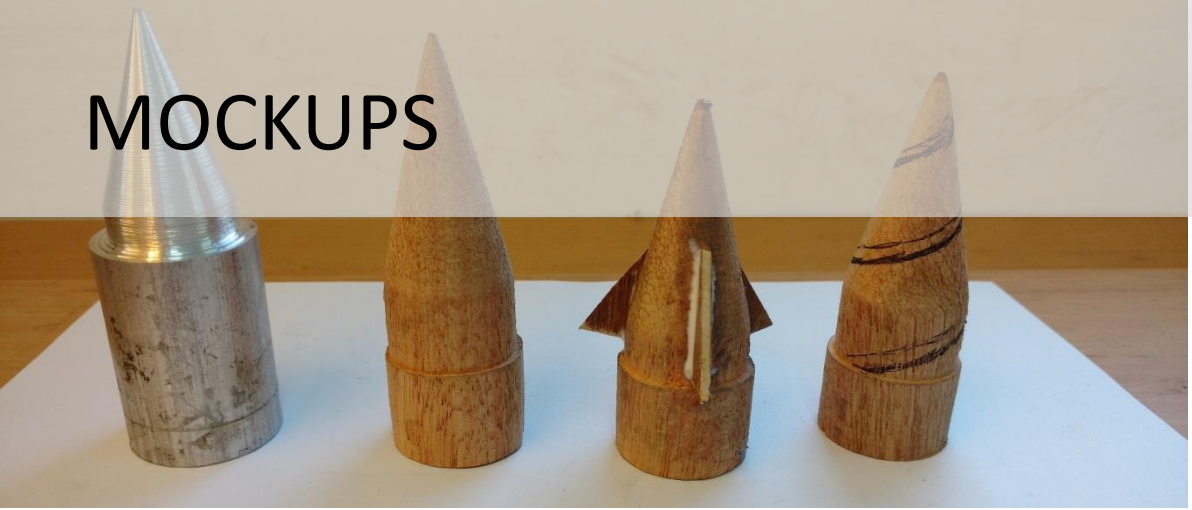
MOCKUPS


Closed condition- At the time of insert sensor is not exposed


Open condition- Sensor is exposed to humid air inside the soil



MOCKUPS

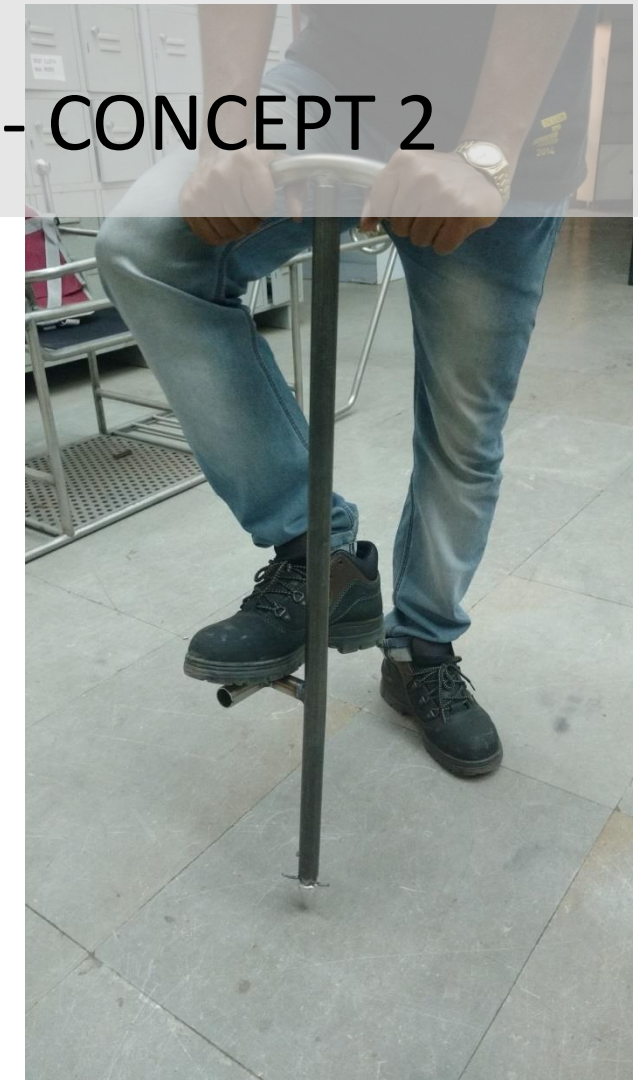


TEST RIG IN STAINLESS STEEL TUBE- CONCEPT 1

TEST RIG IN STAINLESS STEEL TUBE- CONCEPT 2

STEPS INVOLVED- CONCEPT 1

STEPS INVOLVED- CONCEPT 2



TASK ANALYSIS CONCEPT 1

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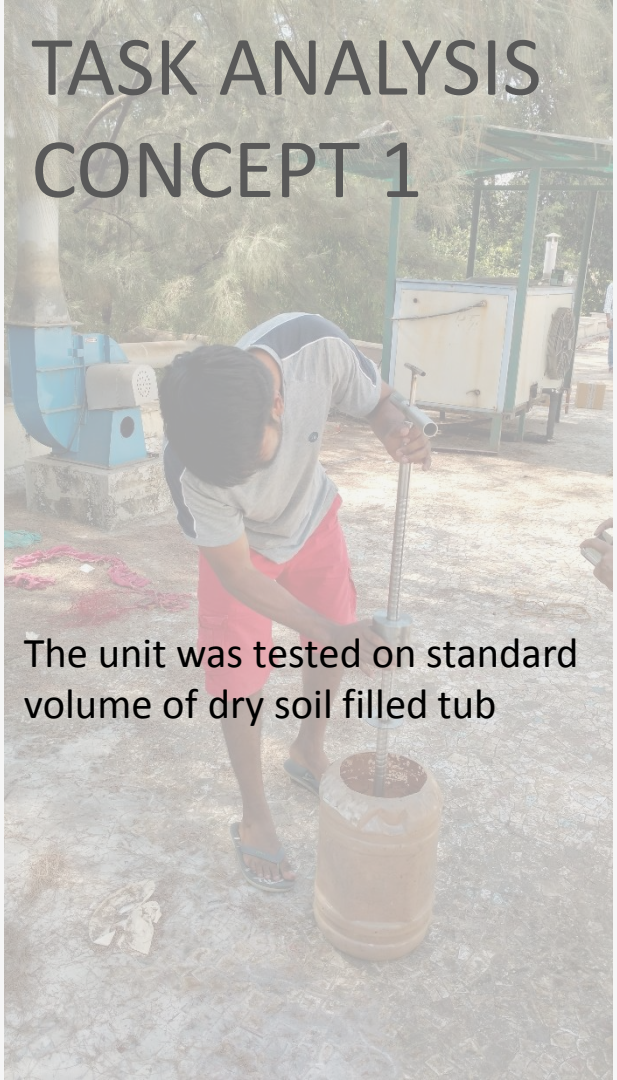
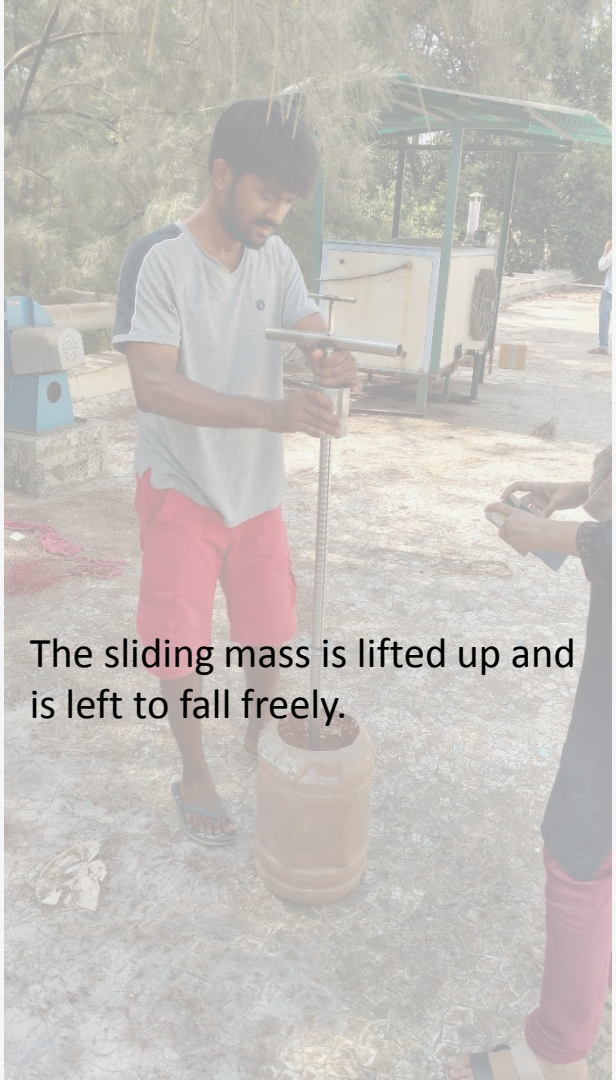


The unit was tested on standard volume of dry soil filled tub

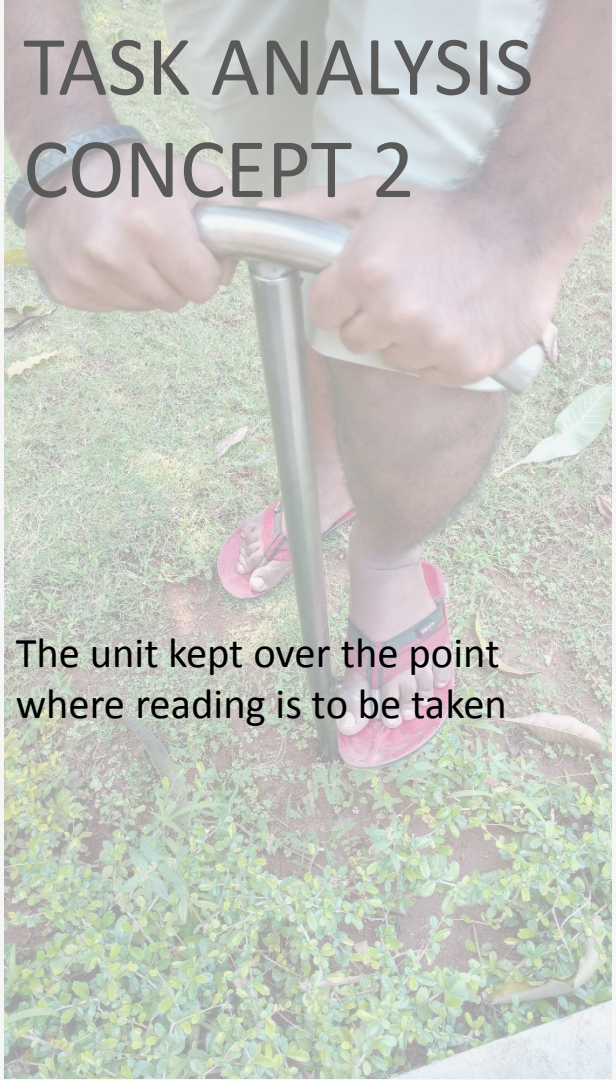


The sliding mass is lifted up and is left to fall freely.

Since the soil selected was too dry it took couple of repeated hammering to achieve desired depth.

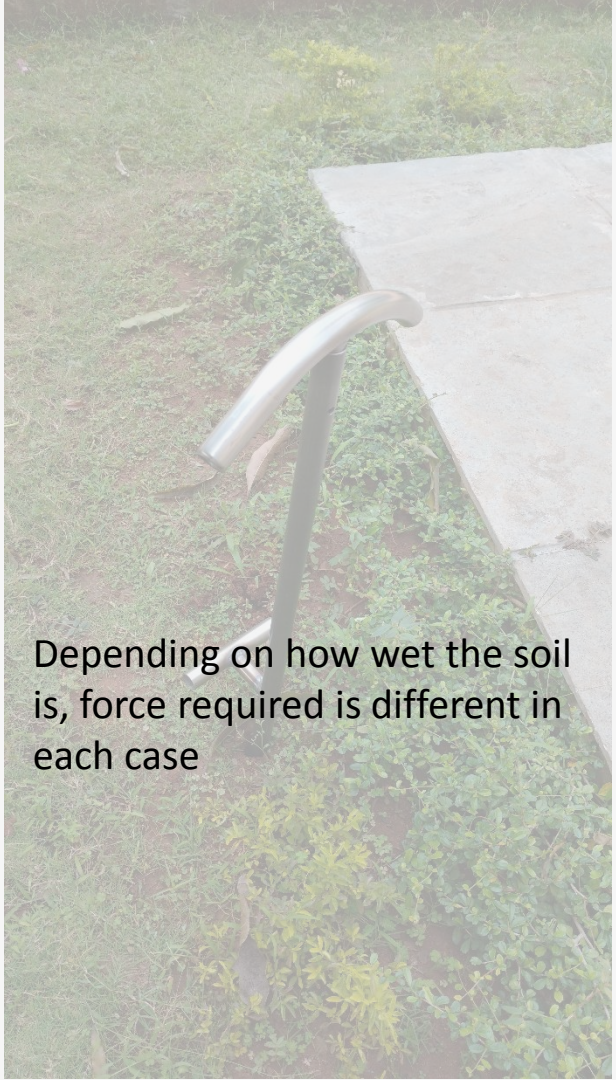
TASK ANALYSIS
CONCEPT 2

TASK ANALYSIS CONCEPT 2



The unit kept over the point where reading is to be taken

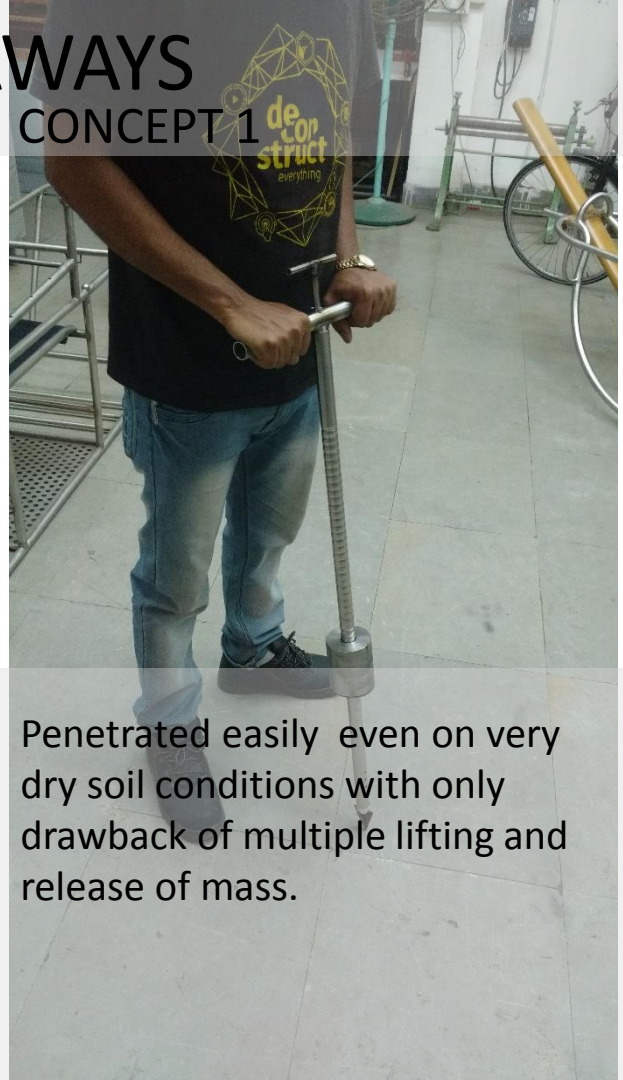
Force is applied over the foot pedal to press down the unit to desired depth



Depending on how wet the soil is, force required is different in each case

TAKEAWAYS

CONCEPT 1

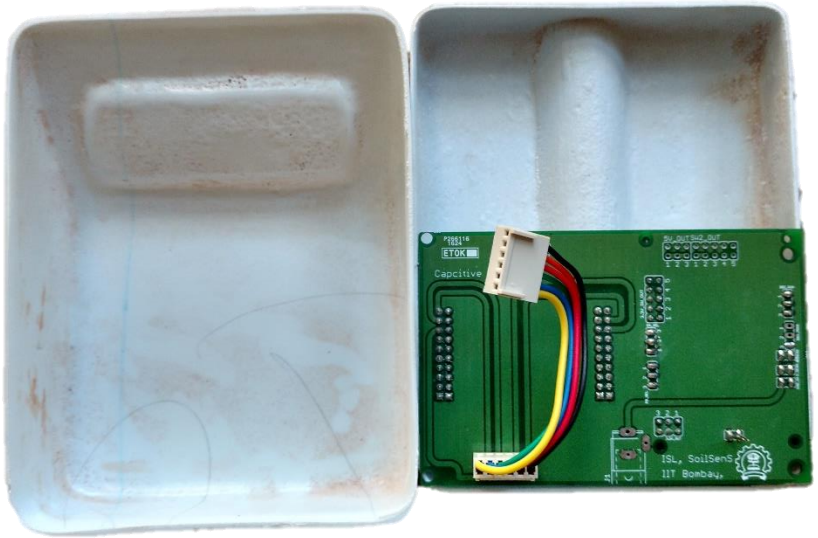


Penetrated easily even on very dry soil conditions with only drawback of multiple lifting and release of mass.

CONCEPT 2

More amount of soil while the unit is taken out making it necessary to clean the unit after use. It was also observed that more effort from the user was required to attain desired depth depending on moisture condition

CONTROL UNIT DESIGN



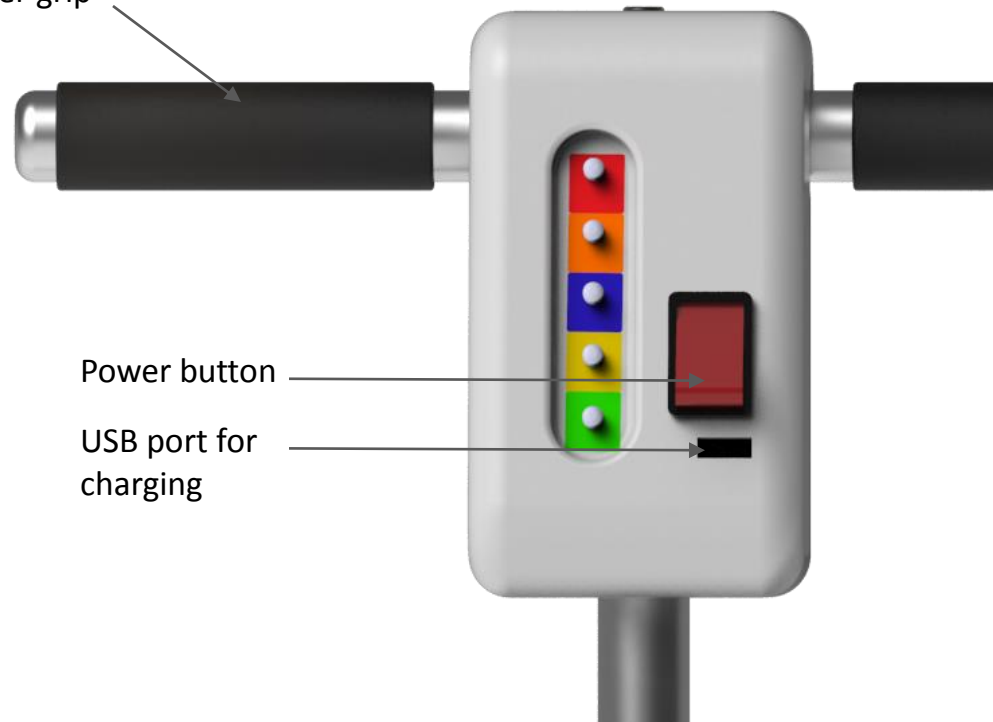
Control unit vacuum formed in styrene

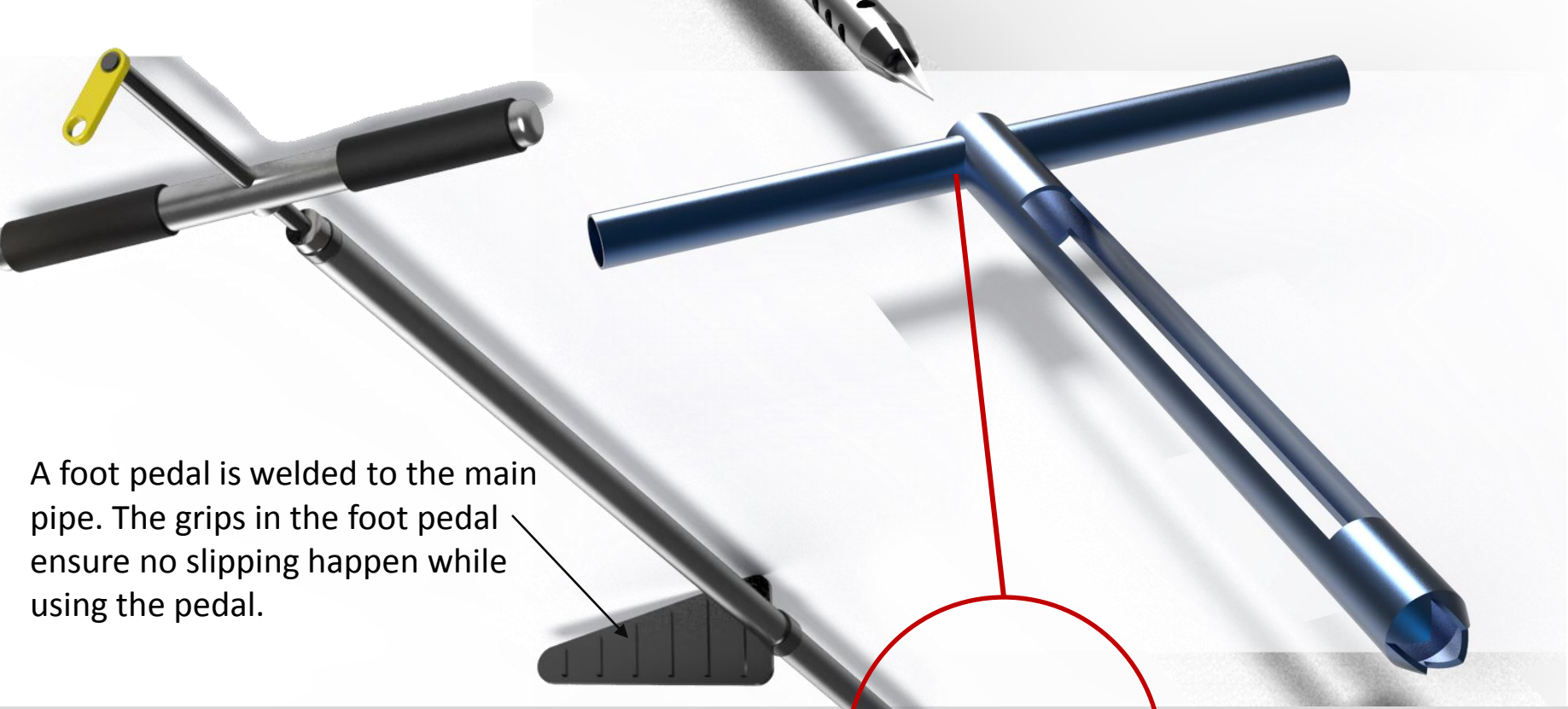
Internal electronics placed inside- The new compact design of circuit board now allows in further optimizing design and make it compact

FINAL CONCEPT

FINAL CONCEPT

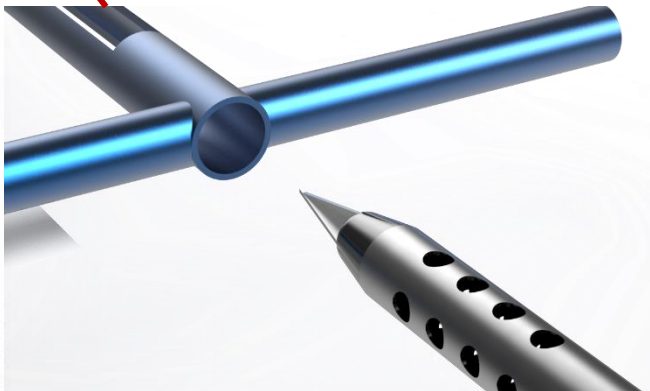
Desirable characteristics of both concepts were combined to arrive into final design. Optimized use of materials ensure stable design and less wastage





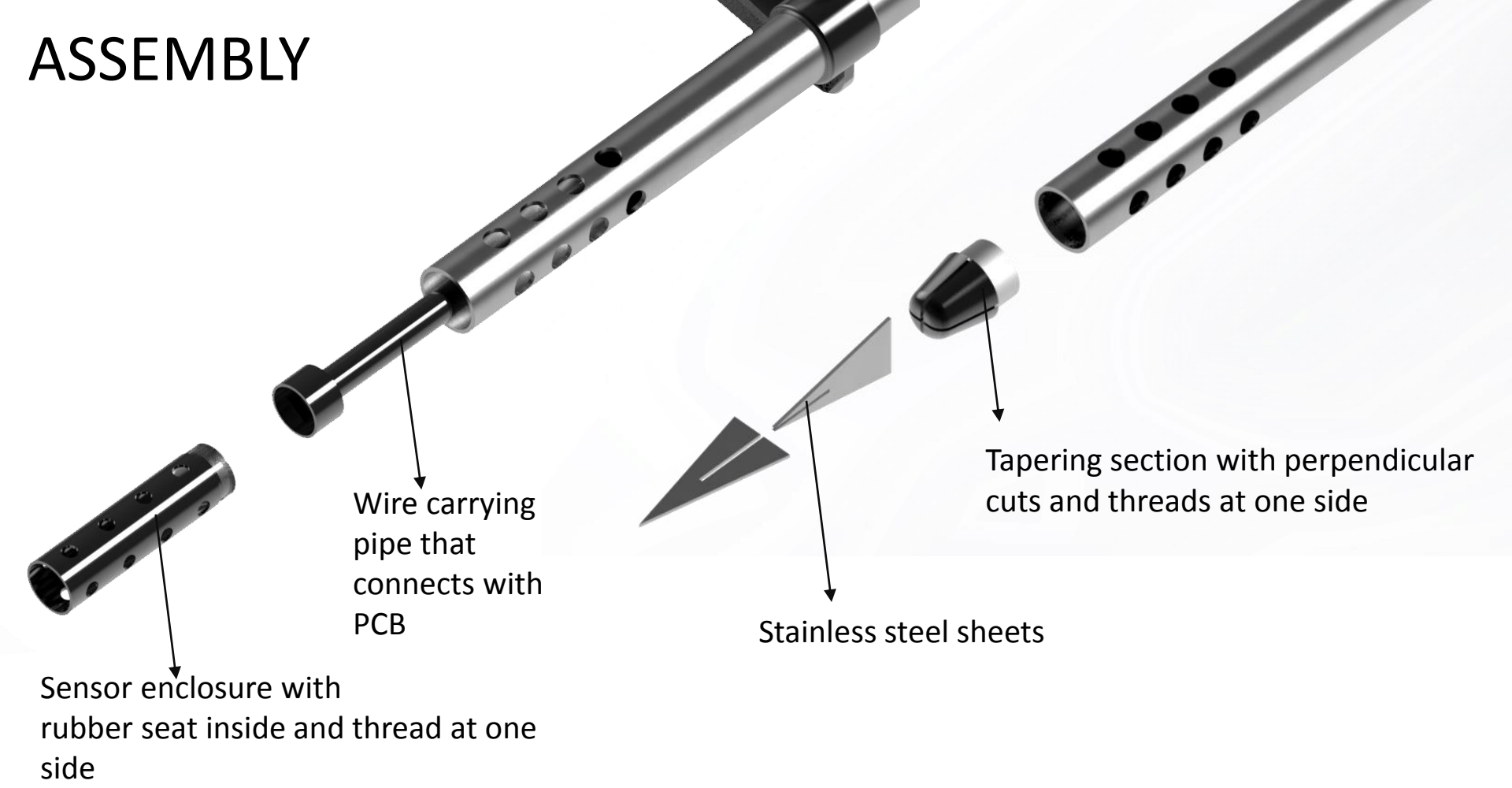
A foot pedal is welded to the main pipe. The grips in the foot pedal ensure no slipping happen while using the pedal.

If the soil conditions are too dry to make direct penetration, an auger tool is provided along with the unit



For easy packaging, the auger tool is fits like a cap for the parent unit. This also helps protect/secure the sharp head of the soil moisture sensor

ASSEMBLY


Wire carrying pipe that connects with PCB
Tapering section with perpendicular cuts and threads at one side
Stainless steel sheets
Sensor enclosure with rubber seat inside and thread at one side

USER INTERACTION

Knob to twist open sensor enclosure

Dry

Semi Dry

OPtimum

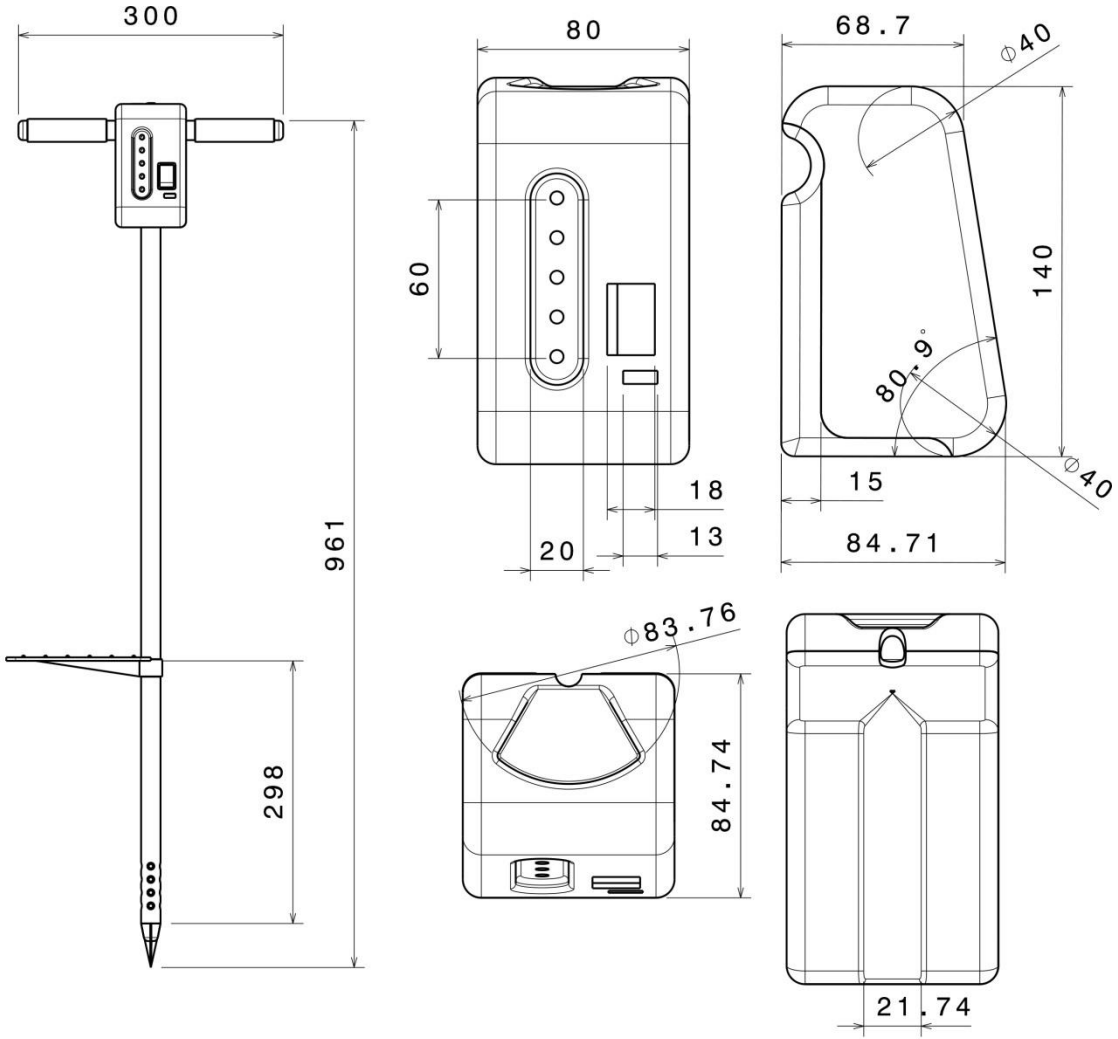
Semi Wet

Wet

The two halves of the box are injection molded and is screwed from behind.

The unit is water resistant with IP 54 (ingress protection from dust and water proofing for water sprays from all direction) is taken into consideration.

Dimensions


300
961
298
80
60
18
13
20
68.7
ϕ40
140
80.9°
ϕ40
15
84.71
ϕ83.76
84.74
21.74

PROTOTYPING

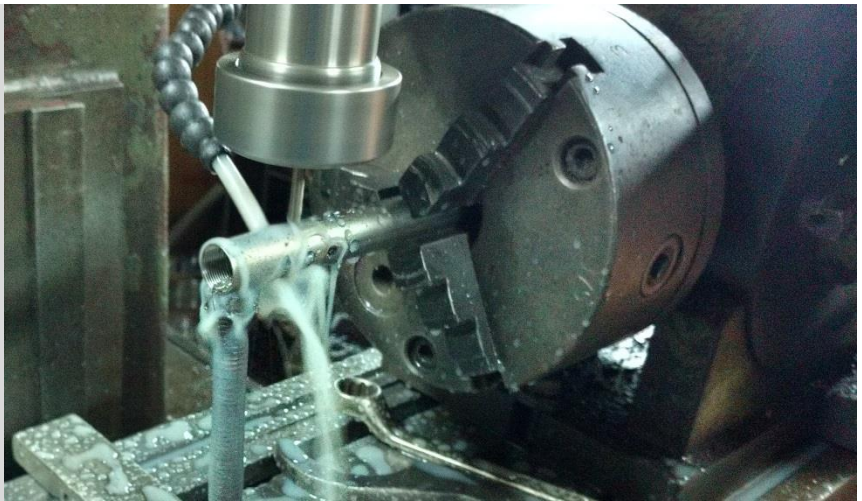
Sensor seat with threads

Sensor seat and head

Head with cross triangular metal tip

Marking before drilling

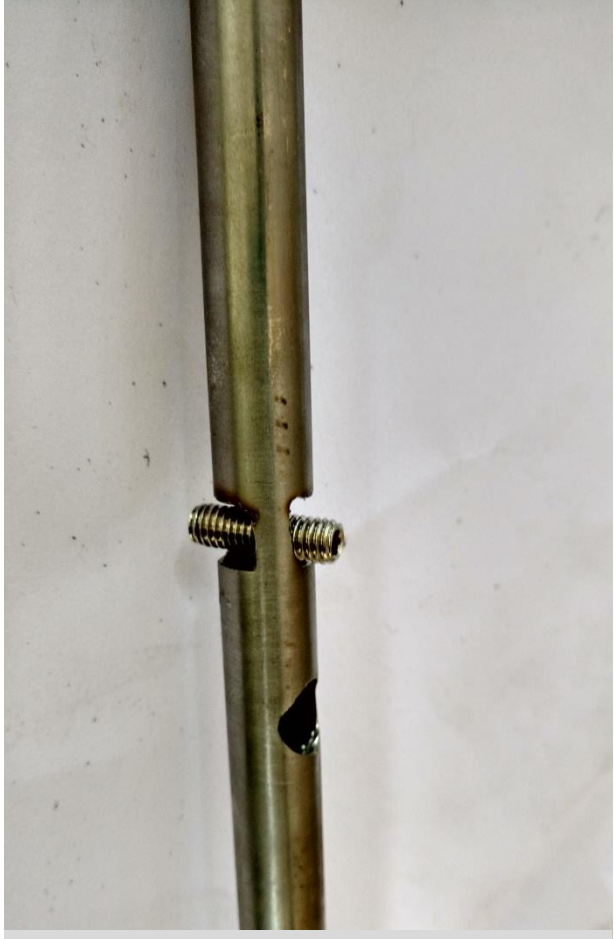
Drilling slit holes in sensor seat using divider and drill machine



Finished sensor seat

Fixing head by screwing and grub screw

Auger tool to assist digging in hard soil conditions



Grub screw near handle area

Vacuum forming of control unit

Model with auger drill

Usage posture


THANK YOU