DESIGN WITH UGANDA

Designing for those with disabilities in rural communities

LUIS A. GARCIA

Acknowledgements:

Special thanks to:

Jim Dewar
Walter Zanneti
Jennifer Tataryn
Andrew Dewar
Nelson Mukiika Kio
Ramathan Kavuma
Kisembo Salim
Moses
Joseph
Bja
Bjarki Hallgrimsson
Navin Parekh
Amanda Cox
Jennifer Vandermeer
Zoe Krug
Charles Williams
Lena Sitnikova
Nate Williams
My amazing classmates.

Table of Contents

Executive Summary

This project started through a collaboration between the READ Initiative at Carleton University and CanUgan, a non-for-profit organization found in Ottawa, Canada by Navin Parekh. CanUgan works closely with KADUPEDI, The Kasese District Union of Persons with Disabilities, in Uganda. Both CanUgan and KADUPEDI focus on providing support through assistive devices to people in need. CanUgan's proposal to the School of Industrial Design at Carleton University was to design innovative devices for people with disabilities in Uganda.

Before the ideation phase could start, much research was needed to be done in order to fully understand the many complex problems that people face in Uganda, and more specifically, the Kasese district of Uganda. The first step was to identify where Uganda is located, how this location differs from Canada and how this different context affects people. Uganda, located in eastern Africa, is a very lush country with a high annual average rainfall.
Uganda, like many countries in the surrounding area, suffers from high poverty rates. Less common, is also the high percentage of disabled people, around 10-15%. The main focus of the research for this project developed around accessibility to water and the importance of agriculture in the country.
The research done through this project proved to be crucial in the development of assistive devices for people with disabilities in Kasese, Uganda. An important fact found was the hardship that disabled people unable to farm go through everyday in order to find sufficient food daily. The solution found was to create accessible ways for disabled people to cultivate and maintain their own crops. This would help disabled people have food and would also enable them to become contributing members of society, hopefully lessening the bad stigma placed on them.

Having done much research the ideation phase was started first by the development of a mindmap. This mindmap helped understand the many complex problems and, how they are related, surrounding the focus of the research. This mindmap also helped attain a deeper understanding of each problem and the root source of them. Ideation followed by the development of concepts dealing with water management, either water collection or water distribution. This process proved helpful but the best solution evetually found was a very complex system of creating a water source and a pump. This system proved to big a project to be done in an 8 month span of time.
A change of focus was required. The focus became making gardening more accessible. Two main concepts were developed, an accessible kitchen garden, and a rolling gardening chair to make gardening more accessible in general. After recieving feedback from KADUPEDI, it was decided to make the rolling gardening chair the final design direction to follow.

The preliminary design development revolved around the simplification of an existing north america gardening chair in order to make it usable in a Uganda context. This process proved to be successful when the first prototype was made. The first prototype was made using the least parts possible. It was also made the most versitile possible, this ensured that the prototype could be tested in with many different wheel configurations. Through the lessons learned while testing with the first prototype, a second prototype was made with an improved frame that allowed for even more possibilities for testing. One of the more imporatnt aspects tested was the maneuverability of the device and the way the user would be able to propulse said device. The most succesful steering and propulsion system was discovered when the wheels were pushed on, similarly to a wheelchair.

This method gave the user the most control possible over the rolling gardening chair. Lessons learned in Canada helped prepare us for out trip to Uganda.

Once in Uganda, we were fortunate enough to receive invaluable feedback from the many people that we met. Our trip started with a vist to Makere University where we presented our projects to a group of faculty members. This presentation and the feedback received helped us prepare for what was to come in Kasese. Once in the Kasese district, we were introduced to many board members of KADUPEDI, Kio and his team. No time was wasted, as a steering handle was added to the device after introducing the rolling gardening chair to Kio. Kio was able to quickly understand the concept behind the chair and gave feedback and made improvements to the design the same day.
Our second day in Kasese, we were fortunate enough to meet Mark, my main user tester. Although I was not able to add anything to my prototype, I was able to get very valuable feedback from the most important person, Mark. With his help, I was be able to take this project to a level closer to helping people. Mark was very interested in my project and how it can help many people keep a kitchen garden. Although he was convinced something as raw as my prototype would help people as is, he helped me understand a few issues that need to be addressed in order to improve my design.
On the following two days two propulsion mechanisms were explored as possible options. The first mechanism explored consisted of a ratchet attached to a wheel. This mechanism did not achieve the desired results as not enough force was able to be applied to the wheels. The cost of the ratchet also proved to be too high, making the solution unfeasible. The second mechanism explored consisted of a crank and sprocket system attached to one of the wheels. This mechanism also proved to be unsuccessful as the gear ratio used proved to be too high for the user to push wheels.
Although neither of the propulsion systems proved to be very successful, many lessons were learned that were later applied to the chosen propulsion system.

Once we were back in Canada, the final design development phase started.
This phase started with the creation of many sketches and CAD models dealing with the addition of many features. Features added included a seat with armrests and a backrest, a basket holder to act as the storage system, footrests, and more importantly a propulsion mechanism. This mechanism was inspired by the mechanism used in Amos Winter's Leverage Freedom Chair. The mechanism was adapted to fit the rolling gardening chair, and instantly became the more successful mechanism tested. The final prototype was built with feedback from Uganda in mind. The design changed in many ways in order to withstand the rough Ugandan terrain.

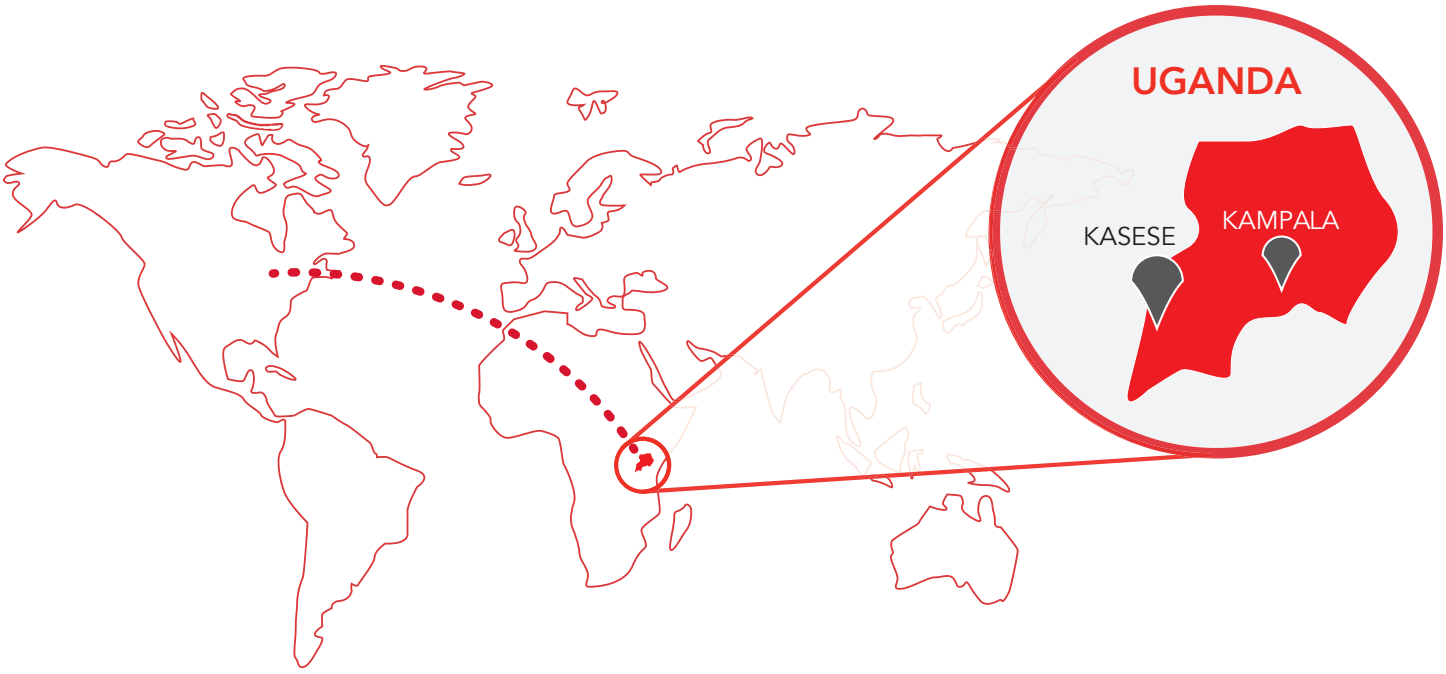
Through out this project the ability of quick creative thinking proved to be an advantage in every situation. This ability makes the design process more flexible and able to adapt to any situation presented.
The project changed direction many different times, but each time lessons learned were always applied and kept in mind when moving in a different direction.
Perhaps, one of the biggest lessons learned during this project was to fail quickly. Failing quickly is a metaphor for learning quickly. This is crucial to achieve a successful design.


ARUA
GULU
Ora
NEBBI
Victoria Nile
DEMOCRATIC REPUBLIC
OF THE
CONGO
2°
MASINDI
Masindi
Lake Albert
Shari
Bunia
Hoima
HOIMA
Kafu
Lugo
Ituri
Nkusi
KIBOGA
KIBAALE
Semliki
BUNDIBUGYO
KABAROLE
Fort
Portal
KYENJOJO
Mubende
MUBENDE
KAMWENGE
KASESE
Kasese
Katonga
MPIGI
SEMBABULE
0°
L. George
Ibanda
Kazinga
Channel
Lake
Edward
MASAKA
Masaka
BUSHENYI
MBARARA
Bugala
Mbarara

RESEARCH


PADER
Gulu
Agago
Acuwa (Moroto
Moroto
Lira
Okok
Oker
MOROTO
APAC
LIRA
Lothaa
KATAKWI
2°
Lake
Kwania
KABERAMAIDO
Katakwi
L. Bisina
Soroti
Namalu
NAKAPIRIPIRIT
SOROTI
Lake Kyoga
Kumi
SIRONKO
Kapchorwa
KUMI
KAPCHORWA
ASONGOLA
Victoria Nile
KAYUNGA
KAMULI
PALLISA
Mbale
Kitale
Kamuli
MBALE
LUWERO
TORORO
IGANGA
Bombo
Iganga
Tororo
JINJA
Bungoma
Jinja
KAMPALA
BUSIA
Nzoia
Buvuma
KENYA
Damba
Sigulu
0°
Kome
Lolui
MAYUGE
BUGIRI
Winam Gulf
Kalangala
MUKONO

Group Research: Project Location



Uganda:

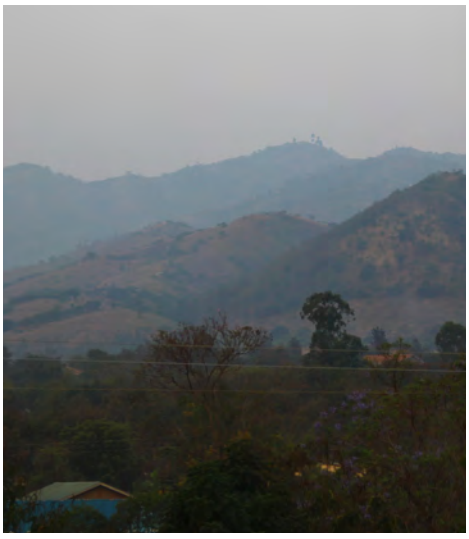
» Capital: Kampala
» Oficial Languages: English and Swahili
» Population: 35.8 Million
» 49% are under 15 years of age
» Area: 236 040 km2
» Climate: Tropical; Rainy with two dry seasons
» Literacy Rate: 73.2%
» LIfe Expectancy: 53 years

Kampala:

» Population: 1,659,600
» Area: 189 km2
» Density: 9,429.6/km2
» Main Language: Luganda
» Elevation: 1190m
» Climate: Tropical Monsoon
» Served by Enetebbe Airport
» Home to Makerere University
» Headquarters to the East African Development Bank

Kasese:

» Population: 74 300
» Main water bodies: Lake George & Lake Edward
» Borders the Congo
» Originally built around mining
» Close proximity to the Rwenzori Mountains & Queen Elizabeth National Park
» ~350 km from Kampala



CanUgan & KADUPEDI

An Introduction to

The Project:

CanUgan in association with KADUPEDI presented the need for devices to assist people with disabilities in the rural areas of Uganda. The goal for this project is to design products that not only assist these users but also create empowerment by allowing these devices to contribute to the quality of life of the user, their families, and the community. This project is a continuation from the previous year's group who all created devices that were based on KADUPEDI's current tricycle design. Although the objective for this project is to design assistive devices for those with disabilities, the focuses have expanded from the tricycle to other devices, users, and disabilities

Navin Parekh founded CanUgan in 2010. It is a non-profit organization based solely on a volunteer basis and has partnered with KADUPEDI (Kasese District Union of Persons' with Disability) to protect, promote, and provide assistive devices to people with disabilities in Uganda. KADUPEDI is an organization located in Kasese that was founded in 1996 and has on 9 members of the executive committee both who work on a voluntary basis and all experience a disability themselves. The goal of KADUPEDI is to protect and improve the rights of all people with disabilities in the country. Their projects are district wide, and comprise both district level and grassroot activities that address the needs of various disabilities (CanUgan, 2013).

Group Research: Disabilty & Poverty

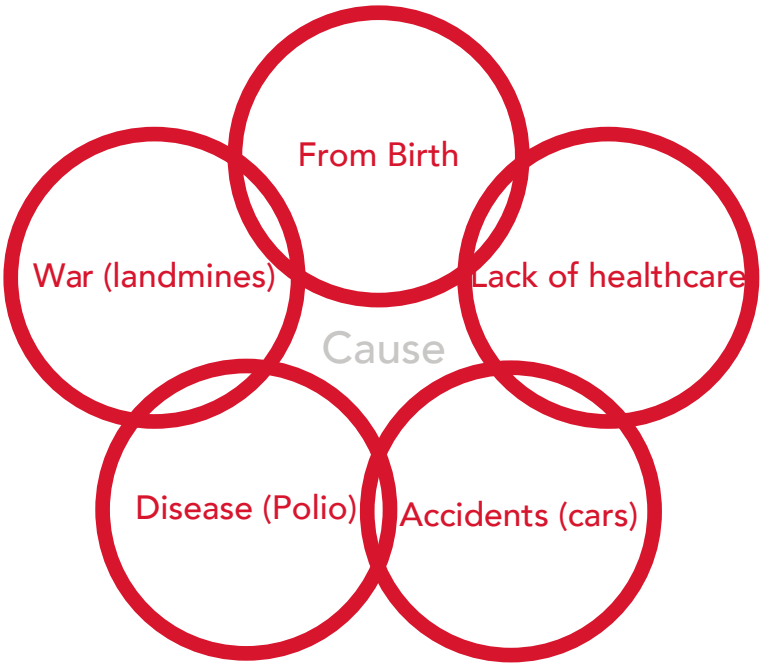
Disability

The population of Uganda is 35.8 million and has been steadily increasing at a fast rate. Within this population, it has been reported that 10% of the country suffers from a disability. Of the roughly 3.6 million people that are classified as disabled, 2.4 million are classified as chronically poor.

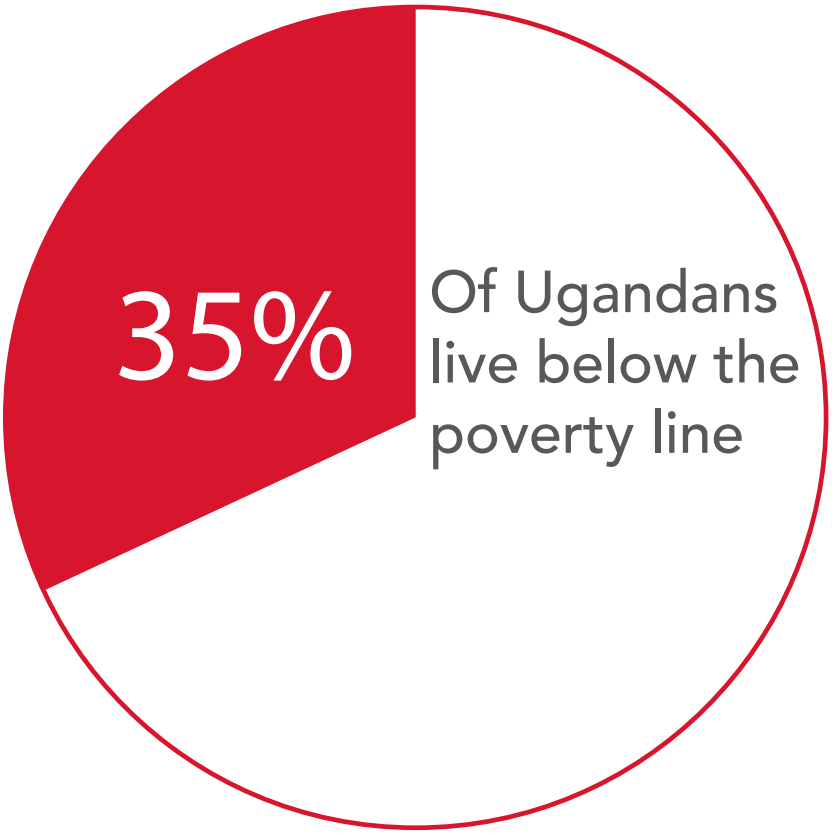
Mobility Impairment:

Mobility impairment is one of the most common types of disability in Uganda, and the Kasese region more specifically. Civil strife, lack of healthcare, diseases and accidents all contribute to this relatively high number of people.

Due to the high number of mobility impaired people, CanUgan and KADUPEDI spend much energy in providing these people with assistive devices, such as hand powered tricycles. These assistive devices not only help mobility impaired people move around, but also empowers them by giving them the opportunity to generate income in many ways.



"Any restriction or lack of ability (resulting from an impairment) to perform an activity in the manner or within the range considered normal for a human being. Disability may thus be considered to be funcitonal limitations, occurring in any population, and people may be disabled by physical, intellectual, or sensory impairment, medical conditions or mental illness. Such impairments, conditions or illness may be permanent or transitory in nature"
(Lwanga-Ntale, 2003)



Poverty

For Ugandans in rural areas, people are generally considered poor if they are unable to pay school fees and/or to buy soap on a relatively regular basis

2.4 million disabled people may be classified as chronically poor persons

Disabled women's children often lack social amenities, proper parenthood, psychosocial support and hence are lead to poverty.

Many disabled children grow into illiteracy and therefore lead to perenial poverty through:

- -No access to school
- -Lack of proper teacher attention
- -Absence of skills
- -Alienation from the socio-economic of other peoples

"Poverty and disability are similar and mutual..."
Lwanga-Ntale, 2003

"Disability is not inability"

Accessibility to Water

18% of Uganda's total area is covered by rivers, lakes and wetlands.

Mean annual rainfall is 1300mm but can vary from 100mm to 3000mm.

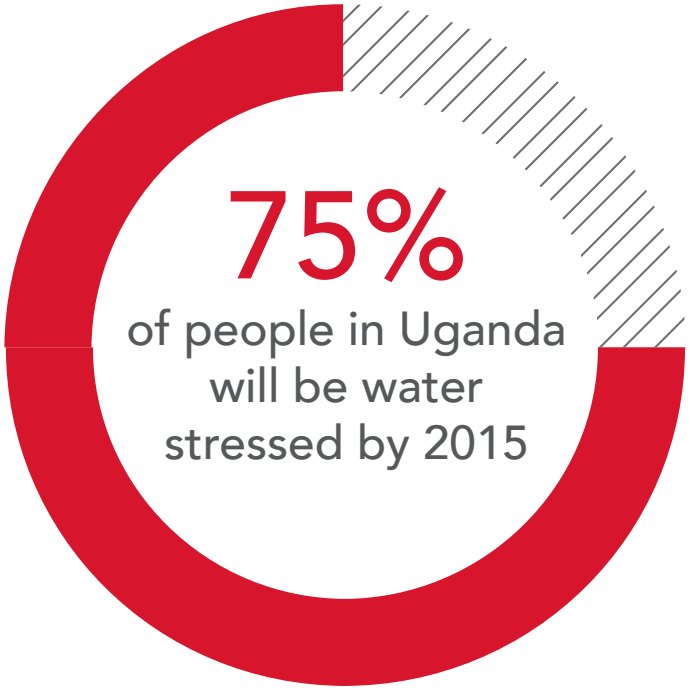
National per capita water consumption target is 20L/day (minimum quantity of water to meet basic health needs).

Average rural per capita water consumption is about 13L/day.

Deep wells and boreholes are the most common way of getting water, yet tehre are new technologies being put to practice

Unsafe drinking water is the leading cause for contracting diseases like cholera, dysentary and intestinal worms.

Diarrhea accounts for roughly 19% of infant mortality



People with "access to safe water" commonly have limited access, can only consume limited quantities and still suffer from droughts during the dry seasons.

Tipical water jerry cans used in Uganda

Agriculture

The cultivation of crops is engrained in Ugandan culture. Farming is a part of the everyday life of Ugandans of every socio-economic level.

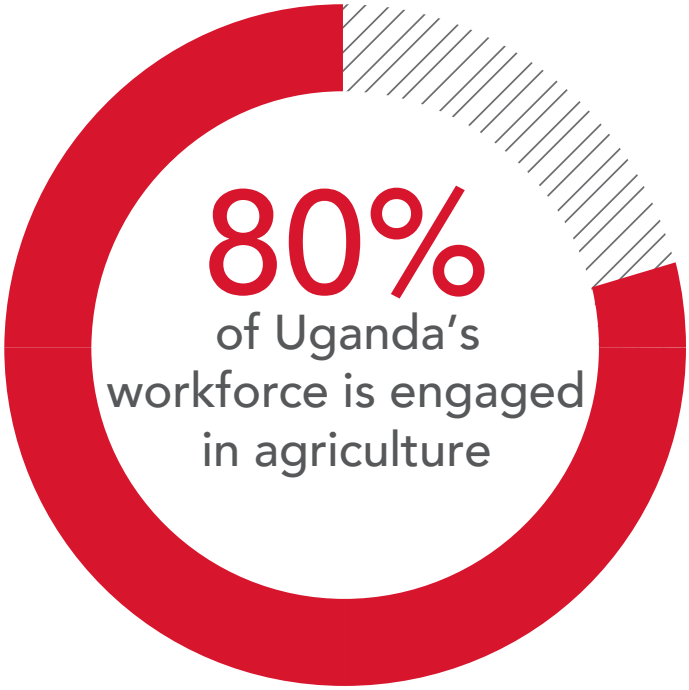
Most Ugandans' income come from agriculture (Shively & Hao, 2012)

Agricultural export production in Uganda relies on the efforts of rural producers who typically receive the least benefit from the production of their crops.

Most of the current methods in growing and harvesting agriculture in Kasese are out dated.

Farmin is very labour intensive. Disabled people have much difficulty performing the necessary tasks for the everyday cultivation of crops. Disabled people are not able to contribute to the farming process due to inadequate tools.

Giving disabled people of Kasese access to tools for harvesting could help them not only improve family nutrition but also create extra income by selling excess crops.



"Ending the poverty of most people in the world who now survive on less than a dollar a day requires the creation of a transformed agriculture that develops labor-intensive cash crops, tools and the cultivation methods capable of optimizing income on small farms"
-Paul Polak, 2008

Final Opportunity Found

86%

of the population living in rural areas rely on subsistence agriculture for their everyday food.

Dependency

Unable to grow their own food, many disabled people have to depend on community donations

Stigma

Historically, there has always been a bad social stigma placed on disabled people in Uganda

Vicious Cycle.

Due to dependancy, bad stigma and poverty, many disabled people struggle to find sufficient food on a daily basis

Opportunity:

Solve dependency by empowering disabled people to cultivate their own food

Overcome bad stigma by enabling disabled people to become contributing members of society

Group Design Objectives

Group design objectives were set based on both primary and secondary research. Following these objectives ensured that every design stayed within CanUgan's and KADUPEDI's focus. By following these objectives the group stayed close to designing useful devices for disabled people in Kasese.

ECONOMICALLY FEASIBLE

Total costs are low enough for local users to afford.

ENVIRONMENT

The designs are able to withstand the harsh road conditions reducing the frequency of repair

EMPOWERMENT

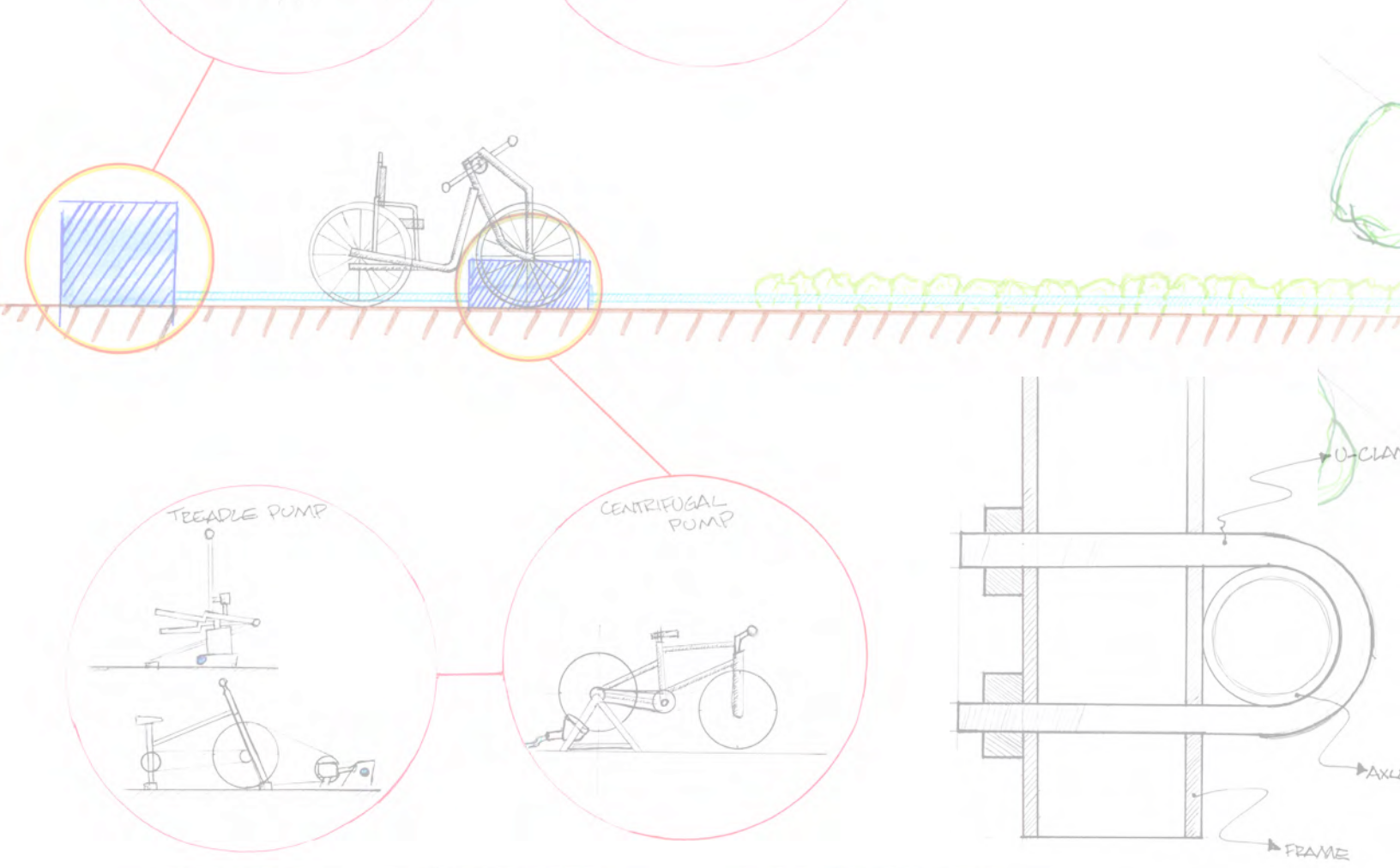
These devices allow people to contribute to their family and the community

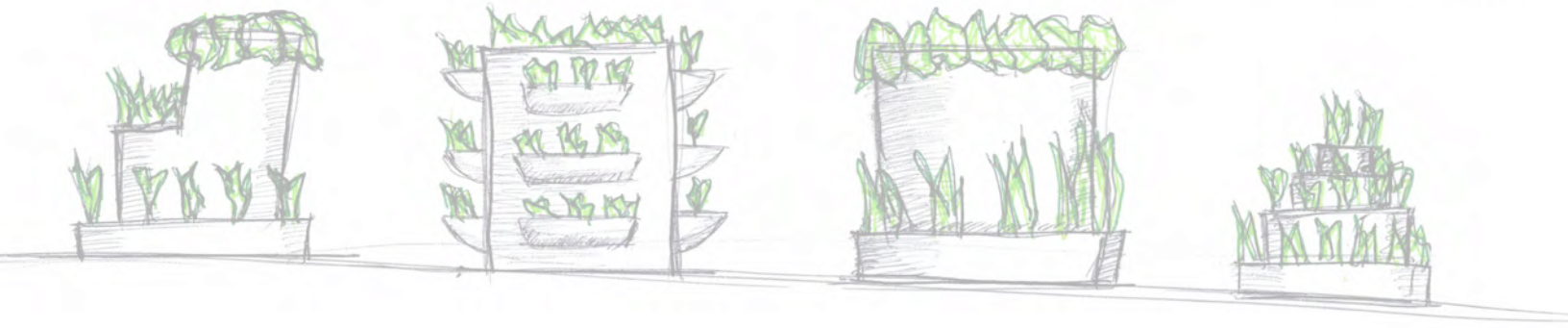
LOCAL MANUFACTURABILITY

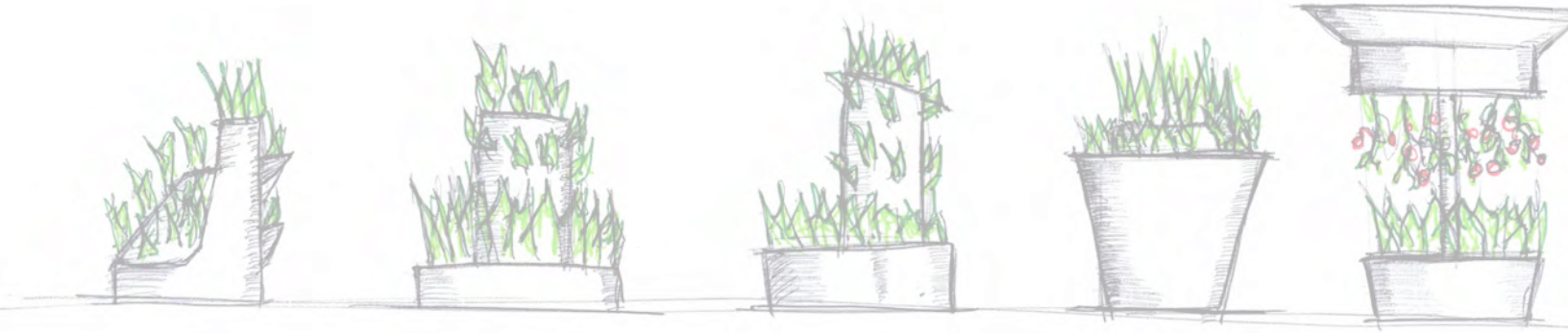
All materials can be sourced and built by the local manufacturer

SAFETY ASSURANCE

All of the designs have ergonomic considerations and users are safe when using the devices

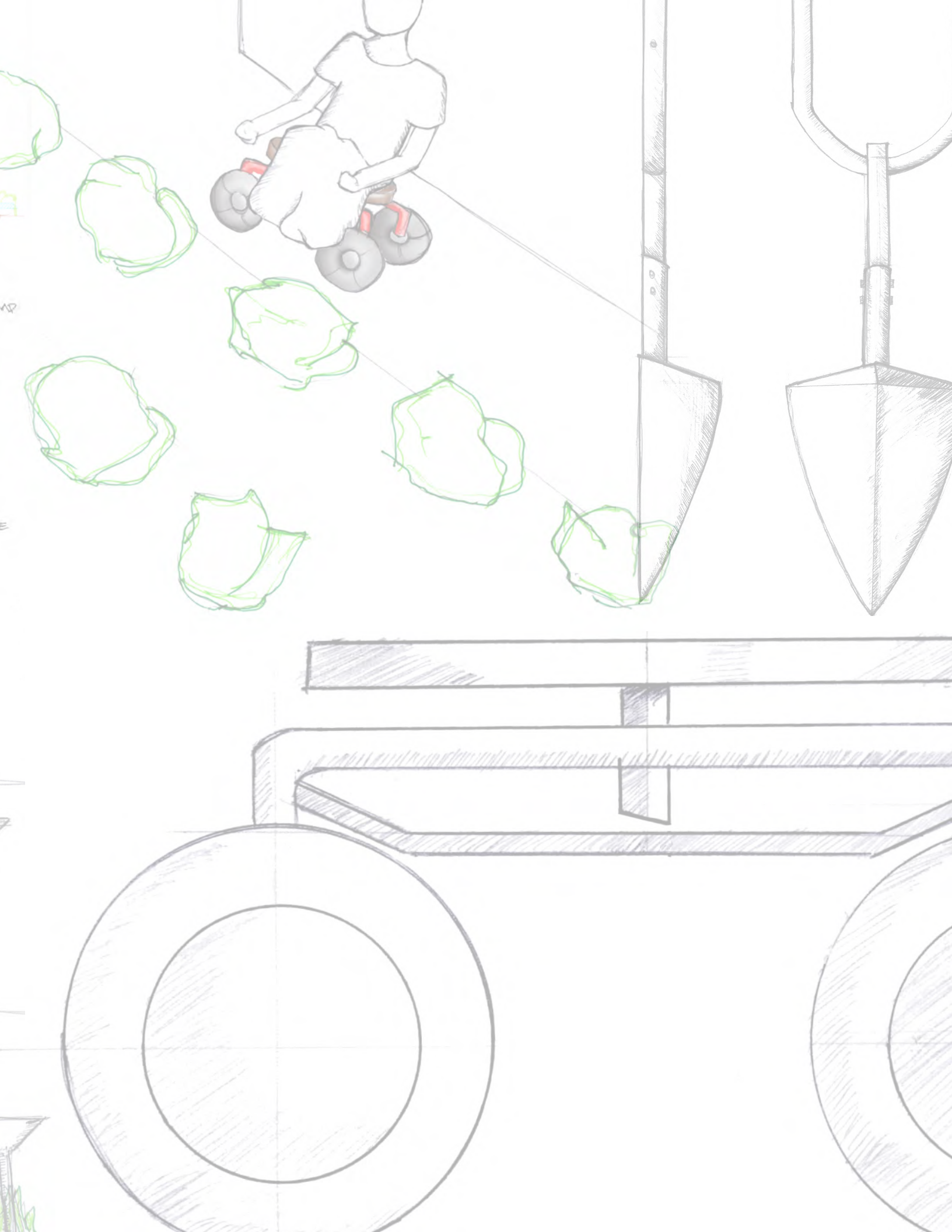

TREADLE PUMP
CENTRIFUGAL PUMP
U-CLAM
AXL
FRAME



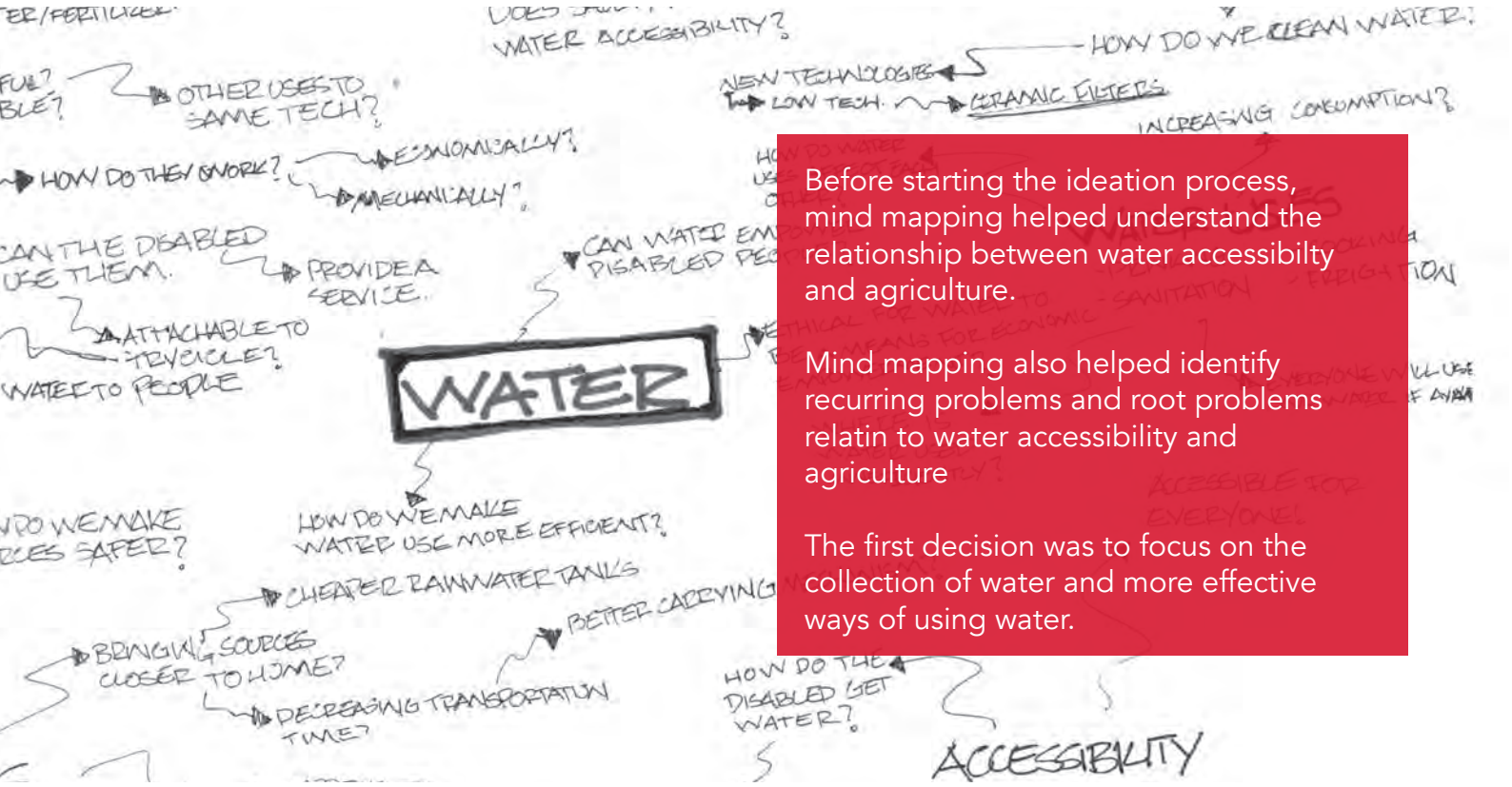



RAIN WATER COLLECTOR
IRRIGATION TANK
RAIN WATER COLLECTION

IDEATION



Mind Mapping

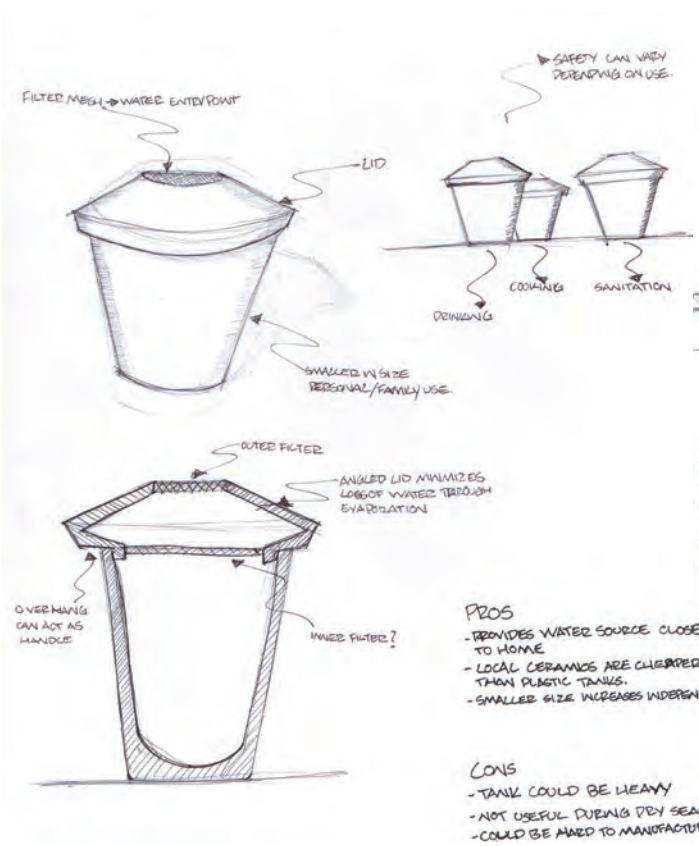


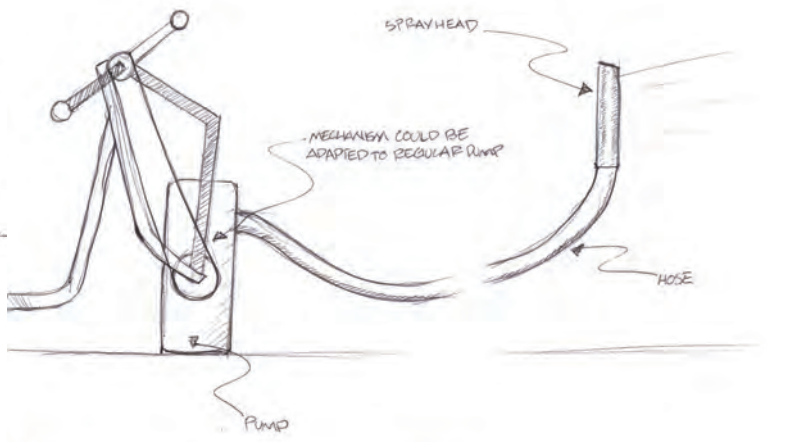
Before starting the ideation process, mind mapping helped understand the relationship between water accessibilty and agriculture.

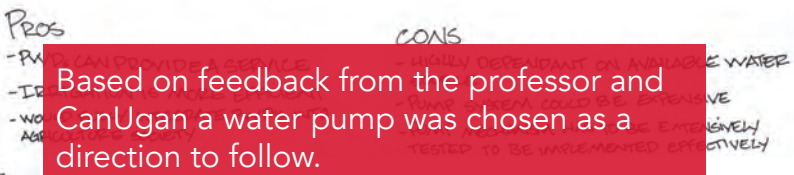
Mind mapping also helped identify recurring problems and root problems relatin to water accessibility and agriculture

The first decision was to focus on the collection of water and more effective ways of using water.

Early Concepts



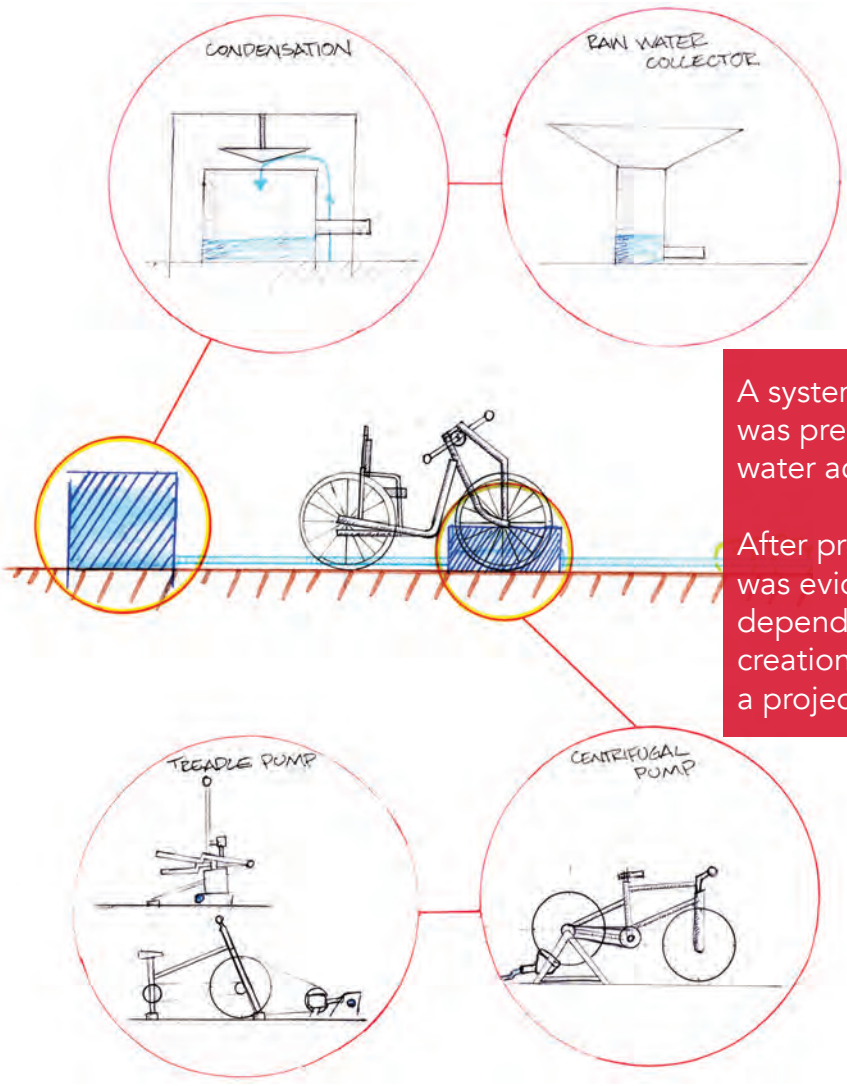




Based on feedback from the professor and CanUgan a water pump was chosen as a direction to follow.
However, due to lack of water sources in Kasese, it was clear that a pump alone would not be suficient.

Concept Refinement

Early Concept Evolution



A water collection method for the irrigation system. Because drip irrigation is very water efficient, I believe it is possible to design a way to collect and store enough water to be able to irrigate a small plot of land (1/4 acre)

A system consisting of water source and pump was presented as a more proper solution to water accessibility

After presenting the concepts to CanUgan, it was evident that the system being looked at was dependant on too many unknown variables. The creation of this system was also deemed to large a project for an 8 month span of time

A pump powered by the CanUgan and KADUPEDI tricycle. Because the terrain in the Kasese district is very mountainous, it is very likely that a pump will be needed to push the water through the irrigation line.

Change of Focus

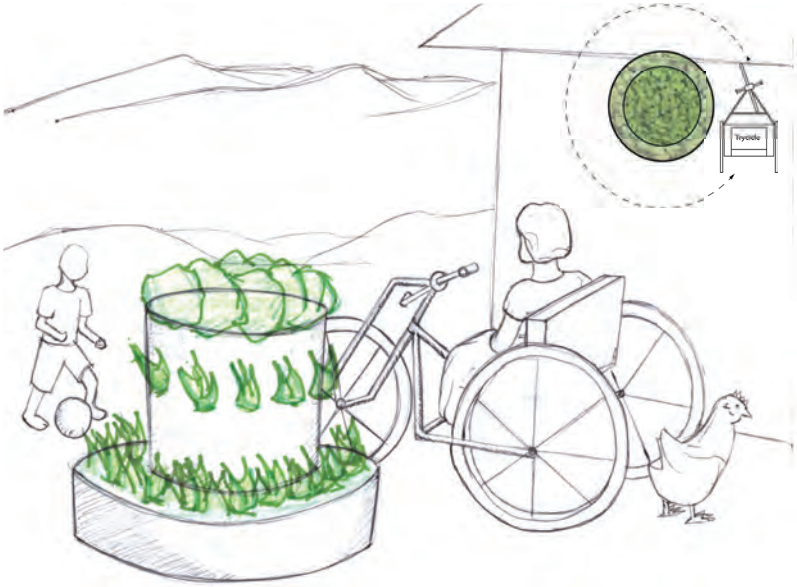
After the first round of concepts it was clear that a new direction was needed.
The focus of the project changed into creating ways of making simpler, more manageable forms of gardening for disabled people.

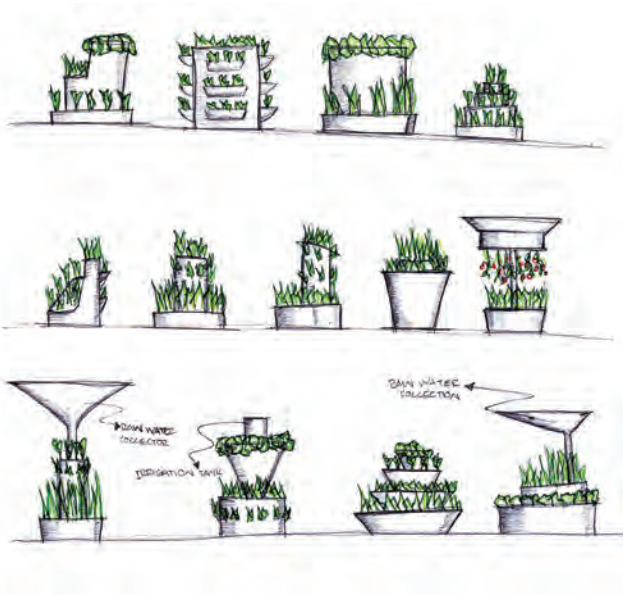
This could be done by either miniturizing vegetable gardens or by creating ways in which disabled people could cultivate and maintain a garden.

"... kitchen gardens which most people with disabilities would be able to manage at home other than going large distances; this would also improve family nutrition and income generation..."
- KADUPEDI

Concept Refinement

Option 1: Accessible Kitchen Garden





Raised, circular kitchen garden accssible from the tricycle. This garden would facilitate the cultivation of high value crops that can later be used for food and profit.

Benefits:
- Can have more than one planting level.

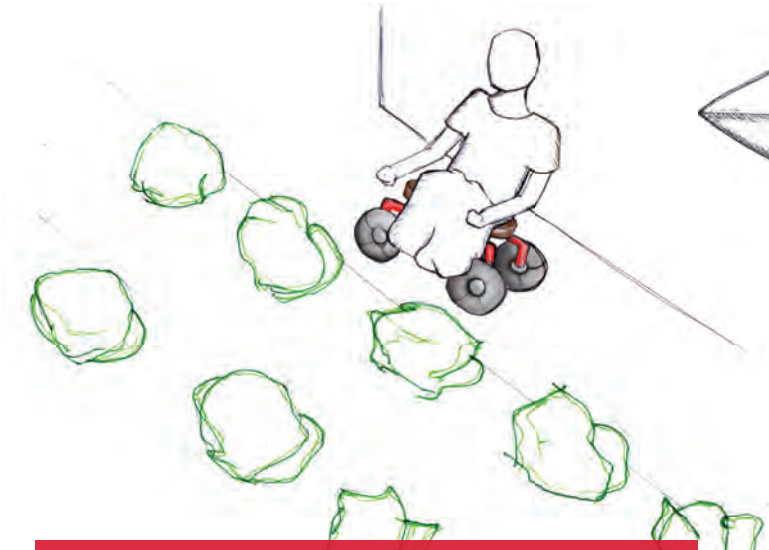
- Planting vertically results in more efficient use of land

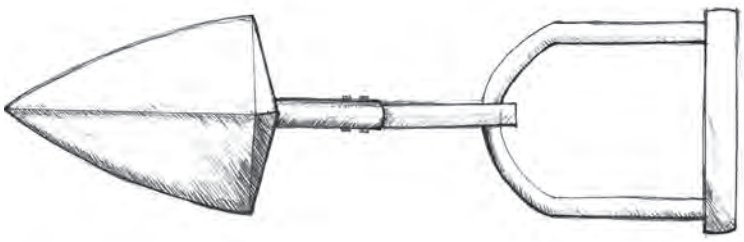
- Raised bottom level brings vegetables closer to tricycle users.

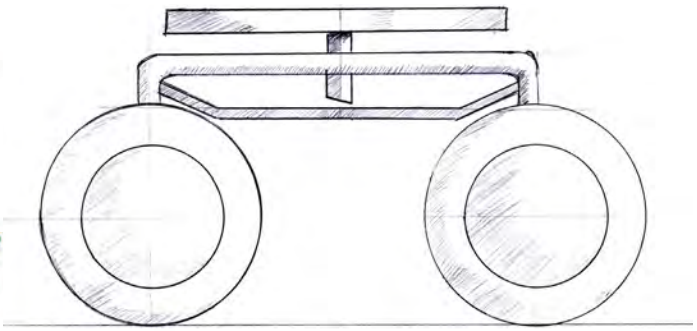
- Vertical format means simpler irrigation systems can be applied to garden.

Concept Refinement

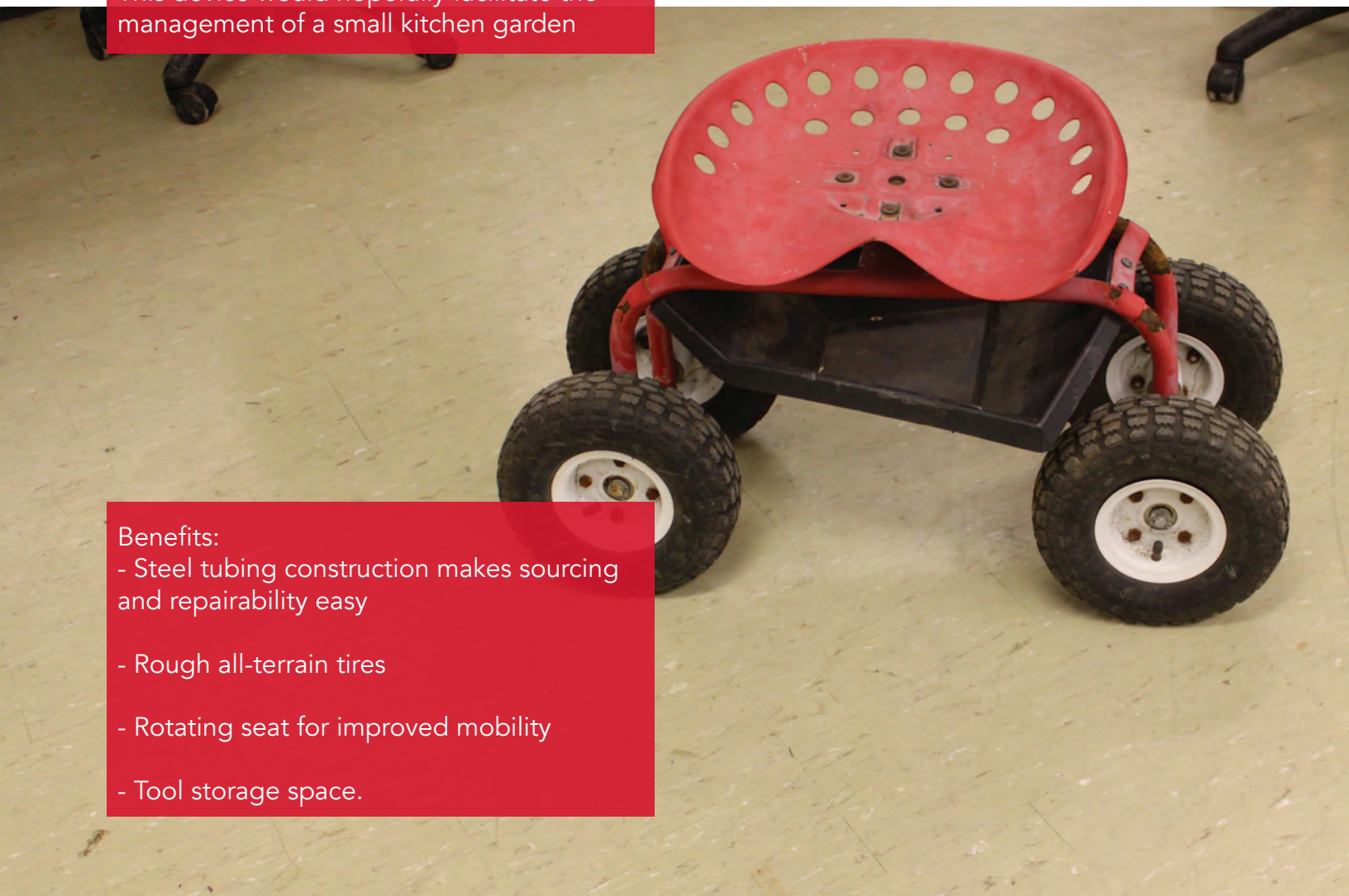
Option 2: Rolling Gardening Chair







Small rolling graden chair that disabled person can sit on to tend their garden. This device would hopefully facilitate the management of a small kitchen garden



Benefits:
- Steel tubing construction makes sourcing and repairability easy

- Rough all-terrain tires

- Rotating seat for improved mobility

- Tool storage space.

Final Concept Direction

Feedback from KADUPEDI

An e-mail was sent to KADUPED in order to recieve the necessary feed back to make the most informed decision on which concept to choose as the final design direction.

Preliminary Questions:

- What vegetables would you describe as the toughest to grow?
  -Tomatoes, Onions, Cabbages, carrots, Green paper, Egg plant, Dodo and others. They need a lot of labour to grow yet and yet they you get enough income if they grow well.
- What vegetables or plant would you describe as having the highest value in term of price at a market?
  -Tomatoes, Onions, Cabbages and Eggplants.
- Is gardening something that a PWD would be interested in doing?
  -Most persons with Disabilities in rural areas are engaged in gardening as a source of income but with hardship. Some of them are cripples and others walk on crutches while in the gardens and they use Hoes to cultivate.
- Are PWD's currently able to garden? If so, what tools do they use? Which tools are the most useful?
  -The Tools commonly used are Hand Hoes, Pangs, Reck, forks and Axes. While in Big farms, most people use tractors. Most of our people here are peasant farmers.
- Do people in Kasese use any kind of irrigation systems for their family farms?
  -Here in kasese, the Irrigation scheme we have belongs to Government because peasant farmers cannot manage to maintain the scheme but they hire from Government to plant crops. A few individuals are now trying to practice the system on small scale especially those staying near running rivers.

Accessible Kitchen Garden

Description: Raised circular garden accessible from the tricycle. This garden would facilitate the cultivation of high value crops that can later be used for food and profit. Garden would include an easily accessible irrigation system to maximize the growth of the crops

Questions to consider?

- What do you think of this idea?
  - The idea is good especially for mobility PWDs except the idea of the irrigation is required in big farms and what can be done for this case is to carry water from the main river using a tricycle to gardens around the kitchen. Here we shall need a watering cans, jerricans, spraying pumple, purchase of manure. knowledge about organic system. This knowledge is very important for the case of kasese District.
- Will it grow enough vegetables?
  -If PWDs are empowered with farming knowledge, improved tricycles that can roll into their Gardens they would be able to produce or grow enough vegetables.
- What kind of vegetable would be suitable for this kind of garden?
  Tomatoes, Onions, Cabbages, carrots, Green paper, Egg plant, Dodo.
- Would it be preferable to have a circular garden like this compared to a typical on the ground kitchen garden?
  -Both circular and typical gardens could work better because of shortage of land here in kasese and also it depends on the disability category/severity.
- Do you think an irrigation system is needed?
  -The irrigation system is good and needed by PWDs staying a long running rivers and the nature of land they are staying in plus knowledge of how to use the system.
- How will this help PWD's?
  -It will help them not to rely on seasons, here in kasese we have only two seasons in the year for crop growing.
  -It would also help those PWDs staying in the lowlands of kasese where the equator crosses because this area is ever hot for crop growing.

Rolling Garden Chair:

Description: Small rolling chair that the disabled person can sit on to tend their kitchen garden on the ground. This would hopefully facilitate the management of a kitchen garden for PWD's

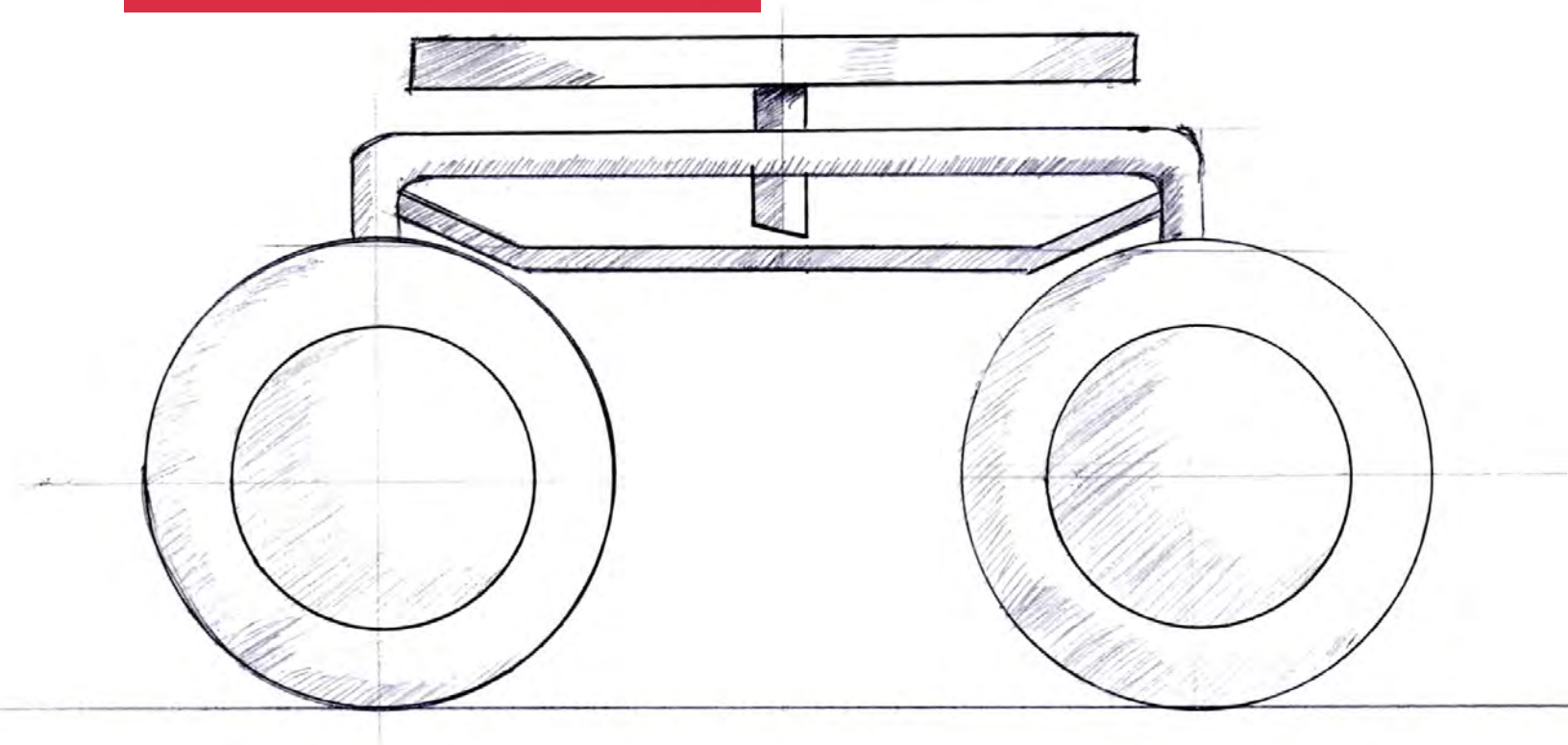
Questions to consider

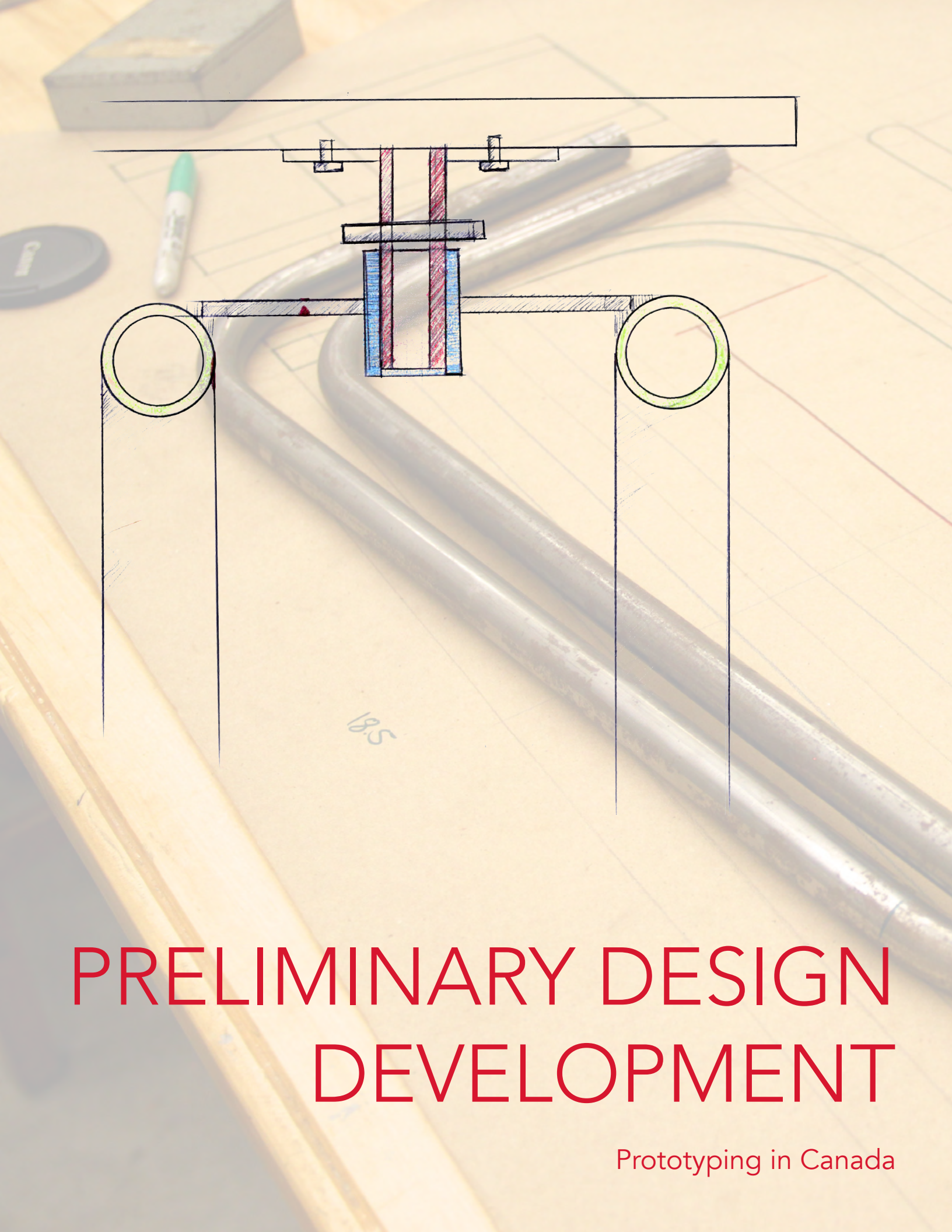
- What do you think of this idea?
  -We have also heard about the rolling chair from you and therefore we had never seen some one using it especially attending to their Kitchen garden. But looking at the picture, if it can roll someone through the garden it would be the best Assistive device. Because those using Tricycles/Wheel chairs leave them at the side of the Garden to cripple down in the garden for work.
- Would it help people with a disability become more able to have their own kitchen garden?
  Yes.
- Would this help increase the number of vegetables able to be grown?
  - Yes.
- How will it help them? It will create easy movement to maintain the garden frequently and if it can roll in the garden for the person using it, be able to weed, spray, harvest without support from someone to be paid wages/ salary which affect the profits.

Final Concept Direction

The rolling gardening chair was chosen as the final direction with the feedback from KADUPEDI.

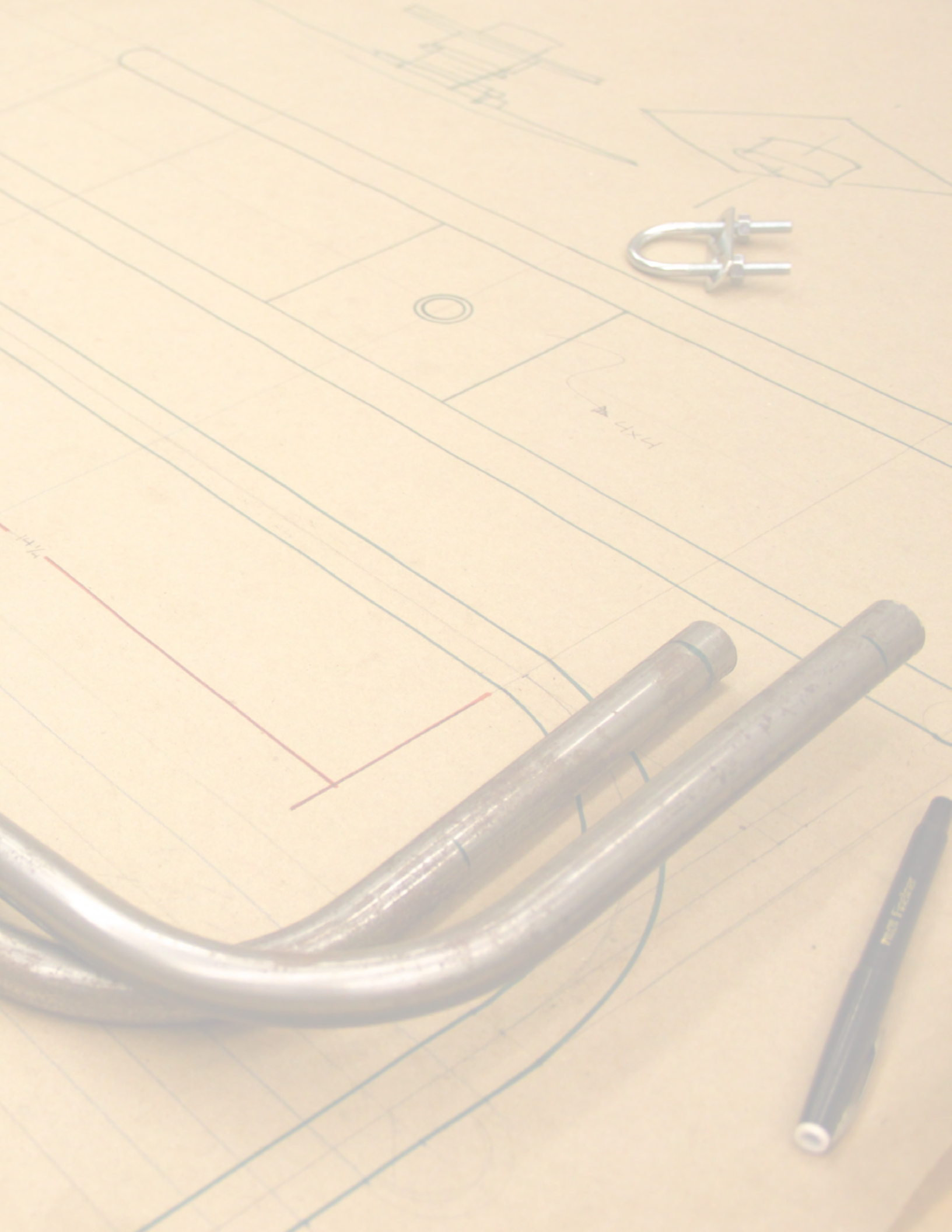
Since the inspiration for the rolling gardening chair came from an existing north american product, the design needed to be simplified and designed in a way it could be built in Kasese, Uganda.





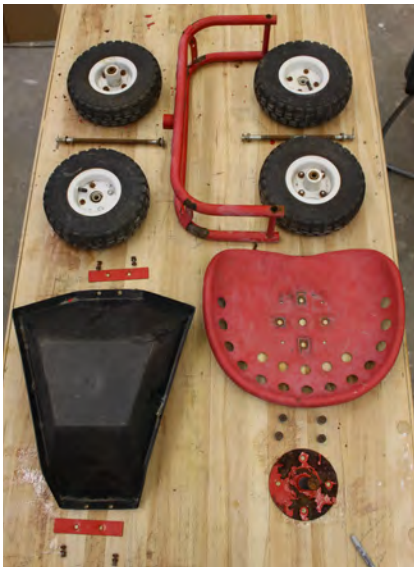
PRELIMINARY DESIGN DEVELOPMENT

Prototyping in Canada



Preliminary Design Development

A Simple Start



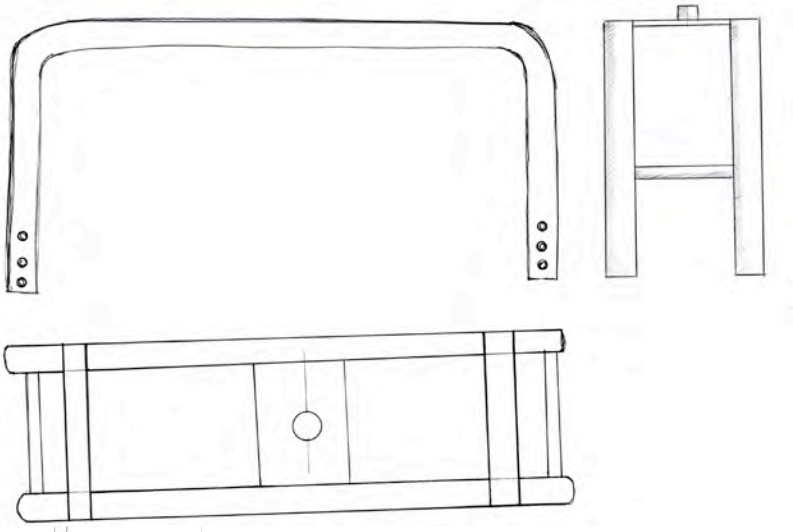
Simplification of existing design:

The first step in the simplification of the exisiting design was to understand how it was built and understand how each of the components affected the functionality of it. To study this, the device was taken apart and then put back together.

After analysing the existing design many parts were noted as either unmanufacturable in a Ugandan context, not functional, and/or unnecessary.

It was clear that the design could be much more simple in its manufacturing and assembly.

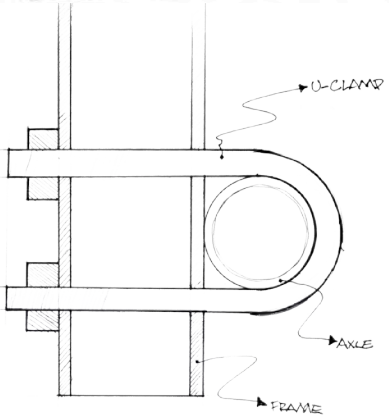
Planning the First Prototype



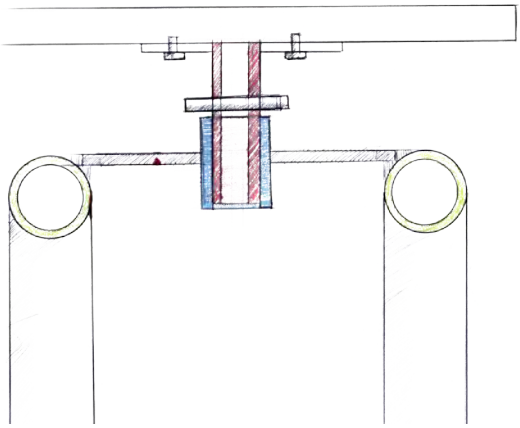
The first prototype started as a series of sketches to determine the simplest way to manufacturing and assemblying a design that would work within a Ugandan context.

The main components that needed simplification were:

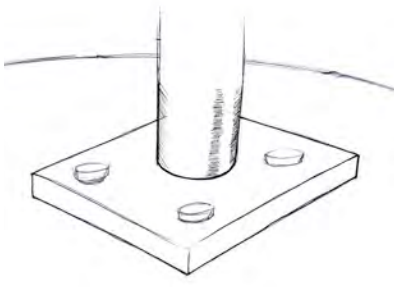
- The axle and frame attachment
- Adjustable rotating seat attachment point
- Seat construction.



» Main water bodies: Lake George

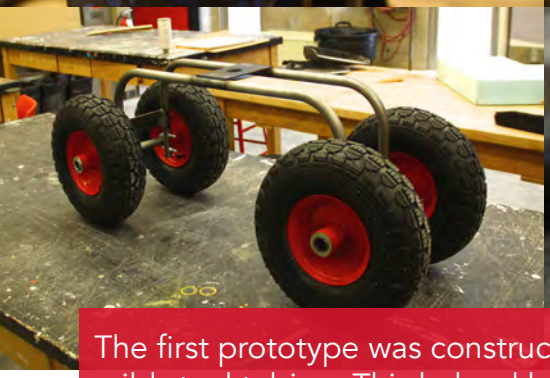


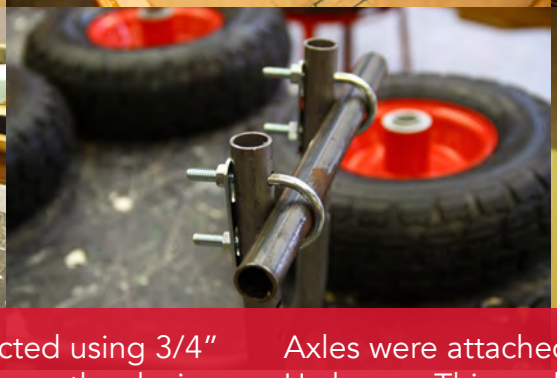
» Main water bodies: Lake George



» Main water bodies: Lake George

Building the First Prototype





The first prototype was constructed using 3/4" mild steel tubing. This helped keep the device light while providing enough strength to support the necessary weight. The frame was designed so as to need the least amount of welding possible saving time and labour.

Axles were attached to the frame using steel U-clamps. This worked quite well

Seat was built to rotate and be height adjustable by using a very simple pin mechanism.

Seat was reduced to a simple wooden wheel big and strong enough to support a person.

First Prototype

Testing and Iterations on First Prototype



These configurations were very useful in revealing many aspects that need improvement.
Problems noted:
Seat is too high. This makes it very hard for a person to reach the ground. This height would make it hard for a person to propulse themselves without using their legs.
Seat is sometimes unstable even when putting feet on the ground.
The current use of this frame does not provide a way to steer.



One of the main problems with the wheel arrangements tested was the lack of steering and manoeuvrability.
With new concept, users are able to steer by turning their seat.

Much user testing was done with this particular wheel configuration in order to find ways in which it could be improved.

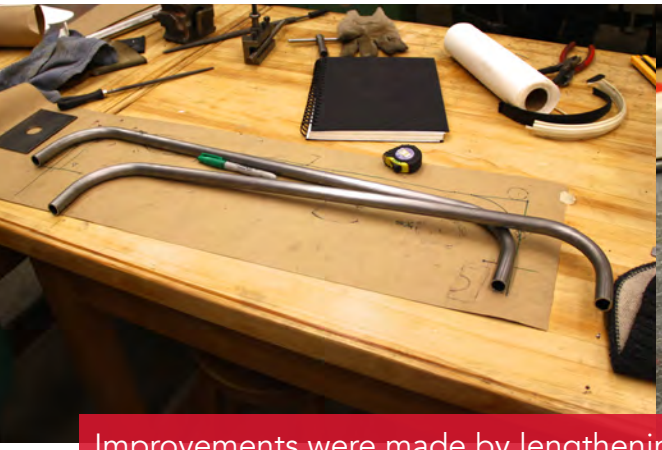


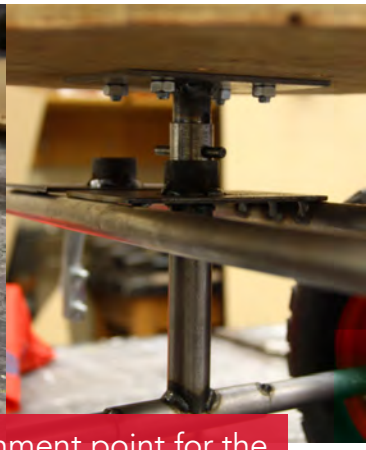
- Due to the short distance between the front and back wheel axles jackknifing becomes a problem when making hard turns.
- Due to the length of the front wheel axle the harder the turn the more unstable the vehicle becomes.

Another problem noted was the thickness of the tube used as an axle. The 1/2 inch thick tube used started bending with a load of about 150lbs
Better results were achieved when the switch to bigger wheels was made.

Building the Second Prototype

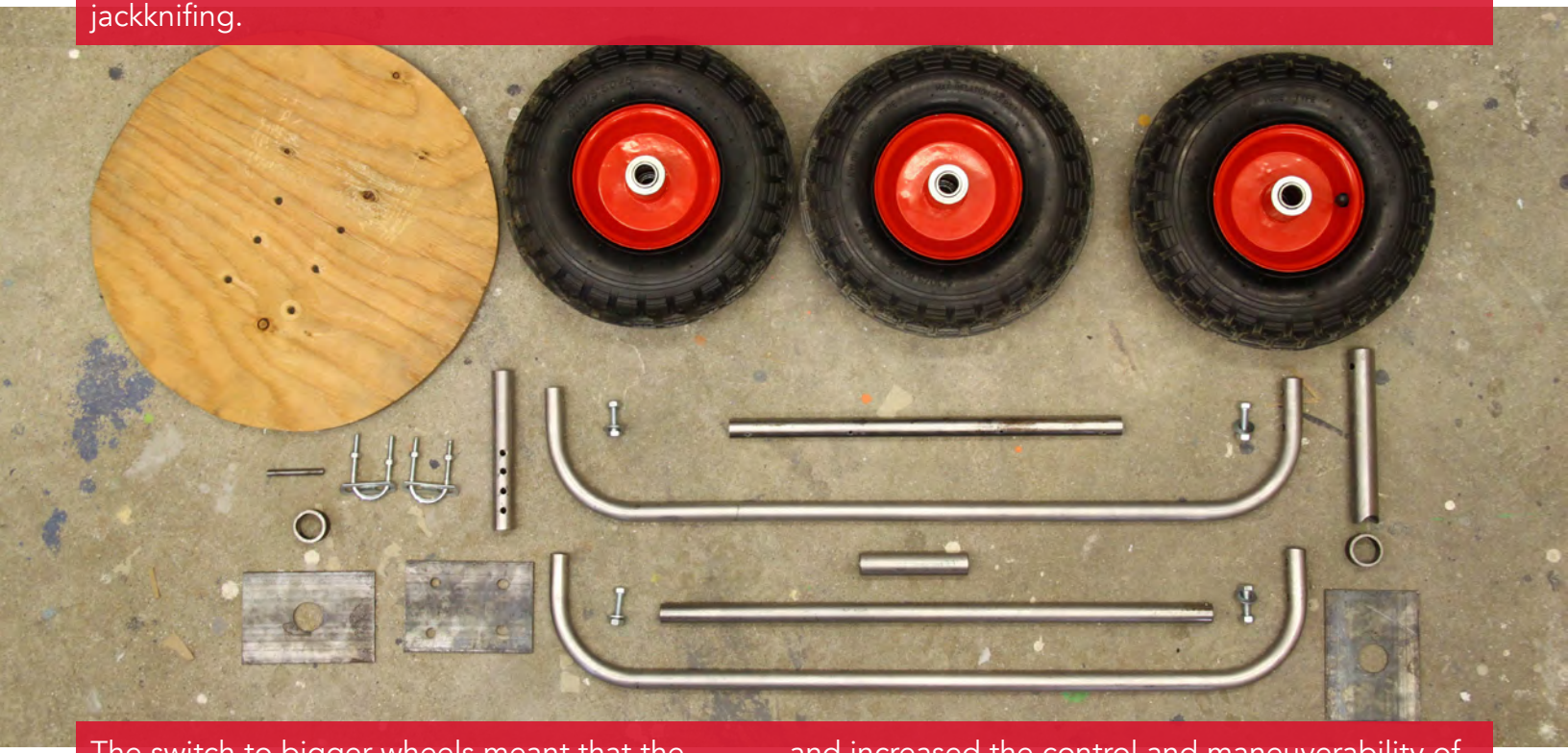
Much was learned through the different tests and iterations that the first prototype was put through. All this new knowledge was put through the development of a new prototype. The main changes were done to the frame. The frame became shorter in height and longer in lenght. Another change to the frame was the addition of a second attachment point for either the steering or the seat.





Improvements were made by lengthening the frame. Lengthening the frame made the device more comfortable to sit in
By widening the wheelbase, the device became a lot more stable while it also prevented jackknifing.

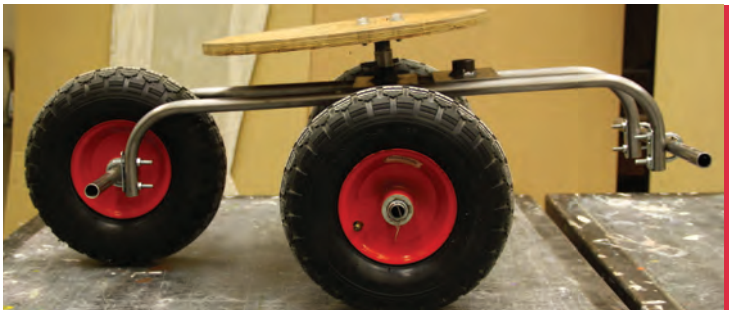
The addition of a second attachment point for the steering mechanism allowed the wheels to turn freely from the wheels. This change increased the number of configurations that could be tested with this prototype.



The switch to bigger wheels meant that the device could be used in different ways.

The bigger wheels allows the user to push on them, similarly to a wheelchair, and therefore propulse him/her self. This method worked well and increased the control and maneuverability of the user over the device.
Design was kept as simple as possble, an example of this is the few parts required for the device.

Possible Configurations



Configuration 1: The seat is placed on top of the wheel axle so that the wheels steer as the seat is turned. This configuration places a lot of weight on the rotating front wheels, adding unwanted friction. This makes itharder to steer when using with no legs. This configuration is the easiest and most effective to use when pushing with legs.

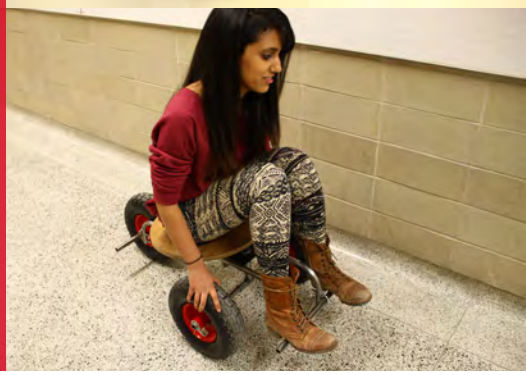
Configuration 2: The seat is slightly in front of the wheel base. This takes weight off of the the front wheels and therefore makes the vehicle easier to turn when using without legs. The positioning of the seat together with the length of the frame make the vehicle unstable and eager to titl forward.

Configuration 3: The seat is slightly in behind the front wheel axle. This takes weight off of the the front wheels and therefore makes the vehi-cle easier to turn when using without legs. The positioning of the seat does not affect stability. With this configuration it is easier to push wheels backwards.

Testing and Iterations on 2nd Prototype

Much testing was done with different users with the second prototype in order to find the benefits and disadvantages of each configuration. Testing included:

- Testing all 3 different configuration styles
- Testing seating position
- Direction of propulsion
- Steering
- Maneuverability in different terrains
- Seat height



Conclusion Before Travelling to Uganda

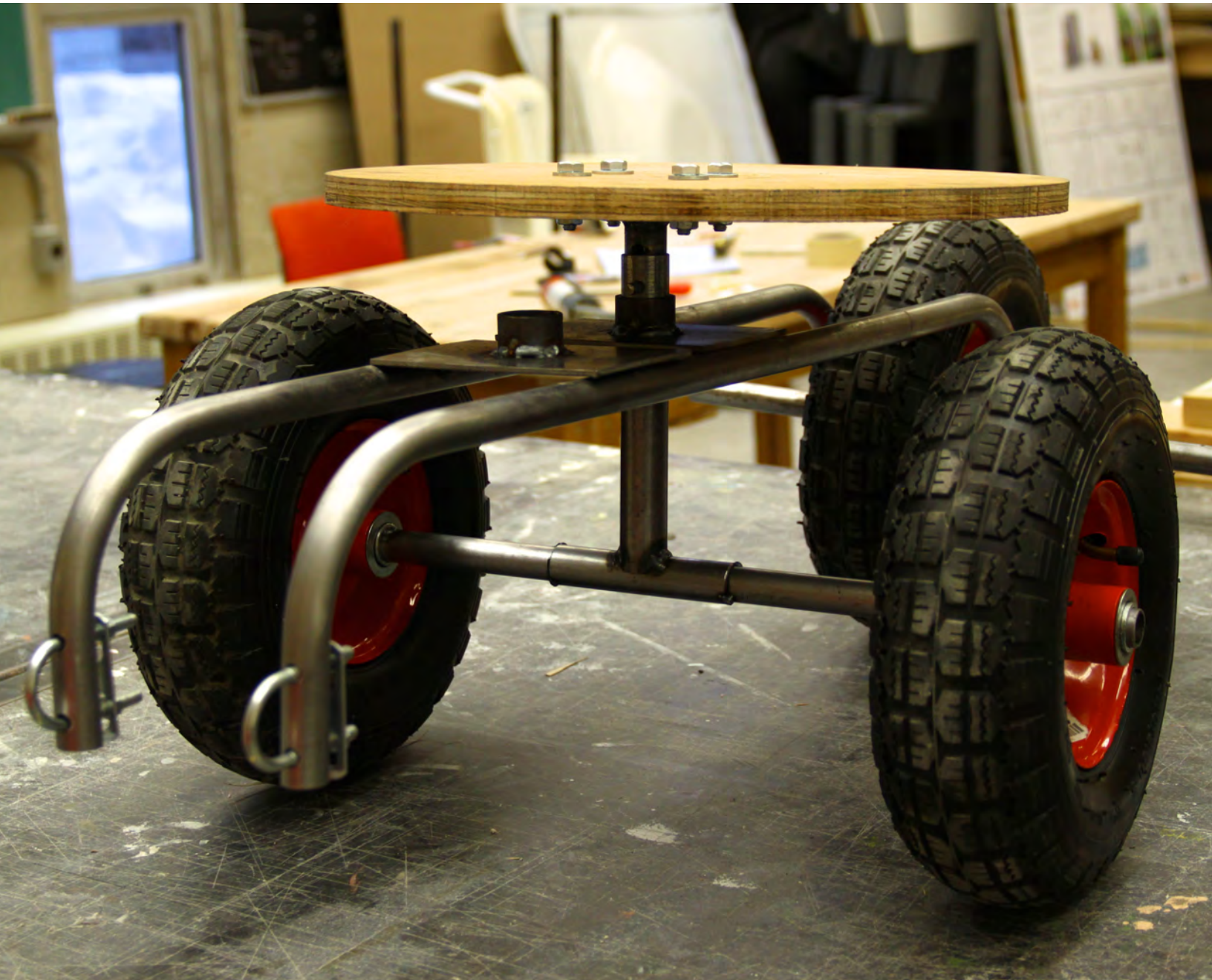
Thanks to the large amount of iterations on the design and the many different test conducted, the protoypes were able to be made very usable in a short period of time.
The final prototype will travel to Uganda so that it can be tested with real users and so that feedback can be received from all stakeholders.
Through testing and iterating these points were found as beneficial:

- Adjustable seat height provides lots of functionality
- Steering and propulsion work well
- Design is robust and should withstand the rough environment in Uganda.
- Versatility of the prototype allows it to be tested many different ways.

Through testing many aspects of the design were also found to be lacking. Although some of these aspects were left out on purpose, these areas will need more work in Uganda:

- Propulsion mechanism
- Storage system
- Seating
- Steering (with new propulsion system)

Testing in Uganda will inform my design at every level. Although feedback in Canada has been very important, the most important and guiding feedback will be the one recieved by the real users and the manufacturers of the device.



DEFINITIVE DESIGN DEVELOPMENT

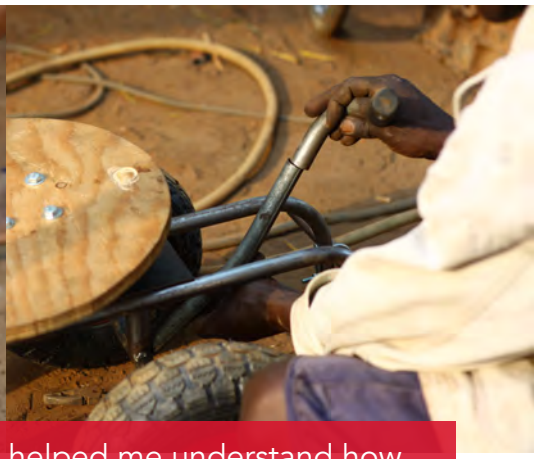
Prototyping in Uganda

Day 1: Introducing the Rolling Gardening Chair

On our first day in Kasese, Uganda we were introduced to the boards member of KADUPEDI and the other organizations that we have been working with. We also met with Kio and his team to start iteratinga and testing our designs.

The first step of the day was to introduce the prototype and, most importantly the concept behind it, to Kio and his team.
Kio was very quick to understand both and was able to provide feedback almost immediately.
After testing the prototype himself, he was able to start ideating on how the current prototype could be improved.
The first thing added was a a steering handleto help control the wheels when riding the rolling gardening chair.

The addition of the steering handle improved control of the wheels but also limited the turning radius of the device. Some of the additional feedback from Kio and his team was the need to have a brake system to have better control of the device. Kio also mentioned changes to the seat and also started thinking of ways to making a propulsion system



After a very busy and productive day, I was able to better comprehend some of the issues that everyday farmers in Uganda have to face. Kio was able to understand and then improve my design by adding a steering handle to help manouver the device. Working with him, together with his feedback, has really helped me understand how to move forward with this project. Improvements need to be made to the propulsion mechanism and the maneuverability in the gardens' loose dirt terrain.

Day 2: Meeting Mark & Presenting to Kasese Community

On our second day at Kio's shop we were fortunate enough to meet Mark. Our main user and one of the many inspirations for our projects.

Mark is unable to move his right leg and foot. He also has limited mobility of his left leg. Despite his disabilities, Mark is a successful member of his community. He is a talented shoe repairer and maker.

Testing with Mark gave me a better insight into what was really needed from the device in order to make it more usable and safer for users.

Feedback from Mark:
- The device needs a one handed propulsion system
- New seat should include support bars and backrest to help user be more stable
- Storage system should be easily reachable but should not interfere with the user's gardening.
- Footrests should help hold users' feet in place.
- A brake should be added to help maneuverability of device.

This day was a very successful day. Although I was not able to add anything to my prototype, I was able to get very valuable feedback from the most important person, Mark.
With his help, I was be able to take this project to a level closer to helping people. Mark was very interested in my project and how it can help many people keep a kitchen garden. Although he was convinced something as raw as my prototype would help people as is, he helped me understand a few issues that need to be addressed in order to improve my design

After a long day at Kio's shop, we had the opportunity to present our projects to many community members from the Kasese district.

This opportunity led to very useful feedback and dialogue from more potential stakeholders.

Day 3: Propulsion Mechanism #1

On day 3, we focused on the addition of a propulsion system for the device. Our first iteration for the propulsion system consisted of a modified ratchet attached to a wheel of the device. The extended lever of the ratchet gives the user more leverage to push wheels. The ratchet also contains a switch in order to change the direction of the propulsion.

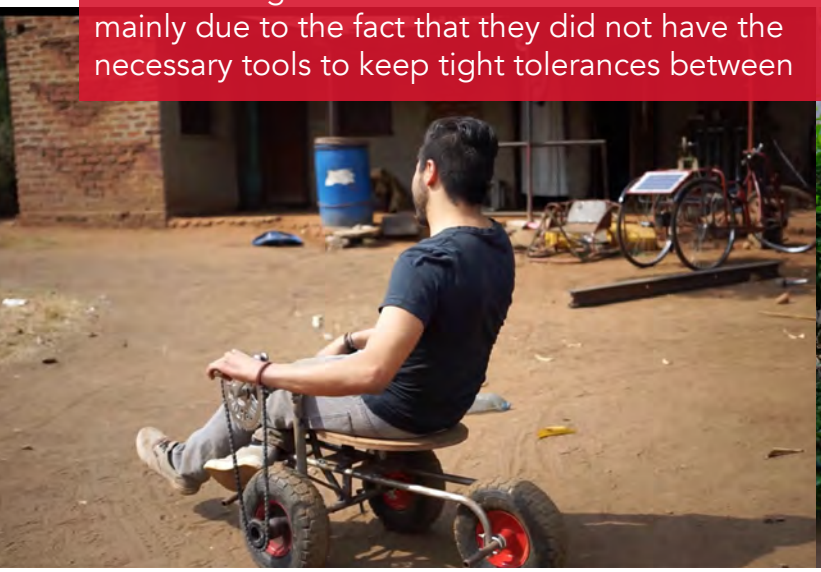
During testing we noticed that for the system to be truly efficient we needed to have one ratchet on each wheel. This contradicted what Mark had asked for. We also noticed that because the wheels only turned as much as you could turn the ratchet (90° at most) and due to the postitioning of the ratchet, it was impossible to give the wheels enough thrust to either go up hill or over obstacles.

Perhaps the most important setback was the fact that the ratchet we used (the only one we could find) was worth 60 000 Ugandan shillings (about $30CAD). We found this cost too high and therefore unfeasible.

Although we were hopeful our first propulsion mechanism would work well, we noticed too many flaws with it and were discouraged to continue working with the same system. Despite these setbacks, much was learned about what we need from a propulsion system. This kind of quick prototyping allows us to fail faster in the search of better solutions.

Day 4: Propulsion Mechanism #2 & Visit to Garden

Day 4 was focused on the addition of the second propulsion mechanism. This propulsion mechanism consited of a a crank and sprocket connected to one of the device's wheel. Construction of this mechanism was found to be a challenge for Kio and his team . This was mainly due to the fact that they did not have the necessary tools to keep tight tolerances between all of the components needed.
We were able to test this mehcanism at Kio's shop. Through this testing, we discovered quite a few flaws withing the mechanism. Some due to its construction and some due to the principles behind it. As this was the last day with Kio, I tried to get as much feedback from him as possible before leaving



After working at Kio's shop, we were fortunate enough to have been able to visit a local kitchen garden. Here I was able to test the device within the environment in which in would be used everyday. Much was learned, including the fact that the original propulsion mechanism proposed (your hands) worked very well within this environment.

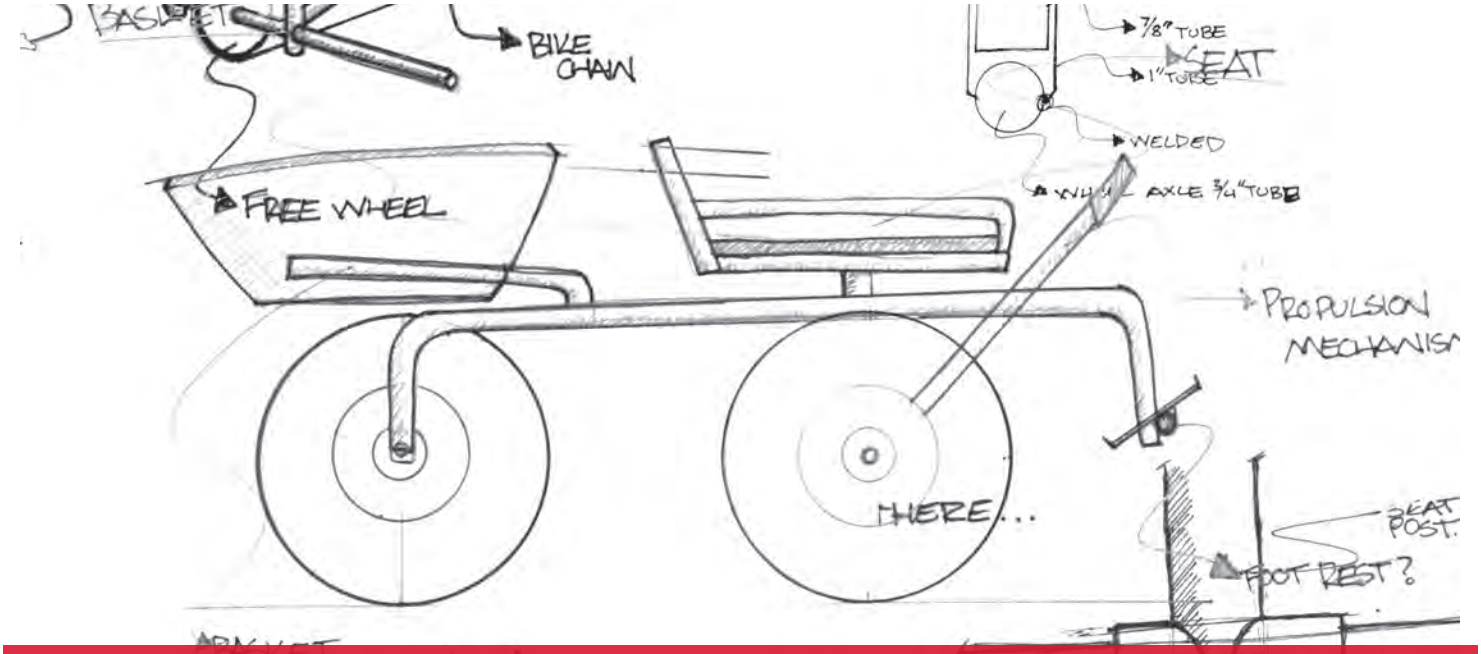
Again, our propulsion mechanism was not very successful. But like the ratchet mechanism it brought up more things to consider when designing the propulsion system. We used the wrong ratio as having a bigger gear as a crank, together with the angle of leverage, made it incredibly hard to push the wheels forward. We were lucky enough to still conduct a few tests at the kitchen garden though. We got some great feedback from the owner, who was very excited to see and hear about my project.

FINAL DESIGN DEVELOPMENT

Applying Feedback and Lessons Learned During Travel

Final Design Development

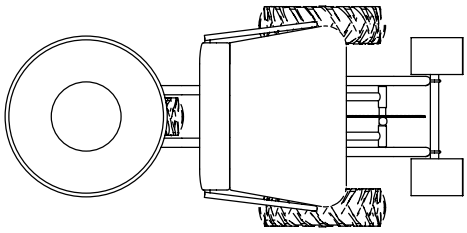
Planning the final Prototype

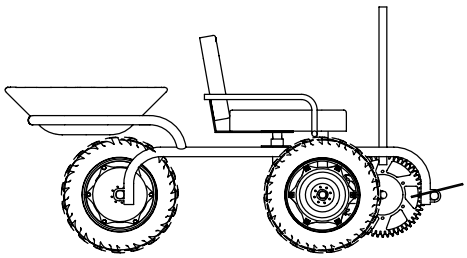


After travelling to Uganda, all feedback was collected and analysed in order to be applied to a new design.
The new design had to include features like:

- A seat with arm and back rests
- A storage system
- A better propulsion mechanism
- Footrests

These features were added through a series of ideation sketches and CAD models.
Perhaps the biggest addition is the introduction of a geared ratchet mechanism inspired by Amos Winter's Leveraged Freedom Chair.
This mechanism was added between the two wheels, resulting in a one-handed propulsion mechanism able to push the device through many types of terrains.

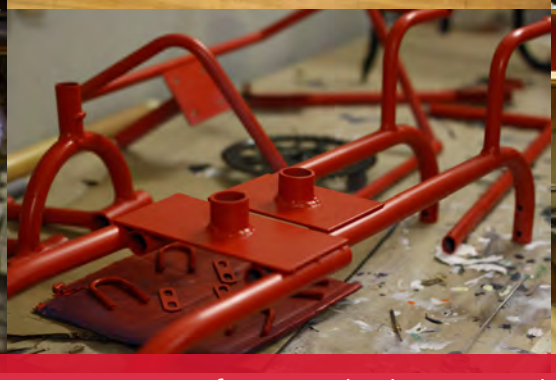




Building the final Prototype



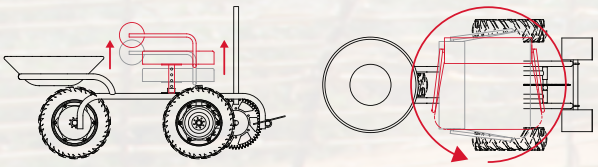





The constructio of the final prototypes span a few weeks in which problems were resolved similarly to how they were resolved in Kasese, through quick iterations and modifications to the design based on the aspects that best worked.
Some changes included the use of a thicker 5/8 steel tubing in order to make frame stronger. The addition of a padded seat with arm and back rests and a basket holder to serve as the storage system. The geared ratchet mechanism included a freewheel, a crank and a bicycle chain all brough from Uganda.

Final Design

Seat



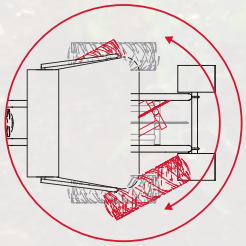
Seat is height adjustable and rotates 360 °

Basket Holder

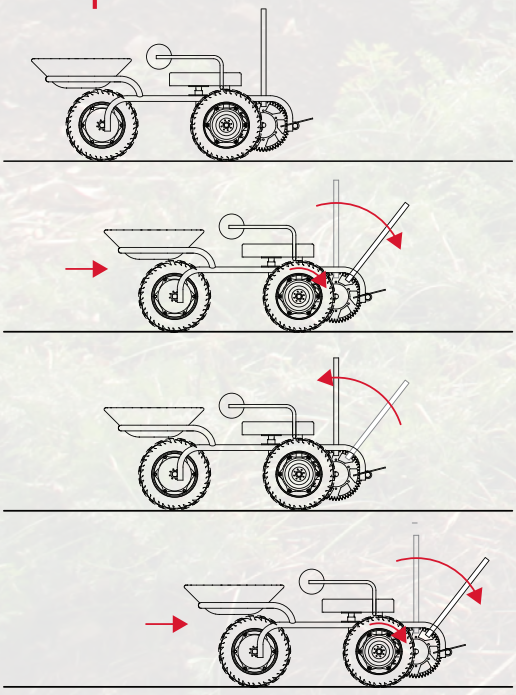
Basket holder provides space for storing crops

Steering

Front wheels steer to make device manouverable



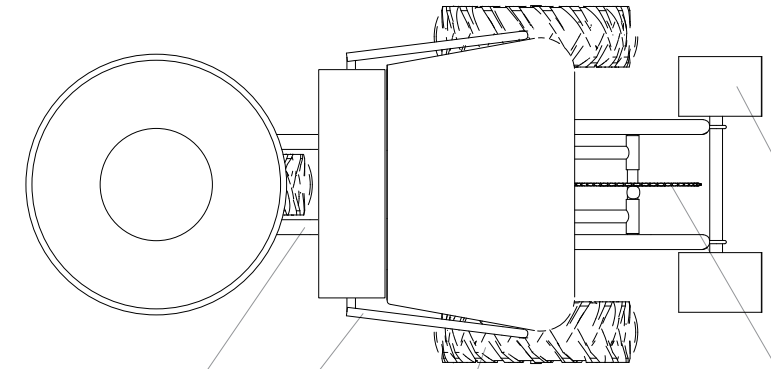
Propulsion Mechanism:

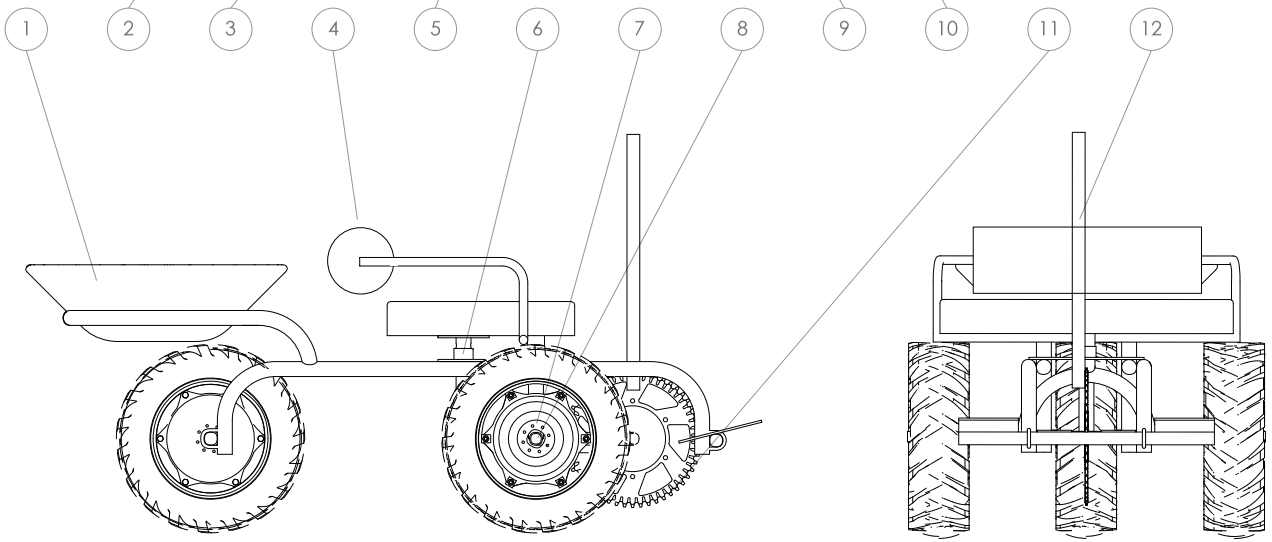



Basket Holder
Lever
Rotating Seat
Crank
All Terrain 12” Wheel

Detail Shots of Final Prototype

APENDIX A





BILL OF MATERIALS

ITEM	PART	MATERIAL	QTY
1	BASKET	-	1
2	FRAME TUBING	7/8" STEEL TUBE	2
3	SEAT FRAME	3/4" STEEL TUBE	1
4	SEAT	FOAM/WOOD	4
5	WHEELS	STEEL/NATURAL RUBBER	3
6	SEAT HUB	1 1/4" STEEL TUBE	2
7	FREEWHEEL	STEEL	1
8	AXLE	5/8 STEEL ROD	2
9	CRANK	STEEL	1
10	FOOT REST	1/8" THICK STEEL PLATE	2
11	BICYCLE CHAIN	STEEL	1
12	LEVER	3/4 STEEL TUBING	1

CARLETON SCHOOL OF INDUSTRIAL DESIGN
OTTAWA, CANADA

TITLE: GARDENATOR		TOLERANCES: DECIMAL ± 0.00 ANGLE ± 0.0°	
DRAWN: LUIS GARCIA			
CLIENT: CANUGAN		MATERIAL: TYPE	
CHECKED: KW	DATE: 06/03/14	SHEET 1 OF 1	1
DWG. #: AAA-111	SCALE: 1:8	B 11x17	

APENDIX B

APENDIX C

Design is ...
Luis Garcia

ROLLING GARDENING CHAIR

ASSISTIVE GARDENING DEVICE FOR PEOPLE WITH DISABILITIES IN RURAL UGANDA

FINDING AN OPPORTUNITY

A CULTIVATING CULTURE

86% Of the rural population in Uganda relies on subsistence agriculture

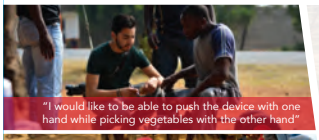
A VICIOUS CYCLE

Due to dependency, bad stigma and poverty, many disabled people struggle to find sufficient food on a daily basis

DISABILITY IS NOT INABILITY

Empowering disabled people to cultivate their own food enables them to contribute to their families and society

USER FEEDBACK

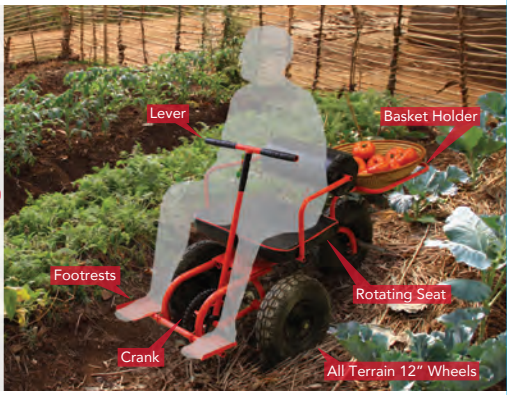


"I would like to be able to push the device with one hand while picking vegetables with the other hand"

"Device should be made of thicker tubing to withstand Ugandan terrain and climate"

"This device would allow me to move around in my garden. It would make gardening much easier"

THE DESIGN



PROCESS

1 Ideation | 2 Initial iterations | 3 Iterations in Uganda | 4 Final Prototype

SID CARLETON UNIVERSITY SCHOOL OF INDUSTRIAL DESIGN · CanUgan · Carleton UNIVERSITY · IDRC CRDI · DESIGN WITH UGANDA