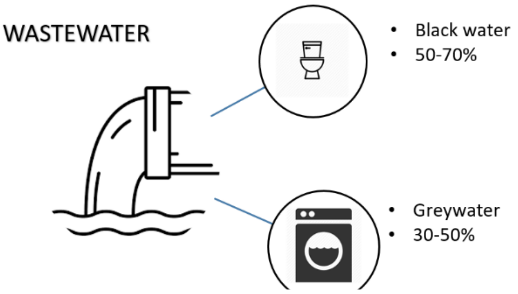
WET-TECHNIK

WEGE PRIZE

OUR SOLUTION

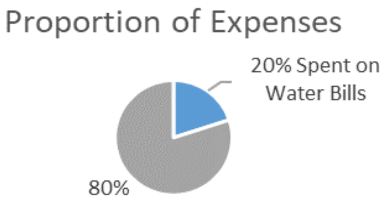
Wet Technik is a student start-up founded at Makerere University by a multidisciplinary group of students looking at reducing the costs of water usage and environmental pollution by hazardous wastewater through the use of constructed wetlands. Focused on solving the ever-present problem around wastewater handling, we want to bring to light the potential of its recycling to enable optimum water usage. **Through using a mixture of modified waste bottle caps and pumice in our constructed wetland**, we have proven that it will **reduce the area requirements**, making this system accessible to the factories, schools and eventually households.

PROBLEM STATEMENT.



Wastewater is mainly in two categories namely; black and greywater. Greywater comprises of a large proportion of wastewater generated in households and institutions. The reuse of greywater serves two fundamental purposes namely reduction in the fresh water requirements and reduction in sewerage generation.

Wet Technik is targeting recycling wastewater from schools and factories as these have knock-on effects on the surrounding communities, as well as the respective schools and factories.



Number of schools surveyed=6
Average Population= 1400 students
Water bill monthly= 1.5 - 2 Ushs. Million

The amount spent on water is a significant proportion of the total monthly expenditure in schools.

Per Capita Water Consumption	Non Potable	Potable
Most of the activities consuming the water were **non-potable** uses.	• Washing • Flushing toilets 27 liters (per person daily)	• Cooking • Drinking 10 liters (per person daily)

There is great potential for the use of water, from our solution, to satisfy these purposes hence reducing the effective water bill.

Growth of industries	
2001	11968
2018	20747

[1] *6.5%growthrate*

Urban population growth	
2005	14,838
2014	17,597

[2]

Fish Export volume (tons)	
2005	238 533
2011	183 824

Uncontrolled industrial development in urban areas has been a major source of pollution in the country [1]. Rapid increase in Ugandan's population needs a large public sector investment especially in regards to wastewater treatment. The increased pollution from both the urban settlers, whose waste volumes are alarming and the industries have contributed to the declining fishing industry. The economic effects of industrial pollution have knock-on effects, through the decreased economic potential of resources that are polluted and affect those that derive their income from the water resources e.g. fishermen in Lake Victoria and also the reduced output from workers through waterborne diseases resulting from environmental pollution. Uganda has a population of about 1.3 million people involved directly or indirectly in the fishing industry.

A study [3] on the management of industrial and municipal effluents in the Lake Victoria basin in Uganda indicated that most factories do not have effluent treatment plants and even where they existed most of them were poorly designed and constructed. Therefore, of those that have effluent treatment plants, only a few were achieving effluent discharge standards. This is a major threat to both the bio-diversity of the lake and the continued sustainable use of the lake resources which are a backbone to most of the population living in their vicinity. An environmentally friendly, cheap but circular alternative is needed to effectively filter out the toxic substances before release into the natural streams.

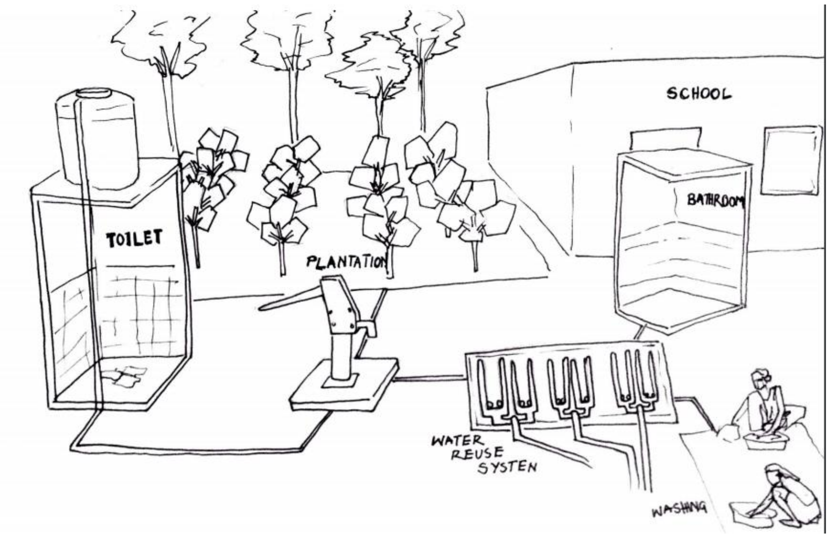
Solution Overview

Constructed wetlands have been adopted as a solution to treating and recycling wastewater. A **constructed wetland** is a shallow basin filled with some sort of filter material (substrate), usually sand or gravel and planted with vegetation tolerant of saturated conditions. [4] They are cheap and easy to maintain solutions as compared to other wastewater treatment systems. The major barrier to their implementation in various settings i.e. households, institutions, communities and factories is the large area requirements.

An extract showing the area required for various constructed wetlands in different applications.

Case Study	Wastewater Flow per day (m^3)	Population Equivalent (PE)	Total Surface Area (m^2)	Surface area per PE m^2
Kathmandu University wastewater treatment	30	193	628	3.3
Environment and Public Health Laboratory Kathmandu	0.7	6.8	15	2.2
Sunga Municipal Wastewater treatment	10	285.7	300	1.05
Winery Factory Italy	70	N/A	1330	N/A

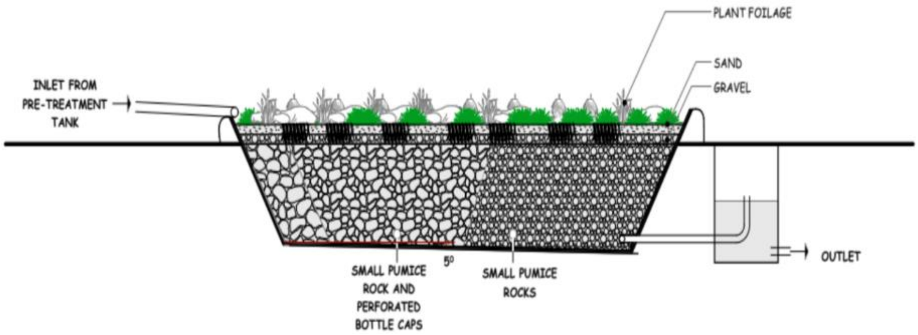
Source: UN-HABITAT, 2008



Our innovation looks at the use of **pumice** and **modified waste bottle caps** as a filter material to reduce the area requirements while maintaining the quality of water effluent from the system. Wet Technik wants to use **beautiful wetland flowers and other plants** and **creative landscape designs** that coupled with the less area requirements can have the system placed within the school's interactive space. Therefore, there will be more value for maintenance of the system due to its increased visibility, making our solution more sustainable.

Our solution will be more applicable in places with limited land like households in urban settings and factories that have limited land but require a wastewater treatment facility. The product we are presenting gives an opportunity for households and institutions to recycle their greywater generated hence optimum water usage and factories a treatment option for their wastewater to meet the discharge standards of the National Environment Management Authority(NEMA).

How our system works.



Greywater is collected and directed to a pre-treatment system where most solid particles and other pollutants can be removed. The water is then directed to the inlet pipe at the wetland bed and flows into the bed. The water flows through the main bed in a horizontal path for the recommended retention time and undergoes filtration and other processes that improve the quality of the water by removing pollutants both organic and inorganic. The water is collected at the collection point where it is to be accessed for re-use. The flow of the wastewater is sub-surface and this does not allow stagnation of wastewater on the surface that can be a breeding ground for vectors and this makes it advantageous compared to other constructed wetland technologies.

Impact Assessment

In the wastewater sector at the moment key players are waste handling companies such as cesspool emptiers who collect wastewater from households at a fee and National Water and Sewerage Corporation (NWSC) which is the regulator and collects wastewater from households through sewer lines.

Existing Linear System Models from field visits.

There is **no value** gained by those who let NWSC handle their wastewater as it is taken for further treatment before release into Lake Victoria. We look at creating value from this wastewater released by households, institutions, and factories by availing it for reuse on site in various applications such as subsistence farming hastening the change towards the circular economy as this is a popular economic activity in the country.

The impact of the constructed wetland will be measured for a given setting in which it is set up. The following key performance indicators will help us clearly track our progress and impact and predict our success.

In Katanga and Kasokoso slum communities in Uganda, wastewater is disposed onto roads and channels for rainwater. In some cases, wastewater is collected in a shallow pit (soak pit)

In schools, there are designated places for washing and bathing and greywater is directed into a channel before disposal into natural swamp or drains. There is a separation between black and greywater.

Most factories do not have existing wastewater recycling solutions and mainly dispose onto existing water bodies such as streams etc.

Outcome	Indicator	Methodology
Improved quality of water released by factories and schools.	Quality of water released meeting required National Standards.	Effluent discharge tests on the water coming out to detect any changes.
Less pollution of the environment from the factory and related diseases on people and animals	Better quality of effluent water and lower rates of human and animal waterborne diseases Reports from nearby hospitals.	Surveys and Interviews with nearby communities to assess the impact of our system.
More water for reuse	Reduction in freshwater quantity (amounts) used by school	Monitoring of flow meters on water used by the school.
Reduced water bill per month	More than 20% reduction in the water bill	Financial analysis reporting on the water bills on a monthly basis.
Proper disposal of greywater in the school(s) where we have installed the system.	Downstream effects minimized e.g. diseases and economic impact of pollution.	Surveys on the community to check on diseases, general benefits of the system.
Increased product awareness.	Increased number of partners and clients. (partnerships with NEMA, NWSC, MOW (Ministry of Water, MOE (Ministry of Education), LC's)	Targeted workshops, coordinating visits of potential stakeholders to our pilot plant and social media such as LinkedIn
Increased profits for the end user through more recycled water availed.	More amounts of water availed for recycling.	Tracking of institutions water meters to get statistics on water used and amount availed for recycling by our system.
Improved economic standing of people in Kisoro district	Further commercialization of pumice through achieving more sales	Surveys and interviews carried out with our suppliers and other locals in Kisoro.

Supporting Policy:

A policy is required to overcome most of the barriers to implementation. The government of Uganda has policies both in the short and long term that foster overcoming of barriers to implementation. The government is implementing a **30-year plan Vision 2040** under the guidance of the **National Planning Authority**. It is looking at using water recycling technologies as a strategy to promote water use efficiency. Our product is timely and a partnership with the Planning Authority will enable the product to gain traction. A partnership with the Ministry of Education (MOE) will avail a large market base since the product is of most value to schools which are always charged with high water bills. According to **The Water Statute, 1995**, under **The Water (Waste Discharge) Regulations, 1998**, higher pollutant loads in wastewater released by industries, farms and other institutions incur higher fees. Our innovation is a direct fit as it greatly reduces the pollutant concentration in the wastewater released making these industries save more while reducing pollution. Effluent with pollution around 5,000 kg/year of Biochemical Oxygen Demand (BOD), which is characteristic of industrial and school effluent, attract a fee of 10,000,000 Uganda Shillings annually, whereas our solution which can reduce the BOD to about 500 kg/year of BOD, would incur a cost of only 1,000,000 Uganda shillings annually.

Prototyping

Our concept was taken on under the Problem Based Learning project where we got funding of $1000 to aid in research and later design and construct a pilot plant. The program also offered mentors who are now partners in working on this idea. We have partnered with Dr. Herbert Kalibbala Mpagi, a public health engineer and lecturer at Makerere University, who has designed and constructed ordinary existing constructed wetlands and he has guided us in the development of this product. He has an established network of potential stakeholders in the water and sanitation field like National Environment Management Authority (NEMA), National Water and Sewerage Cooperation and a factory Uganda Breweries Limited where he designed and constructed this wetland.

In the same PBL program, we have attended workshops with leading wastewater sector players such as NEMA, as well as held workshops on wastewater management at the university level. We also had a site visit to a school (Seeta High School) faced with a problem of managing wastewater and were able to gain contact and exposure. Wet Technik can leverage the resources we have so far to establish publicity for the system. There is a need to integrate deeper research into the materials so that the quality of water is improved and even fit more purposes.

Our product development process started off with procuring of 1 ton of pumice from the local dealers in Kisoro district and also obtained 50,000 waste plastic bottle caps from plastic collectors in Kampala. These materials have been cleaned and are to be used in the development of the initial pilot plant. We also designed our **machine prototype** for modification of the waste plastic bottle caps.

Construction of a pilot plant on the Makerere University campus behind the cafeteria for a hall of residence for girl students (Africa Hall) is ongoing. We adopted a **design with the end user approach** by carrying out interviews with the staff of the kitchen so as to understand their current challenges with the wastewater handling systems. We also carried out laboratory tests on the greywater from the kitchen at Africa Hall and measured the volumes of water produced over a two-week period. This pilot plant will provide water for re-use to the hall and facilitate reduction on water expenditure by the hall's administration which is the primary goal for the project. It will also be used for research by both Wet Technik and the university students who need to grow their understanding of water recycling technologies.

We have also worked closely with United Social Ventures, an incubator for social ventures in Uganda and through their various programs, we have been offered mentorship over a 2-month period in the development of a feasible business model.

Water Quality

Parameter	Regular CW		Our Solution	
	In	Out	In	Out
BOD	881	176	881	18
Phosphorus	12	10.8	12	10
Aesthetics	Not designed for		Aesthetic value attached	

To meet the water quality release standards, we used a modified pre-treatment system using the Anaerobic Baffled Reactor(ABR) mechanism. Microplastic contamination is existent in effluents of all wastewater treatment systems but was found to be significantly less in effluents of constructed wetlands. In addition to this, we have chosen HDPE bottle caps as this material has a higher corrosion resistance as compared to other types of plastic.

BARRIER ACKNOWLEDGMENT

Behavioral Change	The attitude people hold towards wastewater is negative. They do not have sufficient information about its potential. We intend to show the economic value attached to recycling water and the income saved. This will be clearly shown by the business model. The income saved will clearly show the value of greywater recycling and create a behavioral change hence the transition to the circular economy.
Existing plumbing systems	The plumbing systems in place especially in households do not offer separation of greywater and black water but combines the two which does not allow easy recycling greywater. The goal is to start with institutions like schools whose plumbing systems separate the two. This will show the feasibility of our system and will act as a proof of concept.
Low Maintenance culture	Previous technologies have been observed to fail in operation due to lack of maintenance culture. We are attaching aesthetic value to our product such that it is placed within the interactive space of say a school's compound and thereby its maintenance also adds value to the school's environment.
Technology	The modification of waste bottle caps requires machine work to ease the process and quicken production but also keep the process environmentally sustainable. A prototype machine that modifies 5 caps in one go equivalent to about 60 caps in a minute was developed and there is need to improve and develop an improved one to suit even more bulky numbers of bottle caps at a go.
Pricing Standards	The suppliers of waste bottle caps and pumice from communities tend not to have standard rates for their products. We want to have partnerships which will benefit all parties by attaining standard rates that will be fair for the various suppliers, improving their economic standing as well as Wet Technik.

Material Analysis:

The constructed wetland uses pumice, wetland plants (flowers) and waste plastic bottle caps as a filter material to remove the pollutants in wastewater and make it suitable for reuse in institutions and households and suitable for discharge into *the* environment by industries. The pumice rock is sourced from volcanic areas in Kisoro district, South Western Uganda. The local communities in Kisoro are involved in its collection as a source of livelihood.

The plastic is obtained from waste plastic collectors since there is a huge drive to reduce plastic waste in urban centers. Its collection has tremendously increased by different low-income communities. A partnership with these groups guarantees a constant supply of the materials to enable effective construction of our systems. The plants are obtained from nursery bed gardeners which is a common business in Uganda. They grow various plants for sale including flowers which can be used to give the constructed wetland aesthetic value.

Pumice

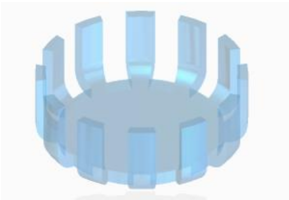
The pumice is a unique rock with a porous spongy surface that harbors the micro-organisms as water flows over it, that feed on organic matter in the wastewater effectively treating it. This compared to the ordinary gravel used in similar systems offers a bigger advantage in terms of treatment efficiency due to the unique surface texture of the rock. This rock is in great abundance in the region but due to limited valuable uses, it is left un-utilized and can be seen even left on roadsides. We want to increase its applicability and further commercialize it through use in our system. This will create jobs for those who are involved in the supply chain i.e.in its collection, transportation, and sale. In our pilot plant, we have already involved 5 unemployed locals in collection of the pumice, packing it and transporting. More jobs will be created for the locals in Kisoro when our systems are installed countrywide. The average price of a 100kg sack of pumice rock is 20,000 Ushs ($6). This makes the material quite cost friendly in setting up the system.

Waste plastic bottle

The waste bottle caps are mostly made of High-Density Polyethylene. They are modified by adding perforations along the circumference and at the top. The perforations give the bottle cap a larger surface area compared to the ordinary gravel. **The plastic media used as a substrate in a constructed wetland is the key innovation in the setup**. Biofilm are a collection of micro-organisms and their growth is necessary for the treatment process as water flows through the constructed wetland. Biofilm are directly involved since they carry out the pollutant break down in the greywater hence increasing the quality of the water. The more the surface area provided by the media, the more biofilm present.

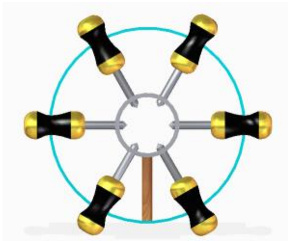
The constructed wetland with plastic media receives three times higher hydraulic load than the one with gravel. Plastic media as a substrate allows the constructed wetland to occupy four times smaller area compared to the ordinary one consisting of gravel. It also has a high porosity which ensures clogging minimization since the material has more void spaces for biofilm and root zone growth. [5]. The minimized clogging allows the maintenance costs to be much less. The waste plastic material is already being gotten from waste plastic collectors at a very market friendly price (Ushs.2000 per kg, which contains 200 bottle caps) as they are a readily available component of waste in the country. High-Density Polyethylene has a comparatively higher corrosion resistance as compared to other potential materials which gives the product a longer life and is recyclable into other forms after its lifetime in the constructed wetland.

Modified bottle cap

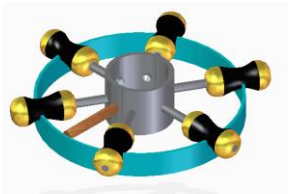


3D cross section view of machine

Plan view of machine



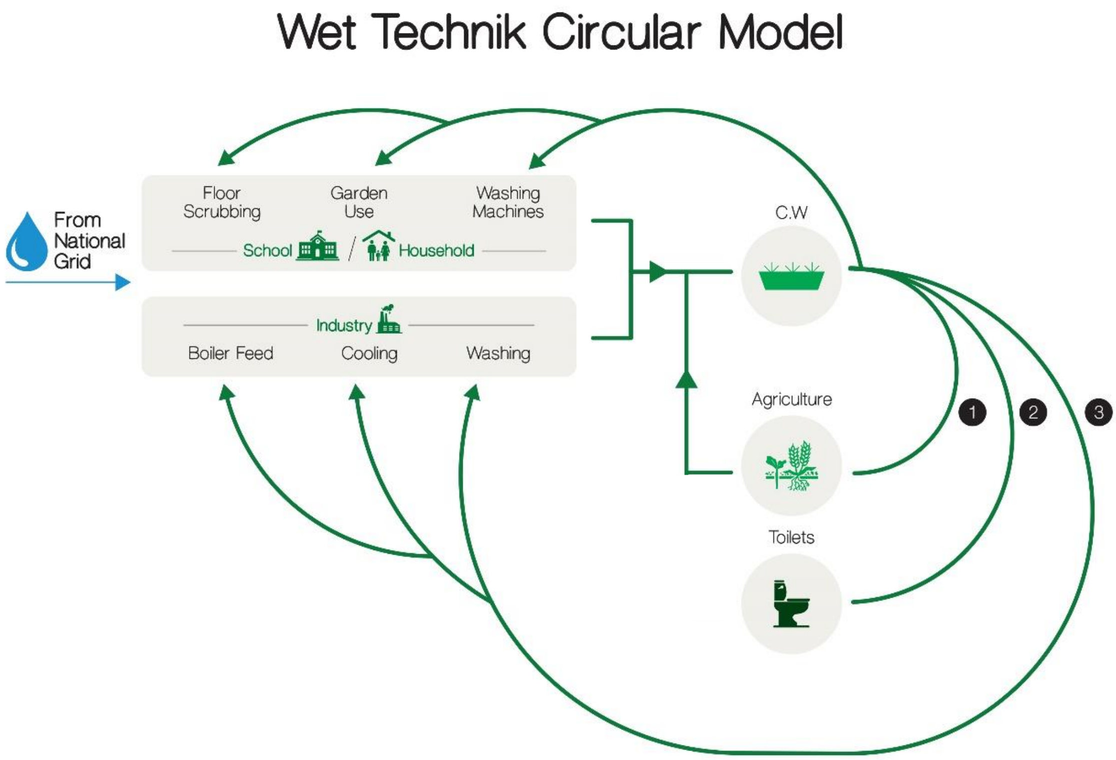
3D cross section view of machine.



The modification of plastic caps is done by a simple machine that creates the perforations along the circumference. Our model is comprised of a cavity in which 5 bottle caps will be placed. A metal component is designed to fill the cavity while creating perforations in the bottle caps due to the force generated. The cut pieces will fall out and will be collected. The perforated bottle cap will fall out of the cavity and the next set will be placed.

These pieces are then returned to a plastic recycling plant in bulk. The plastic material is quite advantageous since it takes longer to accumulate sludge on its surface. The accumulation of sludge on the bottle caps dictates the lifespan of the constructed wetland as water ceases to flow through but stagnates within the system. The life span of the system depends on the composition of the wastewater to be channeled into the system is up to 10-20 years given regular monthly maintenance which, harvesting of plants/ trimming.

Circular Analysis:



The water and wastewater industries in Uganda have significantly been threatened by continuous water scarcity, increasing energy prices to run the treatment plants and high nutrient loading present in the water.

Globally, the transition to the circular economy in the water sector has mainly been inhibited by ever increasing stringent regulations on water quality especially after wastewater recycling and opaque market conditions present in the sector. In addition, the existing water systems are inefficient as a lot of water is polluted, misused and eventually disposed. The gap between available freshwater supply and demand will continue growing.

Decreasing wastage and promoting resource efficiency and recovery through the use of relatively cheaper wastewater recycling facilities i.e. our constructed wetlands on a small scale, will hasten the transition.

Our closed loop system, with cascading water quality options that are determined prior and later differentiated by use will lead to lower production costs i.e. the total cost spent in recycling, which was initially high due to the prior notion of treatment to a water quality that is not determined by the eventual use making it more expensive. Water quality standards to reclaimed water for agriculture, toilet flushing, floor scrubbing as well as industrial applications are not as strict as those for drinking water purposes.

[6] Reclaimed water cascading allows lower quality water to be used in these and many other applications leading to lower costs for recycling while providing value, acting as a major incentive to transition to the circular economy.

In order to hasten the change to the circular economy, incentives like short supply chain (plastic, pumice), short payback time, environmentally friendly solution, lower recycling cost are necessary and locally sourced materials are necessary.

Business Model

Key Partners
- Pumice dealers
- Waste plastic collectors
- Ministry of Education
- Ministry of Water and Environment
- National Environment Management Authority(NEMA)
- Plumbers
- Landscape designers.
- United Social Ventures

Key Activities
- Research on improving system.
- Modification of bottle caps.
- Construction activities
- Marketing of system.
- Raising awareness on wastewater.

Key Resources
- Intellectual property
- Construction equipment.
- Bottle caps.
- Pumice.
- Labour

Value Propositions
- Saving the users money through less bills paid.
- Sludge collected can be used as manure.
- Providing a way to safely dispose of water
- Curb water pollution.

Customer Relationships.
- **Long-term;** The customer will be in constant contact with the product as water will be produced daily and we shall be regularly carrying out O&M checks.

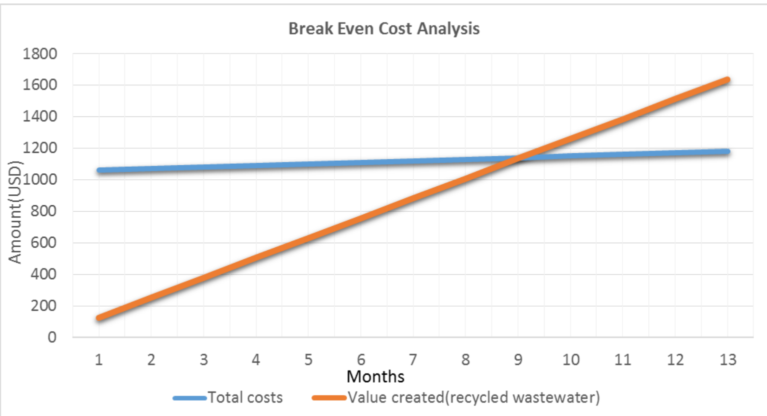
Channels
- Targeted social media marketing about advantages of wastewater recycling.
- Operation and Maintenance checks on installed systems.

Customer Segments
- Households e.g. Apartment blocks
- Institutions e.g. schools.
- Factories.

Cost Structure
- Construction of the wetlands e.g labour.
- Design and testing of the constructed wetland.
- Research and laboratory analysis.

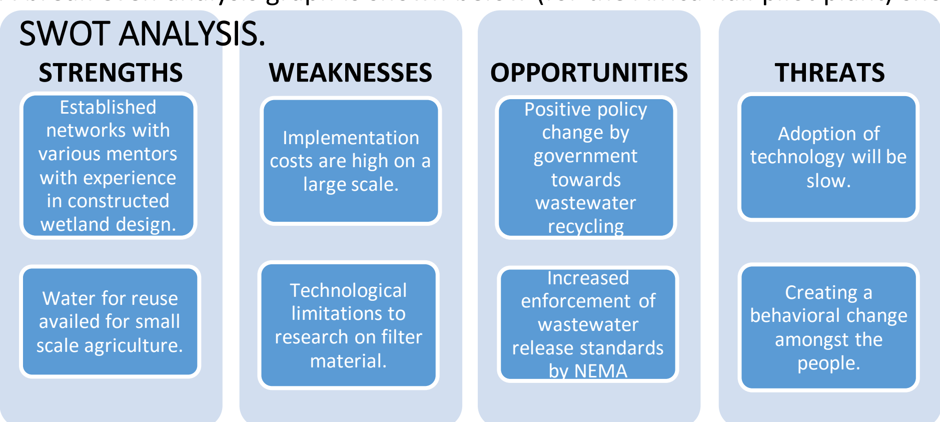
Revenue Streams
- **One-time fee basis-**Product is purchased and paid for at once by end user.
- **Results based financing**. i.e. based on impact especially on pollution. e.g. improvement of water quality and reduction of water borne diseases.

Economic Analysis.



Our constructed wetland will be paid for directly, incurring an upfront cost. Currently, constructed wetlands globally are constructed at an average cost of $40 per square meter. [4]Coupled with the comparatively higher area requirements, these constructed wetlands become a not-so-cheap venture. Through our research and continuous testing, we want to reduce this cost to $30, which will be possible through the use of cheaper locally sourced materials such as the pumice and waste bottle caps. We look to get income from the **design cost** and **consultancy services** of the system as well as the **maintenance cost**.

A break even analysis graph is shown below (for the Africa hall pilot plant) showing the relation between the total cost (which is comprised of the fixed cost of construction, the variable cost of maintenance) against the sales cost (which is the summation of the value of the water availed for reuse and the reduction in the water bill through the less reliance on the water from the national grid).



RISK ANALYSIS

- Regular maintenance checks on the system would need a technical person from the team incurring more costs. This will be solved through early stage involvement of the end user in the construction of the system.

- Exposure of the system to natural elements. E.g. animals and harsh weather(runoff). This will be minimized through strategically locating the system where there's limited exposure to the weather and animals.

BUDGET		
I. Supplies Cost	**Supplies Cost Details**	**Total**
Construction materials for construction of pilot C.W at school and continuous tests	Construction materials like pumice (about 1 ton) and plastic bottle caps (around 100,000), pipes, plants, gravel etc. and equipment hire like compactors, site tools (for about 5 days of construction)	$5,000
Workshop facilitation	2 workshops where rent of facilitation areas, drinks, eats, white papers, sticky notes, and other writing materials etc.	$300
Branding and advertising	Business cards, T-Shirts, website design, article formulation, pull-ups and fliers as well as other promotional material to be used at workshops.	$1,000
Research	Research materials e.g. lab tests, involving various partners, stakeholders and professional consultants to achieve improved product	$3,000
Subtotal Supplies		**$9,300**
II. Travel & Transportation Costs	**Travel Cost Details**	**Total**
Transport for construction activities	Costs incurred in hiring vehicles to transport various equipment and materials e.g. pumice rock from the mining area to site, bottle caps, plumbers and site workers.	$1,500
Transport and facilitation for team members to stakeholder meetings and workshops	Costs incurred by team members to go to various stakeholder meetings, potential partners, workshops and sites, lunch.	$263
Transport used in research	Costs incurred in transportation of water samples to laboratories, pumice, bottle caps and testing in various climatic conditions countrywide.	$300
Subtotal Travel		**$2,063**
III. Personnel Costs	**Personnel Cost Details**	**Total**
Landscape design consultant costs	Payment of professional landscape designer to design the environment around wetland with a rate of $100 per project.	$1,000
Plumber and site workers costs	Costs incurred in payment of site workers and plumbers for about 10 combined days of construction.	$300
Airtime and internet bundles	Purchase of airtime for team members for communication and coordination of activities, as well as internet bundles.	$537
Support staff	2 support staff to aid in initial maintenance and construction of wetland.	$526
Subtotal Personnel		**$2,363**
TOTAL PROJECTED EXPENSES		**$13,726**

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