UP-PLASTIC KAMPALA

Recycling Plastics and steel waste to produce Low Cost sustainable building units

Through setting up a plastic reuse workspace at Makerere University

2017-2018

PROJECT REPORT

TEAM

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SUPPORTED BY OFFICIAL DEVELOPMENT AID FROM THE MINISTRY FOR FOREIGN AFFAIRS OF FINLAND

Aalto University

Sustainable Global Technologies PBL EAST AFRICA

CONTENTS

04
UP-PLASTIC KAMPALA

05
PROJECT WORKSHOP & CLINICS

06
PRODUCT CONTEXT (LCB-Units)

07 COMMUNITY OUTREACH

08 CONCLUSIONS

09 APPENDIX

ACKNOWLEDGMENT

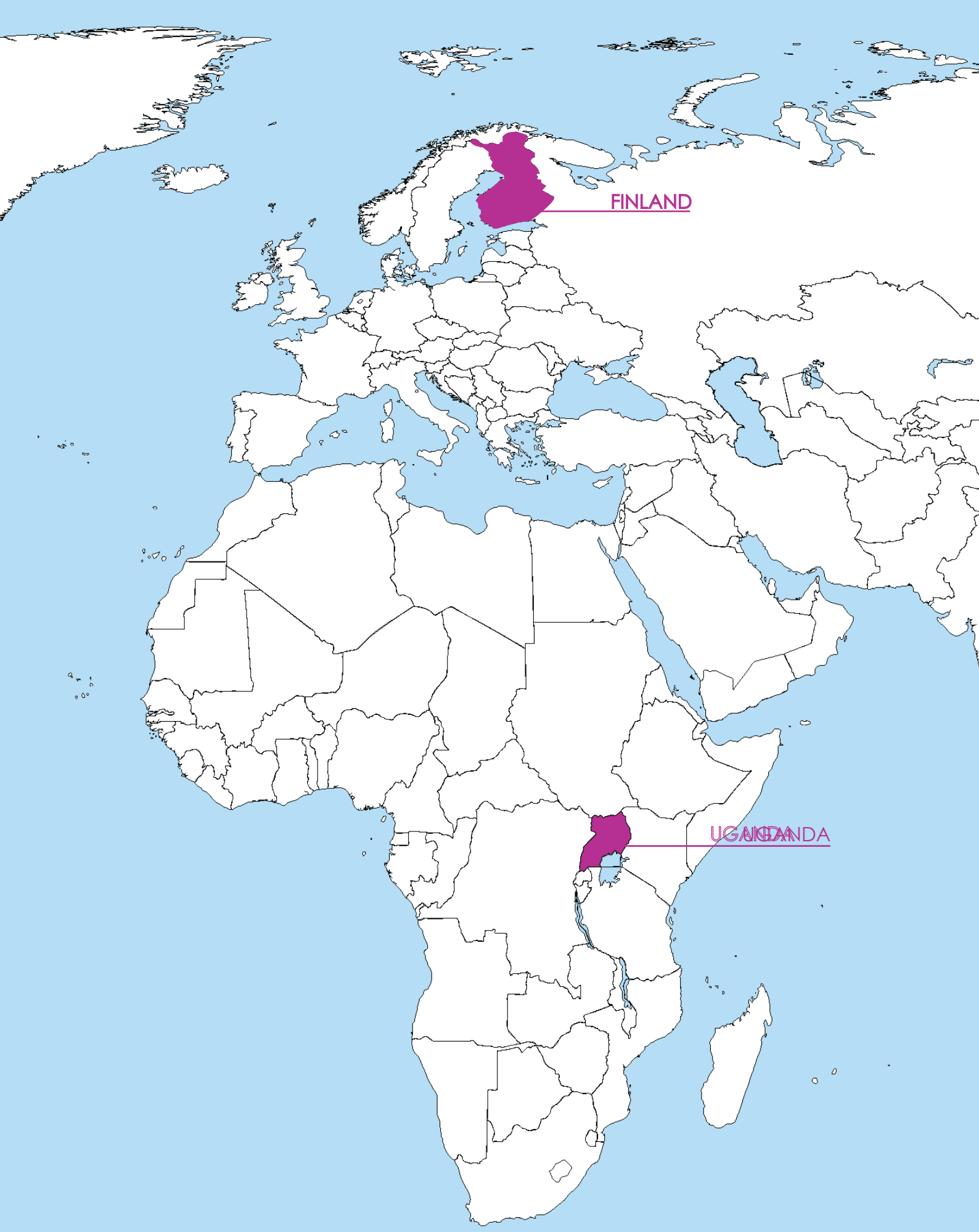
We would like to thank everybody who so generously contributed towards the development and success of the project most especially the Aalto University team: **Sara Gottschalk, Enni Huotari, Anna Kintsurashvili, Olga Mäkinen, Bergpob Viriyaroj** from the **Sustainable Global Technologies** studio, Finland who we shared and developed the project with from the idealization stage to implementation.

Similarly, profound gratitude goes to enthusiastic PBL-Project coordinators **Matleena Mahoneen** teacher at SGT Programme at Aalto University, **Venny Nakazibwe** the deputy principal college of engineering, design, Art and technology Makerere University**(CEDAT)** for their great support and encouragement thought the entire project. We are extremely grateful for people behind PBL East Africa initiative right from Finland Ministry of Foreign Affairs under GST to Makerere University for the funds they injected.in the project

We also whole heartedly thank our awesome mentors **Matias Heino** from Aalto University, **Robinah Kulabako , Raymond Nsereko, Henry Alinaitwe, Philip Kwesiga, Steven Mukiibi, Anthony Gidudu** from MAK for their wonderful teachings and lessons they administered to us from the time of the pitching up to this moment. You have contributed so much to the wisdom and success of the team.

We are also hugely appreciative to the following people who greatly contributed and worked with us during the project: **Pamela Matovu from Makerere Sustainabilty Program, James Ssemuwemba from KCCA, Ruganzu Bruno from ECOART, Mathias Tusiime from UCASDR, Robert Gita, Andrew Wabwire, Babu Talik, Phillip Kisakye, Etwalu Emmanuel Brian and Frank Morris Matovu** from CEDAT for their amazing work they contributed towards idealizing the project and building our compression machine.
The execution of this study would have been not possible if not dependent on the steadfast support and encouragement of all the mentioned above.

Special thanks also go the **Fimboo** team for generously being there for us in any instance we needed help right from the time we visited their workspace to the high level of knowledge they shared with us. They also provided extremely important parts on our **compression machine**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UGANDA

LIST OF TABLES AND FIGURES

ABBREVIATIONS

CEDAT	College of Engineering, Design, Art and Technology
KCCA	Kampala Capital City Authority
LCB unit	Low Cost Building unit
MAK	Makerere University
PBL	Problem Based Learning
SGT	Sustainable Global Technololgies
UCASDR	Uganda community Art skill Development and Recycling (UCASDR)

PROJECT SUMMARY

01

Makerere and Aalto University Team at CEDAT

Figure 1: Up-Plastic Kampala Team at CEDAT

UP-PLASTIC Kampala is a project under the Problem Based Learning (PBL-East Africa which is funded by the Ministry for Foreign Affairs of Finland and was brought to life by Aalto Global Impact. Taking place in 2017–2020, the project engages faculty, students and external partners in the four countries to work on sustainable innovation challenges in East Africa. As a whole, the project brings together multidisciplinary teams from four universities (University of Dar es Salaam, University of Nairobi, Makerere University and Aalto University) to develop sustainable solutions to community challenges while also building regional and global networks in an effort to share knowledge and deepen innovation capabilities in East Africa and beyond.

The project was intentended to contribute to the development of sustainable innovation ecosystems by building the capacity of university students and faculty to respond to global challenges using multidisciplinary approach as they gain hands-on experience in conceptualizing and prototyping environmentally, socially and economically sustainable solutions to community challenges

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The project entrance criteria was based on student challenge on the part of Makerere University where multidisciplinary teams from the College of Engineering, Design, Art and Technology were called up to submit their proposals under the umbrella theme "Working towards a better livelihood in Peri-Urban Communities" in areas of food, water and sanitation, waste, housing and energy solutions. The winning team later on took the collaboration with Aalto University students under the solid waste (plastics) which they saw as the main challenge affecting Kampala.
In the up-plastic Kampala project, the Makerere University team of 6 undergraduate students from the College of Engineering, Design Art and Technology paired and worked with the team of 5 masters students of Aalto University, Finland in developing an innovation to solve challenges of waste management in Kampala under the mentorship of experts from both universities

Project development started in November 2017 after the Makerere student challenge and during the course knowledge sharing and enhancing awareness through workshops, stakeholder collaborations and the development of a plastic recycling workspace at Makerere University was realized.
The Finland team later joined the Makerere team for a period of 2 weeks in February 2018 and this time the team was able succeeded in completing some of the project objectives that included workshops, field trips and setting up a plastic recycling workspace incorporated in it a self-built Precious Plastic compression machine, and having established strong connections between important stakeholders.
The team in the period has developed LCB-Units prototype as the project product through recycling plastics and steel waste and did professional laboratory tests to ascertain its suitability to the community. In the same period the team set up plastic recycling workspace which is at the School of Industrial and Fine Arts at Makerere University.

02

BACKGROUND STUDY

COUNTRY REVIEW & BACKGROUND

Uganda is a landlocked country in East Africa with a population of 42,894,272 (as of 2017). Covering an area of 241,038km, the country is bordered to the East by Kenya, to the North by South Sudan, to the West by the Democratic Republic of Congo, to the Southwest by Rwanda and to the South by Tanzania.

It was colonized by the British who came looking for the source of the Nile Uganda and became a British protectorate in 1894. It was later granted self-governance in 1962. Endowed with fertile soils and regular rainfall, agriculture is the most important sector of Uganda's economy, contributing to nearly all of the country's foreign exchange earnings. (Watch, 2017)

Region	Africa
Population	42,894,272 (as of 2017)
Capital city	Kampala
Climate	Tropical; generally rainy with two dry seasons (December to February, June to August); semiarid in northeast.
Languages	English (official), Luganda, Swahili, Bantu languages, Nilotic languages
Currency	1 Ugandan shilling (Ush$) = 100 cents

Table 1: Key Descriptions on Uganda

Figure 2: Map of Uganda

Uganda's economy has grown at a slower pace in recent years, reducing its impact on poverty. Average annual growth was 4.5% in the five years to 2015/16, compared to the 7% achieved during the 1990s and early 2000s. The economic slowdown was mainly driven by adverse weather, unrest in South Sudan, private sector credit constraints, and the poor execution of public sector projects. Amidst these, and as a reflection of an unrealized fiscal stimulus, growth slowed further to 3.5% in 2016/17. The economy may recover to above 5% in 2017/18, and to 6% in 2018/19, if weather conditions improve, Foreign Direct Investment (FDI) inflows accelerate, the banking system stabilizes and budgeted, capital spending is executed without delays. (WordBank, 2017)

Uganda's Gross Domestic Product (GDP) in 2016 was $26 billion, with per capita GDP of $642. The current estimate of the population is 41 million. Nearly 2.5 million reside in the country's capital Kampala with the number close to doubling during the day owing to the economic attractiveness of Kampala city. Uganda's economy quickly recovered from the 2009 global economic downturn largely due to past reforms and sound management of the crisis. (WordBank, 2017).
With the current statistics that indicate that population of Uganda almost doubles every after 10 years, census results show that 58% of Ugandans are not working for reasons other than pursuing studies which, according to the report, captures the country's non-utilized labour potential. Also, according to the census report, Uganda's population between the productive age of 14 and 64 is slightly over 18million.

Uganda is the second country with the youngest population in the whole world. 48.5% of the country's population is below the age of 15 years. After completing school these youth have to compete for a few available jobs in government or private sector leaving many of the unemployed. The unemployment rate for young people ages 15–24 is a staggering 83%. This rate is even higher for those who have formal degrees and live in the urban area. This is because most of the degree holders lack the vocational skills needed for the jobs. Those without a degree are also not able to obtain jobs because they lack the skills needed for the position or they don't have the resources such as land or capital (Joseph, 2017).

The rapid population growth in the urban areas has greatly outpaced the ability of the urban authorities to provide adequate housing, roads, water supplies and waste management .Kampala being the country's capital city with a population of more than 1.5Million people as of 2017, it has called for urgent measures and ways in which settlement can be mitigated.

Projects initiated by the City's management bodies such as KCCA to curb the problems of Unemployment and sanitation have been put in place for the youth to engage in. Sanitation being the essential beneficial factor to effective livelihood, Kampala with its rapid population increase has brought challenges of waste management amidst different activities that are carried out (KCCA, https://www.kcca.go.ug/Waste%20Management, 2017).

City administrative bodies (such as KCCA) and environmental organs (such as NEMA) have ventured into collaboration with private companies to find out ways with which housing and waste can be managed in the city. (KCCA, https://www.kcca.go.ug/Waste%20Management, 2017)

SOLID WASTE MANAGEMENT IN KAMPALA

Solid waste management is one of the major environmental problems in the world today and its generation rates are rising rapidly. Solid waste refers to the range of garbage arising from animal and human activities that are discarded as unwanted. It is generated from industrial, residential and commercial activities in a given area. Examples of solid wastes include plastics, metal, papers, glass, etc

In 2012, the world's cities generated 1.3 billion tonnes of solid waste per year, amounting to a footprint of 1.2 kilograms per person per day. With rapid population growth and urbanization, municipal waste generation is expected to rise to 2.2 billion tonnes by 2025 (World Bank, 2017).

Globally, poor sanitation is one of the main causes of ill health and socio-economic problems. Poor sanitation is also a major development obstacle in most developing countries like Uganda. (WHO, 2008) However, prioritization and investments in solid waste management by individuals and governments in most developing countries is limited, creating an imbalance between the population's needs and the available services (Kamara etal 2008).

Public Private Partnerships (PPP) act of 2015 which leverages a private sector driven environment in key service delivery sectors of government. Whereas the waste collection and transport was contracted to local private companies under a PPP arrangement throughout the city since 2016, KCCA still provides the same service in critical public premises and some pockets of informal settlements.

The main damping site for solid waste in Kampala is Kitezi Landfill that was commission in 1996 however KCCA upon the extortion of the site has purchased 135 acres of land at Ddundu in Mukono and procured a Transaction Advisory Services of the International Finance Corporation for the forthcoming PPP Contract. (KCCA, Laying the foundation for Kampala city transformation: Strategic Plan 2014/15-2018/19, 2014)

Data from Kiteezi landfill suggests that the actual waste transported to the site is approximately 1,300 tons/day. Approximately 50% is collected by KCCA and the rest (i.e. 33%) is collected by the private operators. The primary sources of municipal solid waste (MSW) generation are private households, transient population, market places, commerce, industry, public administration, kindergartens & schools, hospitals and tourists to be covered by the municipal waste collection system. (KCCA, Treatment, Kampala Waste, 2017)

Furthermore, from the study that was carried out on plastic waste management in Uganda, Kampala central division, 40% of household respondents use plastic bags to store plastic waste, 15% use sacks for storage and, 35% have no containers and dispose waste at a central point located at some distance away from residential areas, burning (incineration) as a method of disposal is done by 13%. Recycling is done by 1% of the manufacturers (Rugwiza, 2012).

The forecast of municipal waste generation is mainly dependent on two factors, namely the population growth and the economic growth. KCCA has estimated waste generation in Kampala based on the following factors;

- Year on year GDP growth of 4.55%
- Population growth
- Growth in per capita waste generation at 0.91%

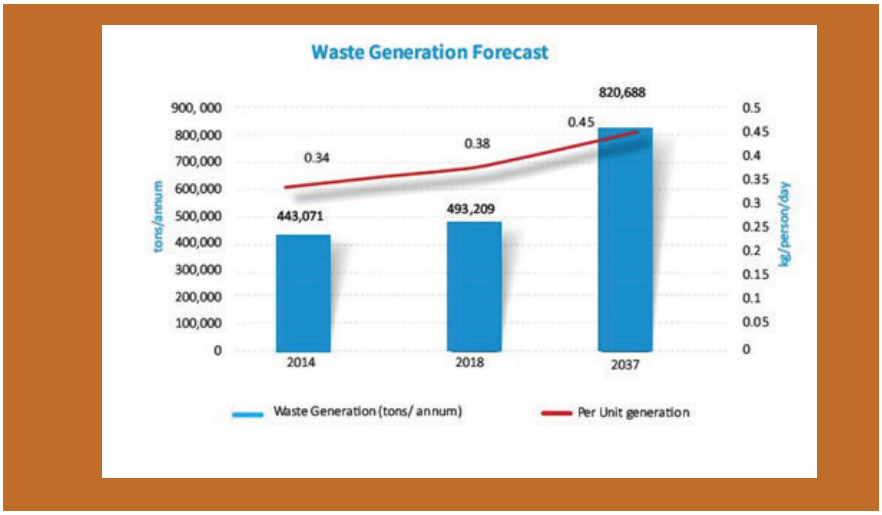


Figure 3: Waste generation forecast in Kampala

Plans are underway by the government to establish a waste recycling plant that will produce fertilizers, generate power and a host of other materials, including job creation for those involved. KCCA is seeking a private partner in the design, build, finance and operate of a waste treatment and disposal facility for Kampala city and its greater metropolitan area. (KCCA, Treatment, Kampala Waste, 2017)

PROJECT FRAME

The project kicked off in early October 2017 when the College of Engineering, Design, Art and Technology called up multi-disciplinary teams of 6 students of from same college to summit project proposals in fields of solid waste management, water and sanitation and eco systems and effecient energy in pursuit to develop sustainable solutions to challenges faced in Uganda in those fields.

Figure 4: PBL Challenge briefing at CEDAT

Upon pitching to defend those proposals, the winning team which had "Recycling plastic and steel waste to produce low cost sustainable building units" (LCB-Units) project that adressed the issue of solid waste managemnt in Kampala that paved way for collaboration with the Aalto University team through Problem Based Learning (PBL-East Africa).

We identified that one of the rappid growing challanges in Kampala city is solid waste management that later contribute to increase of health problems and poor sanitation. The Makerere team through research found out that alot of waste in form of plastics is generated every year in Kampala and a large percentage of ends in landfills and other in drainage channels.

Steel and plastic waste doesnot decomposed once damped in the soils and this hinders fertility putting in considerations that Agriculture is the back-bone of Uganda. We also identified that PET type of plastic (plastic bottles) is the commonest around the streets and less attention

From this background, we made a prototype dubbed LCB-Unit that is made by melting plastic, mixing in sand and mild scale and then moulding the mixture to form a building unit that can be inform of pavers, bricks and blocks. Not only did we focus on adressing the issue of solid waste management in campus but also providing an alternative cheap construction material and later impact on the issue of increasing unemployment in Uganda Ithrough providing citizens with knowledge on how to establish their own recycling centres for a living or once the production of LCB Units is commercialised

In January 2018, we paired with the Aalto team and focused on developing the project beyond a single static thinking through having workshops and field trips which brough in various possibilities and ideas. It is with that we got to discover precious plastic and developed a compression machine.

PLASTIC AND PLASTIC WASTE

Plastics are categorized under 2 basic types: thermosoftening and thermosetting plastics.

Thermo-softening plastics soften easily when we subject to heat them and can be remolded into new shapes. Thermosetting plastics are heat resistant, although if subjected to heat strongly enough they do char and burn. They are made of long-chain molecules with lots of strong covalent bonds holding the chains together.

Thermo-softening plastics majorly include the following types; polyethylene terephthalate (PET) , polyvinyl chloride (PVC) , high density polyethylene (HDPE], Low density polyethylene (LDPE), Unplasticised Polyvinyl chloride (UPVC), Plasticized Polyvinyl chloride (PPVC) Polypropylene (PP)

For this project we focused on PET because they contribute the highest percentage of solid waste collected in Kampala according to KCCA. Examples of PET type of plastic include water bottles, soda bottles and other packaging materials of that caliber.

Plastic types and their potential recycling method

Plastic Type	Characteristics	Common use	Common use for recycled plastic
Polyethylene Terephthalate (PET)	Clear hard plastic suitable for fibre	Soft drink and mineral water bottles	Clear and soft film for Packaging and wrapping, rug fibers, rain coats
Low density polyethylene (LDPE)	Soft, flexible plastic milky white, unless a pigment is added	Lids of food containers, garbage bags, and rubbish bins	Soft film, wrapping industry, plant packaging and nurseries bags
High density Polyethylene (HDPE)	Commonly used plastic in white or colored	Puckered shopping bags, milk storage bags (freeze)	Compost bins, detergent bottles, crates, and mobile rubbish bins
Unplasticised Polyvinyl chloride (UPVC)	Hard rigid plastic, clear type	Sanitary piping, plumbing pipes and fittings	Dishwasher bottles, toiletries detergent bottles, tiles, and plumbing pipe fittings
Plasticized Polyvinyl chloride (PPVC)	Flexible, clear, elastic Plastic	Garden hose, shoe soles, blood bags and tubing	Hose inner core, and industrial flooring Polypropylene (PP) Hard, but flexible plastic

Polypropylene (PP)	Hard, but flexible plastic	Ice-cream containers, potato crisp bags, stools and chairs	Ice-cream containers, potato crisp bags, Compost bins, kerb side recycling crates
Polystyrene (PS)	Stiff but brittle plastic. Clear in nature and glossy	Cheap, transparent kitchen ware, light fittings, bottles, toys, and food containers	Laundry pegs, coat hangers, and video/CD boxes
Polyester (EPS)	Foamed, lightweight, energy absorbing, and thermal insulation	Hot drink cups, and takeaway food containers	spools, rulers, and video/CD boxes

Table 2: Plastic types and their recycling methods

RECYCLING PLASTIC WASTE FOR CONSTRUCTION AND DESIGN

Plastic associates products based have been considered as the world most consumer packaging solution. However, substantial quantities of plastic consumption have led to exponential increase of plastic derived waste. Recycling of plastic waste as valued added product forexample in the case of LCB-Units appears as one of promising solution for alternative use of plastic waste

Even though there are diverse types of recycling techniques for plastic waste as mentioned earlier, the reuse of plastic waste for construction materials can be considered as a promising method to maximize this waste. Through this method, plastic waste can be revitalized directly it disposed by substitute the plastic waste for cement replacement could enhance the environment sustainability or construction materials.

As we had workshops and trips with some of our stakeholders that are so much involved into communities like Bruno(ECOART) and Mathias(UCASDR) we realized that there is much you can do with waste plastic besides construction. We realized one can do much in art and design through recycling plastic and with those stakeholders; we were able to see how they applied plastic in their art works.
Precious plastic community on bazar.preciousplastic.com also describes and exhibits a lot of artistic products that have been made by different people from recycling plastics using their machines which among them is the compression machine. With any specified design of mould, one make a lot of products from recycling any plastic with a compressor machine we have at our workshop in Makerere University

SUSTAINABILITY OF THE PROJECT

One of the key things we learnt through project idealization and development is measuring how sustainable it is to the environment. Through developing LCB-Units we have learnt that the production process is quite challenging and more concerns were raised about the fumes that are generated as plastic is melted. From research, we found out there are industrial source-capture filter machines available from e.g. Sentry Air Systems, Inc. to capture and extract the fumes created. However, these are not used in the small-scale workshops of Precious Plastic. The Precious Plastic community encourages to use good ventilation and wear masks to prevent toxic fumes. Melting one type of plastic at a time at the right melting zone temperature should be safe according to the community. Also sustainability of the project depends on the economy and society. The needs of people in the community can outweigh the environmental impact and in the long run affect their economy.

Figure 5: Precious Plastic workspace container

Precious Plastic

Precious plastic is a plastic recycling project and community that was start in 2013 by Dave Hakkens in Netherlands as his graduation project with the aim of attaching value to plastic waste through developing machines and creating a workspace for plastic community after realizing the amount of waste plastic that is gathered every year. Precious Plastic is a project trying to boost plastic recycling worldwide. We try to do that by providing tools and knowledge to people around the world. For free, of course. Trying to give people solutions to fight plastic pollution. The project counts on the contributions of dozens of people joining the project with their skills and knowledge on how plastic can be recycled. It is now a large community with over 10,000 like-minded people around the world with open source information on how to build the machines and sharing information.

Figure 6: Precious Plastic Machines

Precious plastic as a recycling community was used as a basis and reference of the project on compression machine building because it provided open source information on the procedures and materials required to set up the machine.

However, the machines are designed for a small scale and personal use but not industrial based and recommended for setup in an open environment.

UP-PLASTIC KAMPALA

03

OBJECTIVES AND IMPACTS

The main objective of the project was To recycle plastic and steel wastes to produce low cost sustainable building units through creating community awareness and establishment of plastic reycling workspace.

Solid waste management and Recycling of plastic waste

This project was aimed aimed at adressing the issue of solid waste management in Kampala and paving a way to providing conditions for more efficient collection and recycling of plastic waste from households and other municipal sources around Kampala city. This was after research that we realised over 70% of solid wastes are plastics which can be used resued and co-created to manufacture/make other materials for construction and design.

Establishment of a working space

Establishment of plastic recycling work space was one of the objectives that that came through as we did reasearch after getting to know about precious plastic. This was to provide space for machines like the compression machine and others to be built and also create room for recyling plastics around Makerere University.
The workspace was established officially at the School of Indusrtial and Fine Arts at Makerere University

Figure 7: Makerere University Workspace at BIFA (Inside)

Figure 8: Makerere University Workspace at BIFA (Inside)

Figure 9: Testing Compression machine on Up-plastic event

> One of our Key stakeholders KCCA has been in Search of an nnovation to diffuse the amount of plastic waste in Kampala City

SOLID WASTE MANAGEMENT

Over the years, Ministry of Health of Uganda, Kampala Capital City Authority and the citizens have continuously complained about the rapid and constant increase of plastic use in the consumer products that end up as waste after use. They are ridiculing manufacturers of these products, tasking them to come up with sustain- able solutions to recycle this waste. With the PET type of plastic waste dominating the environment, it really triggers an alarm of what can be done to diffuse all this valuably. To raise your expectations high, it is what KCCA as the chief administra- tors of the city have been digging to find. It is by that that Makerere University team manifested an idea from scratch that is supposed to restore the glory of Kampala in collaboration with the Aalto team from Finland.

The project "Recycling plastic and steel waste to product to produce low cost building units" is aimed at creating a sustainable environment with in which we dwell as well as revolutionalise the construction industry by producing affordable building units. Through creating awareness, waste management challenges can be curbed by adding value to waste.

The project will largely impact on the lives of the community and change people's mind set on how they address plastic as waste. It will help people visualize different spectrums on how plastic can be recycled to improve their standards of living. Conserving the environment by reducing uncompelled disposal of waste through setting up appropriate collection centers will cease exposing harmful components to the environment. Everyday tonnes of "what is dubbed as waste" is disposed in drains and landfills like Kitezi in Kampala.

With this kind of setting, more and well-designed plastic centers shall be established following the powerful sensitization initiatives being undertaken. The project will create great impact on the community and environment sanitation, boost creativity in terms of what best can one can craft from plastic waste and as well create employment to the locals.

Following KCCA's and Makerere University's sustainability program objectives about solid waste management, the project is streamlined and directed towards achieving the objective and by far Precious plastic's compression machine have been developed while others are still in the development phase. These machines are supposed to ease the process through which any kind of plastic is recycled to produce any product and in this projects case, building units.

EMPLOYMENT

With high rates of population increase in Uganda, most youth have found it difficult get through challenges of unemployment after and before they have acquired degrees. With that the government of Uganda is sensitizing and encouraging youth to come up with ideas and innovations to foster their finances. This LCB-Unit project is aimed at creating awareness through which people can identify ways of improving their lives economically.

This can be through manufacturing LCB units for sale, setting up collection centered that offers employment to actual waste pickers and providing a learning platform on which the youth can learn different products they can make from waste plastic for their economic benefit.

PROBLEM BASED LEARNING (PBL)

Problem-Based Learning (PBL) a teaching method in which complex real-world problems are used as the vehicle to promote student learning of concepts and principles as opposed to direct presentation of facts and concepts. PBL can promote the development of critical thinking skills, problem-solving abilities, and communication skills. It can also provide opportunities for working in groups, finding and evaluating research materials, and life-long learning. However, Problem Based Learning approach is not actually practiced here in Ugandan Universities. With that, Makerere team and Aalto team through this kind of learning have had an experience on projects development through working in a multi-disciplinary and multi-cultural setting.
This will give us strategies upon which we shall pursue our careers in future

Problem

Waste is not well managed, especially in developing countries. As a result, it ends up in the soil, drainages and water bodies. This has led to huge environmental pollution deteriorating the health of mankind and the other living organisms. In Kampala city for example, there have been various instances of flooding due to blocked drains all attributed to people carelessly dumping wastes in them. Fertility of the soils has been affected due to wastes that do not decompose.

Managing waste properly is essential for building sustainable and livable cities, but it remains a challenge for many developing countries and cities. Effective waste management is expensive, often comprising 20-50% of municipal budgets. Operating this essential municipal service requires integrated systems that are efficient, sustainable, and socially supported.

Furthermore, the costs of construction units are on the rise. This is because the prices of construction materials are constantly increasing. For instance, the price of cement has doubled over the past seven years.

PROJECT STAKEHOLDERS

04

CONNECTION WITH STAKEHOLDERS

One of the major thrust of any project are the stakeholders, with them project can be visualized and can aim to the right direction since they directly in contact with the consumers and communities they serve. As one of the project outputs, the Makerere team together with the Aalto team was able to connect with some stakeholders as the project was executed among them include KCCA, Roofings, Fimboo, Art communities and CEDAT. With them, we were able to establish a working space at Makerere University

Makerere University, CEDAT

College of Engineering, Design, Art and Technology is one of the major collaborators of the project because of the partnership with PBL-East Africa project and Global sustainability technologies with Dr. Venny being the Makerere University Coordinator. They have also contributed funds to run the project and a working space for workshops and machines.

Aalto University

Aalto University

Under its Sustainable Global Technologies studio course funded by the Ministry of Foreign Affairs of Finland, the Aalto team was able to coordinate, meet and work with the Makerere team towards achieving the project objectives. Aalto University has also contributed to the mentorship and funds to run the project with Matleena as the projects coordinator

Makerere Sustainability program

The Makerere Sustainabiliy program is an initiative that was started by Mkarere university to create awareness on waste through its programs such as the **MAK GO GREEN WEEK** where students participate in sensitizing fellow students and Makerere community on waste management and keeping the campus clean. They are also our partners in this project because from the start we realized the program was executing activities that are in line with project undertakings. With Miss Pamela being the program's coordinator, they were able to present with us on the Up plastic event

Kampala Capital City Authority KCCA

The Kampala Capital City Authority was one of the possible partners that was identified during the course of research in accessing plastic waste resources, while being a powerful source for knowledge and one of the most influential actors when it comes to solid waste management in the city. KCCA is the main authoritative organ in Kampala and responsible for activities of social and economic development. A KCCA representative Dr James was involved in the project by giving a presentation to the teams. Further collaboration should be established to access advice, guidelines and other information relevant to the project. Also, waste processing sites Kitezi and Dundu are under control of KCCA and might be vital for further developments

Fimboo and Precious Plastic

Fimboo in Entebbe a Precious plastic community has also contributed to the development of the project by providing electrical components that were used to build the compressor machine and with that, they are have been our partners. They have been a source of useful information upon which we derived project changing ideas.

Precious plastic being an open source platform founded by Dave Hakkens is also a wonderful source of information for machine development where drawings and footprints were 1st obtained. They have also been our guide from the very 1st point the idea of recycling plastic was shared with the Finland team.

Roofings Ltd

Roofings Ltd was identified as the official course of mild scale steel which is one of the production ingredients of the LCB-units. The team had tour to their official industries and strengthened the collaboration and potentially bookmarked as the project stakeholder and partner. They have been with us since the start of the project because it has been the source of mild scale that was used for prototyping LCB-Unit.

Uganda Community Art Skills Development and Recycling (UCASDR)

Uganda community Art skill Development and Recycling (UCASDR) is a program that links Art and Craft to environmental concerns through recycling skills development and innovation in Uganda.

Mr Tusiime Mathias, a plastic artist and the founder of UCASDR and as an art community is also one of our partners and has been there since the start of the project. From bringing on board how recycling plastic can be taken up as an art to change the community, presenting on up-plastic event to organizing community outreach.

ECOART Uganda

Mr. Ruganzu Bruno also a plastic art and founder of EcoArt Uganda has been our partner and has worked with us from the beginning of the project. He presented to us how far he had moved with reusing plastic waste and how great has earned and changed lives with it. He together with other artists collected up their work and presented on the up-plastic event

Project Timline

Team Forming
Forming Teams and brainstorming the topic

Submitting Project Proposals

Pitching
Project presentation to the PBL Panel
Annoucement of challenge winners

Project planning
Scheduling and drafting time frames

Individual Skype meetings
Chatting with Aalto team and sharing project expectations

First Meeting
Introductions to the Aalto team and Kampala Tour

Stakeholder Presentations
KCCA, MAK Sustainability program, ECOART

Fimboo Trip
Learning about plastic properties and recycling

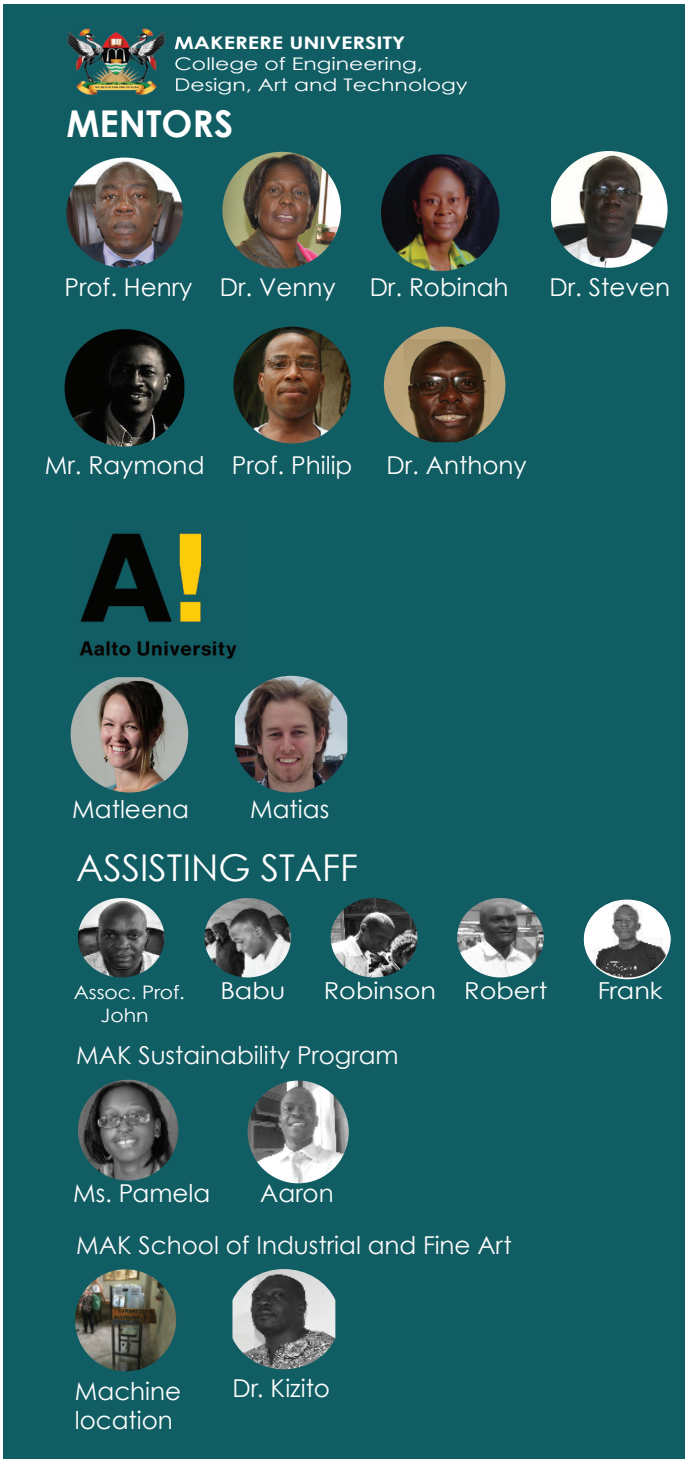
Workshop
Lifecycle assessment of LCB Unit

First Week Review
Plan for next week activities
Formed 3 teams: Prototyping, Machine and Awareness team

Trip to Kitezi Land field

Trip to Roofings Ltd

Figure 10: Project timleline



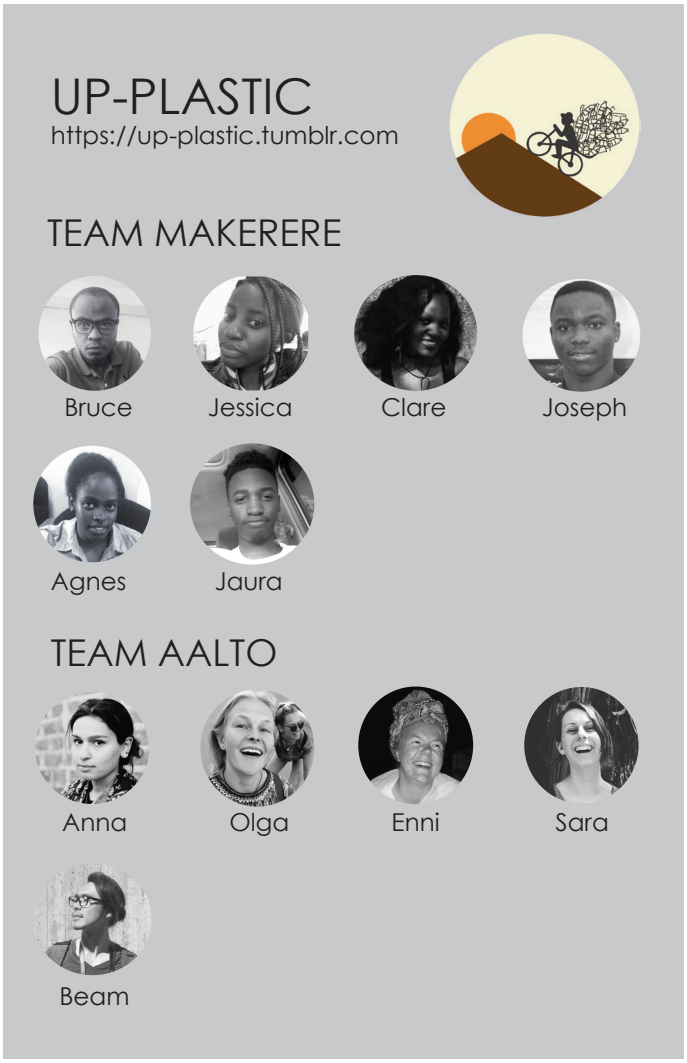


Figure 11: Project stakeholders and Team

WORKSHOPS AND PROJECT CLINICS

05

INTRODUCTIONS

Introducing Cradle to Cradle

Presentation from KCCA

Presenation from MAK Sustainability Program

Presentation from ECOART Uganda

This started the 1st day on 13th Feb 2018 when the Makerere team officially met the Aalto team for introductions and project discussion in presence of the stakeholders that included Miss Pamela from the Makerere Sustainability Program, Dr James from KCCA and Ruganzi Bruno from ECO ART UGANDA as well as mentors from both Universities(MAK & Aalto).

The workshop session started on with discussions about the communities we live in and the importance of recycling with the Aalto team(Olga and Anna) having a small presentation as they introduced the "Cradle to cradle" book to Makerere team. They also provided insights on the idea of pioneering the birth of circular economy.

Connection with Stake holders

Figure 12: Presenation and collaboration with KCCA

KCCA

Bearing in mind the main project objective, the representative of our major stakeholder Dr.James from KCCA on the same introduction day gave a presentation that extracted the main beneficial factors amongst other KCCA plans. He unveiled to the team (both from MAK and Aalto) the current state of Kampala city and how the authority has been managing wastes in and around the city, the key players in activities they are planning to execute and how best the up-plastic project could take part in the planned activities. With his presentation, the team clearly understood the prospectus of the project and different stakeholders KCCA is working with in the waste management sector. The team also got to know the actual statistics of waste generations, the people responsible and the future undertakings of the authority on the same issue. From his presentation, we were able to learn the major KCCA expectations and drive conclusions

KCCA expectations

Tailor made solution fit for Kampala

• Understand local needs, asses the existing system to deliver a sustainable solution for waste disposal and treatment in Kampala
• Develop a communications plan and engage with stakeholders to build a community solution that is socially and environmentally acceptable
Raise long term financing secured to project
• Innovate solutions that are proven and bankable
• Optimize the value of carbon emissions reductions and support KCCA's drive to develop a climate resilient solutions

Design, build and operate a sanitary landfil

• Operate an efficient transfer station at the existing site
• Design a sorting and or treatment facility as appropriate
• At the Greenfield site, build a sanitary landfill with separate disposal cells and an active geomembrane that complies with health and environmental standards
• Collect, treat and monitor leachate and biogas to ensure public health and safety is maintained to the highest standards
• Maintain and operate the landfill to international Standard
Generate value in our waste
• Separate and recover valuable waste through mechanical and or manual sorting
• Work with KCCA to identify appropriate channels for energy recovery from waste and sale of recyclables
• Build a professional organization with waste pickers to maximize recycling and employment
• Establish a structured formal network with full support from KCCA
• Asses the informal market for recycling and design a fully adapted economic model and develop commercial partnerships
• Provide equipment and infrastructure that fits the Ugandan perspective

With the increased cost of housing in Kampala city, according to the World Bank, the average Gross National Income in Uganda is estimated at $650 (Shs2.2m). On a monthly basis, that is an average income of Shs189,000. Going by that calculation, it means that cost of is not within the range of the average Ugandan. This has been attributed to daily fluctuating costs of construction materials on market

Basing on the concerns of the citizens and call ups by the government of Uganda through different authorities the collaborative project dubbed "Recycling Plastics and metal waste to produce low cost sustainable building units (LCB-Units) shall tackle most challenge as per expectations.

MAKERERE SUSTAINABILITY PROGRAM

Figure 13: Presenation and Collaboration with MAK sustainability program

The head of Makerere Sustainability program, Miss Pamera gave a presentation to the team on how and why the program was started and its objectives which among many includes creating awareness amongst students, create solutions to the developing waste challenges in campus.

The team after the presentation identified this program as the closest and quickest it can collaborate with since they are acting in the same line as the up-plastic project objective. This sustainability program is a Makerere University initiative that main focus on reducing waste and keeping the university green by conducting awareness campaigns with the students' body and outsourcing collaboration.

The up-plastic team identified that Coca-cola can as well be a mojor partner since its already in collaboration with the Makerere Sustainability program as presented by Pamela.

ECOART UGANDA

Figure 14: Presentation and Collaboration with ECOART Uganda

The founder of ECOART Uganda, Mr. Ruganzu Bruno presented his activities and works on how he has being using plastic to create awareness and innovations to the communities he has been to. His presentation was informative and it brought up ideas on how wide one can use plastic both in art and construction

FIMBOO

Figure 15: Up-plastic team at Fimboo, Entebbe

The team had visit to Fimboo in Entebbe, a recycling community that stands on creating a positive impact in the community through teaching people on recycling plastics. It had started as an NGO but later on acquiring funds went into developing precious plastic machines that they now use to recycle

They have built extrusion machine, shredder and injection machine and have been using them to make rulers, school bags, key holders and may more things. The team had a small workshop with Fimboo team where they introduced and explained the different machines they developed, how to use them and the different products they make from those machines.

It was from them that we learnt the different categories of plastics and how to identify them with stamps, oil and water. Since our team was planning to build the machines, we believe it was a great experience to see them and get a local opinion of how to build them, and how easy it is, for example, to get the parts in Uganda.

We also heard discussions on the challenges they face during the recycling process and how possibly we could avoid them as we proceed with the project, the different possibilities in recycling plastic and positively this can impact on the community.

LIFECYCLE WORKSHOP ON LCB-Unit

Lifecycle presentation

Lifecycle workshop on LCB-Unit

This was led by Olga and Enni(from Aalto team) with a small presentation about life cycle assessment of products and after that, we started the life cycle assessment in two groups. The idea of the workshop was to learn about the life cycle and understand especially the life cycle of the LCB unit created by team Makerere

Brainstorming and extensive studies were done on the LCB-Unit as we quantified and valued its sustainability. In this phase the values of the idea (LCB-U) in terms of resources, production, use, risks, recycling was clearly discussed and defined. . The discussion phase also dug deeply into the project's sustainability measures- how this can be extended to the community. The team (both Makerere and Alto) developed a consensus that the project should well create awareness as the 1st goal because it's where all other activities are developed.

During the same workshop, we identified the different ways with which the resources are to be gathered and also the final implications of the production process of LCB-Unit as well as the final product on the environment. We had incredible discussions and realized that sharing personal opinions so openly with another was very liberating and inspiring and created endless amounts of content which will be very valuable for moving on with the project. It was just on the same day that the university's Mechanical department was engaged towards development of machines. Later upon all discussions team came to a conclusion that project is worth more researching.

As a wrap of all the week days activities, each team member gave a self-evaluation and key roles played inform of aims and fears generated as some activities were being carried out.

Fimboo Entebbe

Figure 16: Tour to Fimboo, Entebbe

On identifying that there was Prescious plastic workspace in Uganda, the team did a research on it and landed on FIMBOO a plastic recycling com munty in Entebbe that was established under the collaboration between Ugandans and Australians and has been developing machines and making products from plastic waste for over a year

Their main focus is on making skiing poles, scholastic materials such as rulers, pens and also jackets from polythene bags. The team had an informative trip to Fimboo on where a lot of informative knowledge on plastic waste and machine building was shared. They introduced to the team the different prod ucts they make prom recycling plastic and polyethene, how machines were built and how they operate the. It is from the same trip that learned how to sep arate different types of plastic and how important it is in recycling it.
The discussions later went deep into identifying the major drawback of using PET type of plastic in recycling since they had developed experience in the same field fronting that it is one of the trickiest type of plastic to deal with. They provid ed information and helped towards the development of the compression ma chine by providing a PID Controller and thermocouple. As per now they are one of our major collaborators on the project because they helped us visualize ideas more with a lot of challenging questions they imposed on us.

Kitezi Landfill

Figure 17: Trip to Kitezi Landfill

Kitezi landfill was sourced out as a probable and primary source of plastic waste during and after the project protyping however , the team learned that even the communities around Makerere produce large amounts of waste. The Aalto team had a tour to Kitezi landfill which is waste collection center managed by Kampala Capital City Authority where all wastes from different regions of Kampala is damped. From the field trip the team had to the land fill, they learnt that in a few months, the landfill will be closed and substituted by one being set up in Namanve. They learnt that most waste at the landfill is from households and organic in nature with over 1500tonnes piled up each day. Economically the locals are employed to sort all this waste as some can take by recycling companies and in that way, they earn from it.

Roofings LTD

Figure 18: Trip to Roofings Ltd

ON XXXXXX The team had a field trip to Roofings ltd, one of the largest steel manufacturing company in Uganda and this was after the Makerere team identified it as one of the key stakeholder in the project as the source of mild scale. The main incense of this trip was to find out the official source of steel waste since it was one of the main ingredient and component of the project.

The roofings team and the project team introduced each other and had numerous interactions concerning the project expectations and Roofings as the one of the stakeholders. They took the team (both MAK and Aalto) around the factory as they explained how steel is manufactured and its waste products which was the main focus of the tour. Later on the steel waste (mild scale) was officially given to the team.

UCASDR

Figure 19: Trip to UCASDR

With Tusiime Mathias, the CEO of Uganda Community Art Skills Development and Recycling (UCASDR) whose motives and objectives are into sensitizing communities to attach value onto waste by using it in Art works and other related innovations, the up-plastic project has been thriving on the knowledge that was obtained from him and his company. .

The Makerere team had a field trip to his workspace and amazing works were exhibited .Ideas were generated and shared amongst the team because his works triggered more thoughts on how vast plastic waste can be used as an element of art.

In the up-plastic project, UCASDAR is one of major collaborators that have provided an upper hand in the development of the project straight from the beginning to where it is now. It was also possible to have a successful community outreach and awareness with him

Compression Machine Development

Compression Machine Components look up

Machine building MAK's Mechanical workshop

Compression Machine

One of team's objective was to set up recycling center well equipt machines and other tools to simply the process of plastic recycling. The machines included a compressing machine that was built at the College of Engineering, Design Art and Technology, Makerere University (CEDAT) in the mechanical workshop for a period of 4 days by the machine development team.

Its started on One Monday 19th Feb, the machine team started its week with machine parts hunting downtown Kampala city with the help of Mr. Robert, the Electrical Engineer at Makerere University. The team wondered and meandered around different second-hand electrical shops in pursuit for a suitable items and parts to use. These parts included scrap oven, carjerk and electronic components that included heating coil, toggle switch and a contactor. It also involved outsourcing electrical parts such as a PID Controller and a thermostat.

The whole system was designed using e the precious plastic machine development kit that describes and states specifications of the material members. The frame was welded locally in the Universities mechanical lab with the help of Mr. Philip, the Mechanical Engineer with square hollow section and stainless steel plates. The other essential part of machine building came up on electrical systems assembly.

The assembling process took two days, since with constant hands on work by all team members. while being overseen and instructed by experts from both the Mechanical and Electrical Engineering department. Our team cut all the steel bars. With less skills in welding, this process was done with the help of Babu Talik . This was also the case with electrical wirings; Mr. Edward, an employee of Mr. Robert, was commissioned to do all the wirings. Our team was assisting Mr. Edward and worked with other tasks that did not require electrical proficiencies. The control box was designed by us and we helped in many re-assembling processed of the oven that we used for the Compression Machine. The Machine was ready for exhibition on the up-plastic event and now its stationed at the up-plastic workspace at the school of Industrial Art, Makerere University

UP-PLASTIC EVENT

Shredding plastic at Up-plastic event
Photo by :Mark Rujumba

Up-Plastic event was done to create awareness on plastics and recycling at in and around Makerere University. The event took place at CEDAT under the Makerere Sustainability program that were also key players of the event where different plastics, their properties , the different products you can make from recycling plastics as form of creating market for plastic waste were showcased. The compressing machine was tasted and already made LCB-Units were exhibited. The event was also attended by artists who presented their pieces and explained diffenet ways with which you can use plastic to promote and do art and design.

The Fimboo team as well supported the event by showcasing their products that they manufacture from recycling different types of plastics. They also developed collaborations and relationships between the students and other people who attended the event.

The event was so interesting and interactive where people who attended asked a lot of informative questions and shared useful information with team. Awareness, collaboration and partnerships were established the involved stakeholders. Later after the event, all the equipment and the machine were taken to the up-plastic workspace at the School of Industrial Art, Makerere University

UP-Plastic Workspace
at BIFA

“The event leened more on creating awareness on recycling of plastics and launching the compressor machine

The project would hardly be a success if we didn't have resources inform of human resources, funds, research, communication and other physical facilities that we used as we executed our activities majorly towards the up-plastic event. The sub teams that were created were responsible for the identifying and controlling these resources

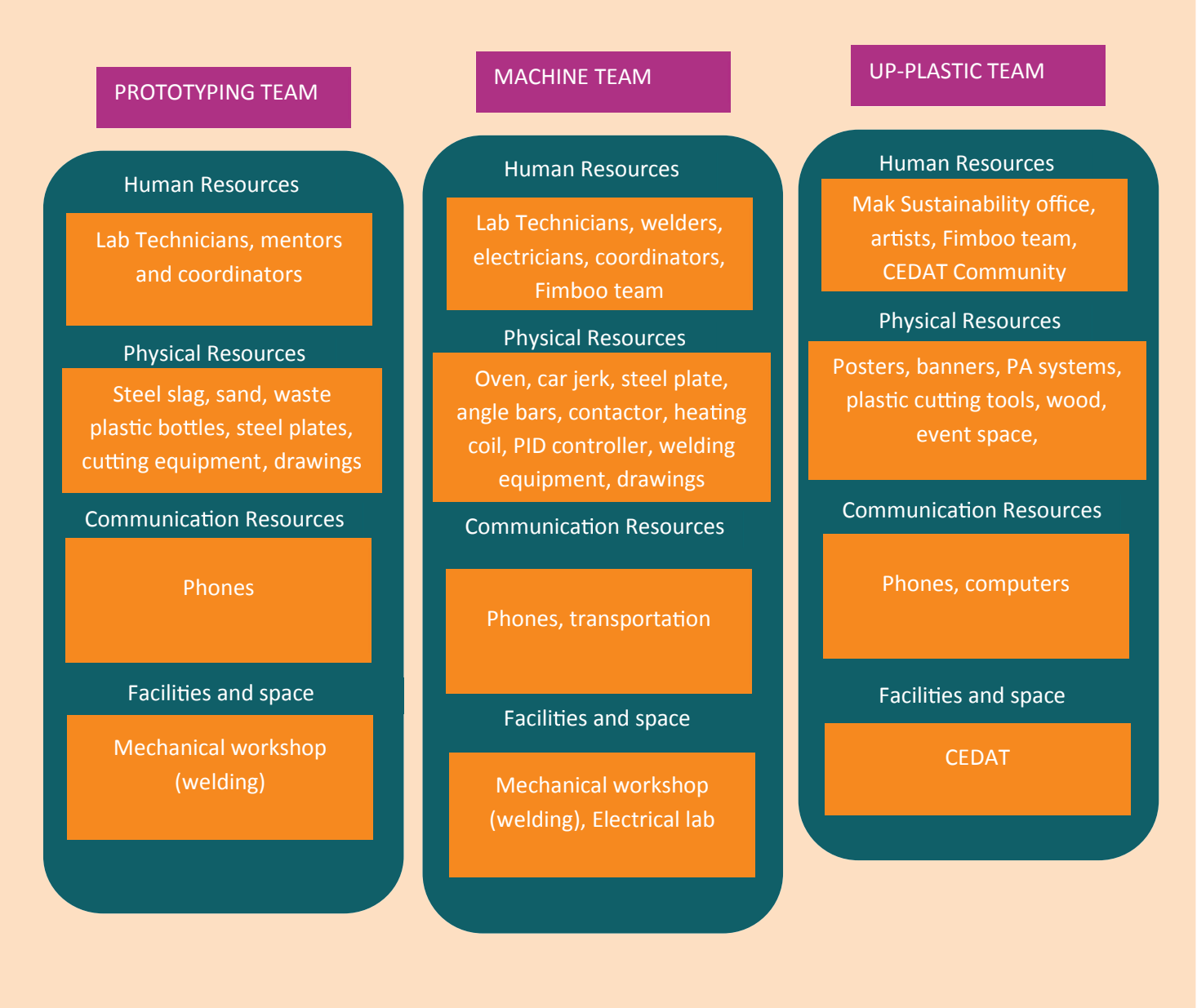


Figure 20: Resources for the Up-plastic event

06

PRODUCT CONTEXT

LCB-UNITS

Product Context

Figure 21: LCB-Units

With Uganda's Construction industry contributing over 12% to the Growth Domestic Product (GDP) of the country and rapid increase in population that doubles by almost 50% in a decade specifically in urban centers like Kampala has in turn escalated the costs of living. This has been mainly due to increased cost of building materials. As form of innovation, this project is aimed at how best one can generate value from waste to curb challenges of high cost of construc tion materials and maintaining a clean city. The KCCA's project Teaser that was published in October 2017 through private companyies puts the project (LCB-Units) at a front as a potential opportunity according to their requirements

One of the Up-plastic project products besides building the machine is the Low Cost Sustainable Building Units (LCB UNITs'), construction materials that are made from recycling plastic and steel waste. Makerere team developed this idea towards solving the challenges of waste management in Kampala and other surrounding communities. It was identified that one of the biggest problems faced by our communities in Kampala is the poor disposal of wastes (solid wastes) and poverty. LCB-Units can be in form pavers, bricks, blocks and other interior design components.

They are produced from plastic wastes (PET), steel wastes (mild scale) and sand. To prove the product for community use, several tests were done on the proto type as discussed in this document and it was found to be a strong product for construction.

PRODUCTION PROCESS

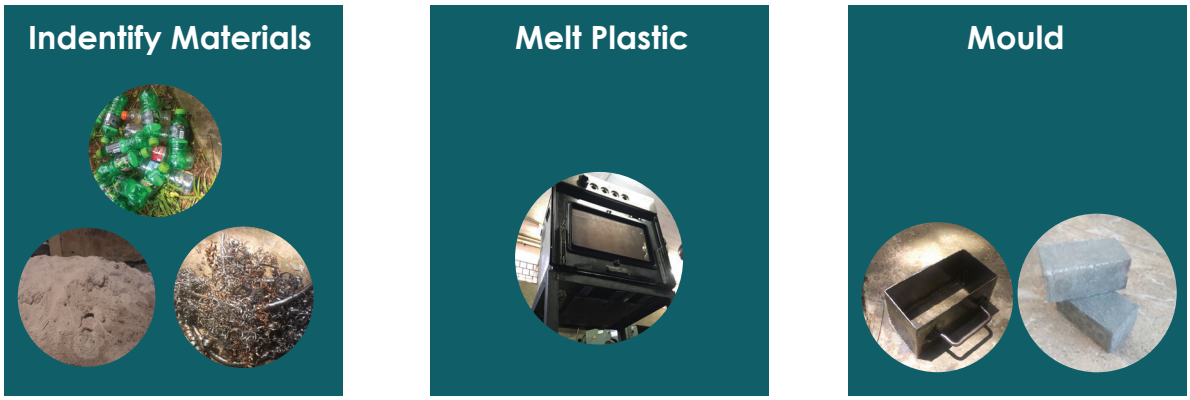


Figure 22: equirements for production of LCB-Units

PET type of plastic was identified as the major waste material and gathering it is the 1st phase of the of production. They are inform of water and soda bottles and can be found everywhere in any community in Kampala, in landfills and waste collection centers. The prototyping waste plastic bottles were obtained around Makerere University dustbins

Shredding them into small pieces that can easily be melted is the second step. This was done by using scissors since the shredding machine has not been devel oped yet. It should be not that plastic bottle type is different from the bottle top because they possess different chemical properties so they should be removed before melting to ensure uniformity.

The shredded plastic are put in a pan/ or an oven upon which they are subjected to a temperature of 2600 which is the melting point of PET type plastic. Locally, this can be done by using pan and melting them with a heat source that can be charcoal or firewood. However, that can be achieved with a compressing machine. Putting the small pan into the made stove and melting the plastics from the pan.

Preferably, when the plastic has melted and it is in its molten state, measured volumes of sand and mild-scale are added and stirred vigorously to obtain a uniform semi-solid mixture/ workable mix. It is then poured into the mold of desired shape and left to coolLaboratory tests have been carried out to identify the quantities and mix ratios before the actual production can be done. This was done in the Makerere University structures lab.

LABORATORY TESTS ON LCB-Units

One of our objectives was to subject LCB-Units to laboratory tests to guarantee their fitness of purpose to the community. With these tests we were able to conclude their suitability through measuring its strength, water absorption and heat absorption.

Heat Test

Figure 23: LCB-Units ready for testing

Figure 24: LCB-Units in Compression machine

2 LCB Units in content ratios of two units different mix ratios of 60 plastic bottles and 5 volumes of sand (each of 250,000mm3) and 5 volumes of steel waste(each of 250,000mm3.) [LCB-U 1] And that of 50 bottles, 4 volumes of sand (each of 250,000mm3) and 5 volumes of Steel waste [LCB-U 2]

The 2 blocks were of dimension 50X50X100mm were put in a oven and subjected to the melting temperature of the major binding constituent, plastic (2600c).
They were observed until that point the bricks started to melt.

Observations

For LCB-U1, it started showing melting signs after 20 minutes and later melted after 30 minutes.
LCB-U 2: It started melting after 45 minutes.
Conclusion:
The sample with lower mixed ration has a higher heat resistance than that with higher mix ratios

Recommendations:

Depending on the melting points of the 2 samples, the bricks shouldn't be used in places with a lot of heat above the room temperature for example kitchens, furnaces and factories that deal with heating in the manufacturing process.
The brick should be used mainly in outdoors such as footpaths, packing lots and other places that aren't subjected to extreme heat

Water Absorption Test

Figure 25: Getting weight of dry LCB-Unit

Figure 26: Getting wet weight of LCB-Unit

This describes the water test that was carried out on the 2 LCB Units in content ratios of two units different mix ratios of 60 plastic bottles and 5 volumes of sand (each of 250,000mm3)and 5 volumes of steel waste(each of 250,000mm3.) [LCB-U 1] And that of 50 bottles, 4 volumes of sand (each of 250,000mm3) and 5 volumes of Steel waste [LCB-U 2]
The 2 blocks were of dimension 50X50X100mm
The dry mass of each sample was obtained using a digital measuring scale.
Then they were dipped /soaked in water for 24 hours
After the 24 hours, the samples were removed from water and left to dry off dripping and surface water.

Their masses were then re-measured using the same scale.
From there, the amount of water in grams absorbed by the each units were obtained and the percentage water absorption got as well.

Observations and Tabulations

Sample	Dry Mass(g)	Wet Mass(g)	Water retained(g)	%ge water absorption
LCB-U 1	622.4	624.7	2.3	0.37
LCB-U 2	547.3	549.8	2.5	0.46

Table 2: Results from the water absorption test

The amount rate of water was obtained by using the formula;

(water retained(g))/(Dry Mass(g)) x 100%

Recommendations

From the experiments, it can be concluded that the LCB-Units are suitable and work perfectly in wet and iced conditions. They can be used in places with a lot of water because its absorption rate is extremely low.

Compressive Strength Test

Figure 27: Sieve analysis on Sand

Before the actual production was done, the team 1st gave a try where 15 bottles of waste were melted with compression machine and they realized the whole thing wouldn't work for just 15 bottles.

They however increased the number to 25 bottles for each sample that was tested. Correctively stating, each LCB unit contained 25 PET bottles.

The sand was first subjected to sieve analysis test to reach the rightful gradation level before it was mixed with steel waste.

Percentages of sand and steel measured in volumes were determined and that's is at 0%, 25%, 50%, 75% and 100% . And the way the mixing was done was that, for each sample, if there was 0% steel, there in was 100% of sand, and if there was 25% of steel, there in was 75% of sand in that order and for each sample. For each percentage set, there were 3 LCB- units as samples. So that amounted to total sample of 15 LCB-units to be tasted.

Steel (%)	**0**	**25**	**50**	**75**	**100**
Sand (%)	100	75	50	25	0

Table 3: Experiment percentage component inputs

After the units were made, they were subjected to tastes after 7 days where before were kept in a cool dry place, and before each unit was tested, it was 1st weighed using weighing scale to get its mass in grams and its surface area determined.

The surface area of the unit was determinant on the dimensions of the mould which was 50x100mm.

The load in KN required to crash each sample was obtained using the "Universal Testing Machine" and this works in a such way that an LCB-unit each at a time is put in the machine and it is subject to a load upon the surface area of the unit until it crashes. At that point where the unit crashes, the corresponding load is obtained from the machine's measuring scale.

The compressive strength in N/mm2 for each unit and the average compressive strength for each set of percentages was obtained by using the load subjected and the surface area of the lcb unit

From there, the lab team went ahead and analyzed the data and came to a conclusion that the LCB-Unit is strong at a point where there is 50% sand and 50% steel waste.

This experiment stand at 7days strength achievement however another completion test to confirm the test has to be done after 28 days as its set by British standards.

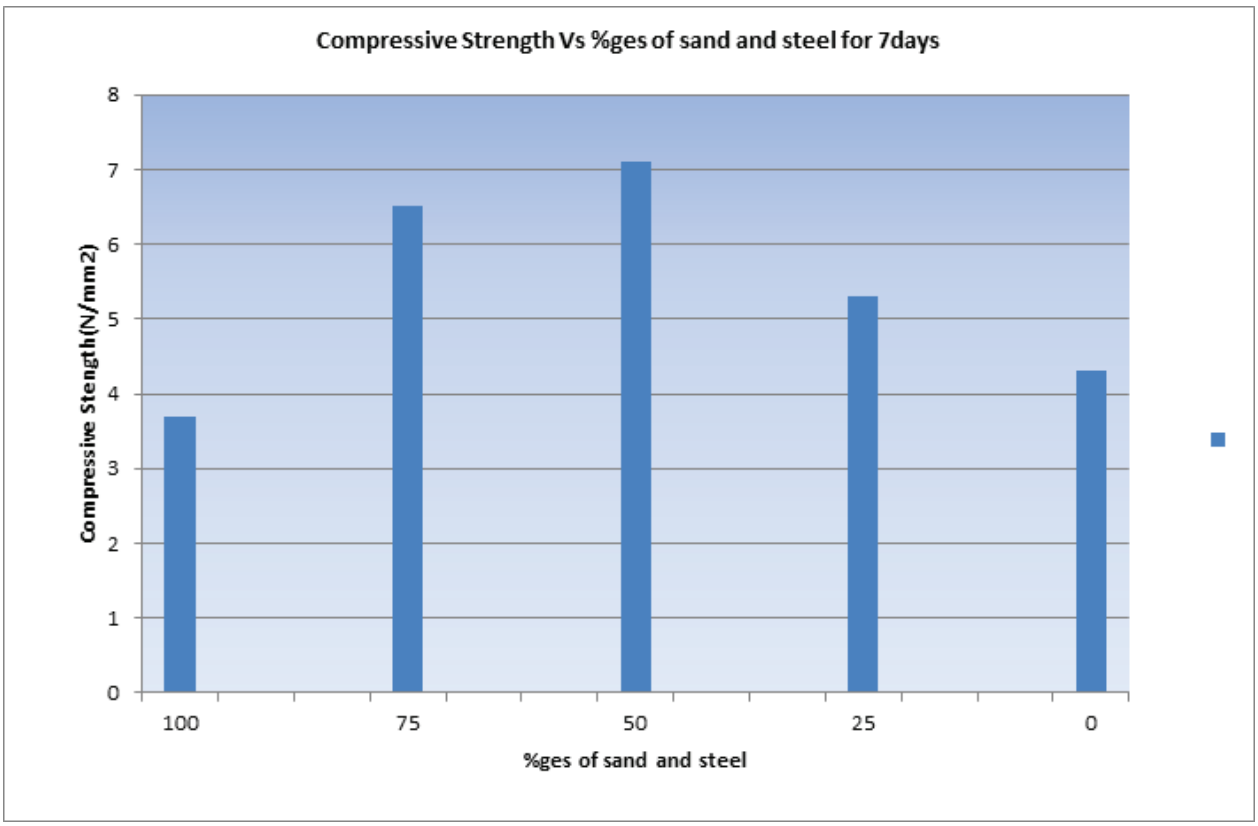


Figure 28: Compressive strength Vs percentages addition of sand at stell in LCB-Unit (Compressive strength test)

COMMUNITY OUTREACH

07

Senstizing people of Kalerwe on plastic waste and managent

Educating people on how to make LCB-Units

Moving with main project objective of sensitizing and creating awareness on how plastic waste can be extremely important to the economic and social life of the people in the community. The Makerere team and their mentors had an outreach in Kalerwa a slum in Kampala city. Together with Mr. Tusiime Mathius, the CEO of UCASDR the program was a success because as our partner, helped us in the organizing the event.

Kalerwe being a slum, is faced by challenges like poor hygiene , poor waste management (poor management of solid wastes like poor disposal of plastic bottles which end up blocking drainage channels , poor disposal of liquid waste and feacal sludge where some people lack toilets , VIPs and poor disposal of hazardous waste inform of clinical waste like used syringes. The community is also faced with poor structures having leaking roofs, congestion of people in the few structures that exist.

Since our project was providing a solution of recycling the plastic wastes that have become unmanageable everywhere in Kampala , in drainage chan nels causing further problems of poor drainage hence affecting the health of the public for example outbreak of waterborne diseases, water based diseases and many others. The idea was appreciated and welcomed by the people of Kalerwe.

The event was held at Godwin's Primary School where we met different people and taught them about plastic waste management, how they can recycle it and boost their economic living.

The event started with invitation of people to the school as the team moved around the community picking all plastic waste damped around drainage channels and around their houses. This was done door to door and some of them joined us in collecting the plastic bottles around that area. t they will make more LCB UNITS and make some improvements where need arises.

After a while, the locals gathered at the school and we educated them about our project right from the definition of the word "waste" which is anything a person considers useless after some time of using it and it is not meant to be disposed off in rivers and streams, "Solid waste management "which involves the process of the generation, collection, storage, transportation, disposal and safe end use or reuse of the waste.

The locals also learnt the different types of plastics for example PET, HDPE, PP, LPDE, and PVC with PET being the main focus for this project. They also learnt the different uses of plastics or the ways through which plastics can be recycled forexample making of umbrellas, raincoats, manufacturing pavers, bricks and in the construction industry.

The locals of Kalerwe also learnt the manufacturing process of LCB-units through the demonstrations we carried out. The process was an interactive one where citizens of Kalerwe asked questions like "Where can LCB Units be used?", "how strong is the Paver?" , " How can we earn from it?" ," How can the government be involved ?" .We answered question by question and later Dr. Venny gave a word of appreciation to the Kalerwe people for giving us their time and for allowing us do something for their community. In the end, they gave a word of appreciation to the project team members for the great work of teaching them skills of solving their problems. . They promised us that they will make more LCB UNITS and make some improvements where need arises.

RESPONSES FROM THE OUTREACH

From community outreach event the up-plastic Makerere University team held in Kalerwe slum, Kampala as a community outreach and awareness on solid waste management, these were some of the questions that were raised by the locals towards the product(LCB-Unit) and the mode of production of the unit. However, some of the questions were answered immediately on the same event while others are a food for thought and implementing as the project progresses. These questions included;

How can we make sure we collect the plastics in a very organized manner because it is a major problem?

Where can the LCB-Unit be used?

Once the LCB-Unit is made, can't be affected by the heat?

How strong is the LCB-Unit?

How long does it take to manufacture an LCB-Unit?

What are other products one can make from plastics besides LCB-Units

Can the LCB-Unit be made without the part of steel waste?, because it's a bit hard to obtain it?

Can't the LCB-Unit be affected by weather such as heavy rains?

How can we earn from the LCB-Unit?

Is there market for the LCB-Unit so that once we start making them, we can get huge out of it?

What is the minimum number of people that are supposed to be present during the manufacture?

How can we protect ourselves from the fumes that might be generated during the production process?

How can we bring in the Government towards development of the project?

PROPOSAL

The Makerere team has done an intensive research towards the development of LCB-Units and has carried out community outreach to fetch ideas from the people who are faced with the challenges of waste. From this the team was able to identify and a get a clear picture of what people in the community actually need. It's by that we are now looking forward to developing new machines that suit well in local communities in Uganda and can be developed by everyone for any individual supplementation. With them they will be able to recycle plastics by producing LCB-units and other products one can get from recycling any form of plastic waste

08

CONCLUSION

CONCLUSION

Solid waste management has been identified as one of the up most growing hazards in Kampala leading to poor sanitation and development of health related diseases.
Recycling these solid wastes to attach value to them again according to the study would automatically manifest this problem through reducing their disposal anyhow. Recycling doesnot only need to be on a large scale and neither does it need to be only industrial based. Established of small scale workspaces in different communities as talked about in this report through which locals can participate and operate from those Recycling workspaces for economic benefits can really foster Recycling.
Plastics as the mojor component of solid waste still dominates around town with PET type being the commonest. PET type of plastic according to this research is the trickiest and most hardest type of plastic with the highest melting point among other type, this makes it a bit more complex to recycle a reason why the still dominate in our communities.

Clear sensitisation and creating awareness to people in the about the dangers of poor waste management and ways through which they can attach value to that waste for their economic benefit and also create sustainable solutions.
Involved stakeholders such as KCCA will need to play a big role besides what they are doing today and move down to low communities to create awareness, set up small workspaces in those communities through which the locals can participate. With this kind of setUp, the issue of solid waste can be run reduced unbelievably.
Production of LCB-Units as stated in this report would be one way of Recycling plastics mainly PET because the results have been subjected to laboratory tests and perfectly suite their use and recommended after those tests in this report.
However, according to research, there quite a lot you can do through Recycling and up cycling plastics, they include, design , architecture, aesthetics and construction. Need to teach communities to adopt these major uses can transform the way we leave.

PERSONAL REFLECTION AND KEY LEARNINGS

Clare

Personally the most important thing i learnt from this project is teamwork. A highly effect and effective team is made of people each with a unique contribution which in the overall run result into new ideas and possibilities one would not assertain onj their own.
I can personally say we ought to have been lucky to all be placed together as the team was perfect as it could be.
Then subdivisions of the team although to same extent made the contribution of each member much more possible and i can say in the prototyping team, making the mould was one of the most enjoyable momentsfor me on the project. It also taught me to be resilent, persistent and more than anything put all ideas at the table and eveluate which one is best.

Bruce

Working in multi-disciplinary and multi-cultural setting was something I had never experienced in my school life. It seemed a bit tough at the beginning when we had a students' challenge and pitching however, after the project started getting more and more defined as we proceeded. It was an amazing time being with the Aalto University team during their field trip to Makerere University because they introduced new project development and learning approach based on Human Centered Design something I had never encountered with. I got to learn new project approaches and no one knew that I could develop compressor machine on a construction management background that seems parallel to mechanical and electrical engineering. This project also taught me the value of sustainability, community involvement and collaborations in any innovation and that any project can change direction during its execution. It was an inspiring and learning pursuit.

Agnes

At first, it was a little bit scarely since it was a competition which we strived to win. I was really so much determined and excited about this project When the Alto University team joined, It was so great as we learnt from each other, shared our views, ideas and skills. I learnt more I have learnt to work with different people, have acquired more confidence and the project has been a success since it has solved problems of some towns like Kalerwe

Jessica

Continuous learning was the key aspect for me personally. Every new day was a new lesson for me throughout the whole project and I am deeply grateful for that. I got a chance to work to my full potential like never before. It was a whole new experience working in a multi-disciplinary as well as a multi-cultural sort of organization, with the excellent members of the Aalto team. it is quite a surprise that we got to accomplish all we did in the short allocated period of time. Team work was a major element during the whole experience as it got us to work faster, efficient and greatly effective.
In a nutshell, the project gave me a whole new perspective in execution of work.

Joseph

To be part of a team working to solve one of the environmental challenges in the world, was a great honor. And the fact that we achieved a lot together, pushing the LCB-Unit from just an idea to an actual product, is something I am proud of. It's amazing how much can be accomplished when people from different academic backgrounds come together to execute a project. That's one of the best things I learned from the whole PBL Project. Multi-disciplinary teamwork is essential, and the possibilities are limitless! I have learnt a lot from this project and I am grateful to the team that made it possible.

Jaura

Continuous learning was the key aspect for me personally. Every new day was a new lesson for me throughout the whole project and I am deeply grateful for that. I got a chance to work to my full potential like never before. It was a whole new experience working in a multi-disciplinary as well as a multi-cultural sort of organization, with the excellent members of the Aalto team. it is quite a surprise that we got to accomplish all we did in the short allocated period of time. Team work was a major element during the whole experience as it got us to work faster, efficient and greatly effective.

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APPENDIX

09

Precious Plastic
Compression Machine

by up-plastic

https://up-plastic.tumblr.com
https://www.instagram.com/up_plastic

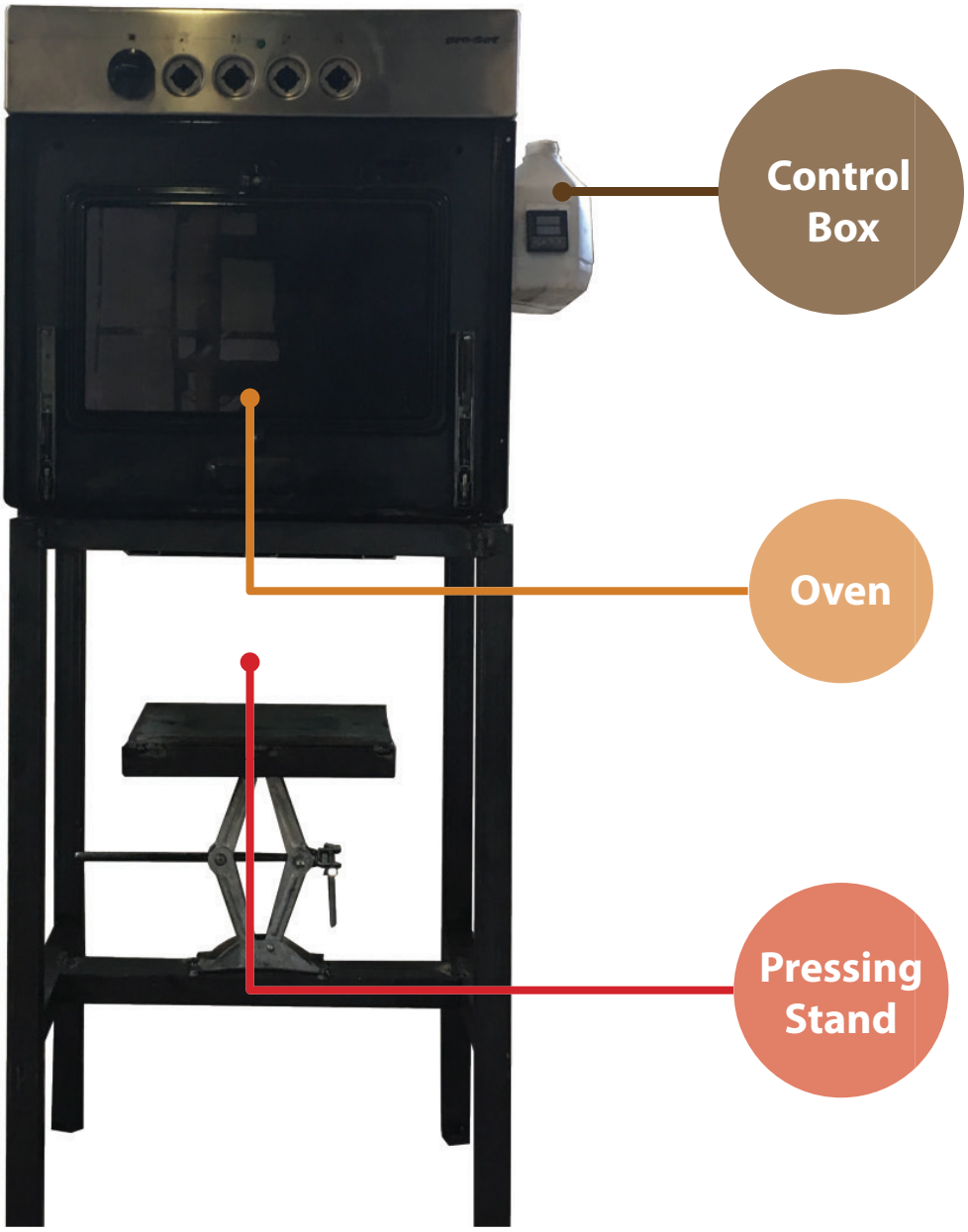


Figure A1: Compression Machine Manual

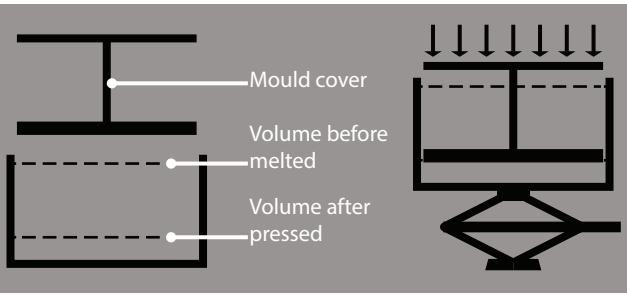
Manual

1) Decide on the product

- Deciding on the product is the first step of the process.
- The Precious Plastic website provides sample products that are compatible with this machine: https://preciousplastic.com/en/creations.html

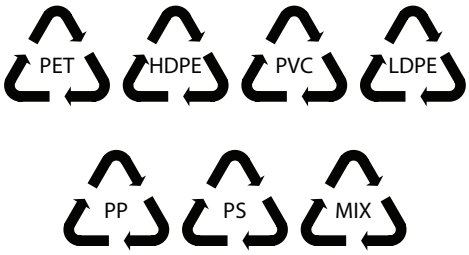
2) Make the mould

- The mould can be made of various material; e.g. steel, cement or clay.
- The mould cover is used for compressing the product, making it solid and strong.
- The volumes of the cover, pre-melted plastic and the product have to be calculated, in order for the pressing stand to effectively compress the product.



3) Determine plastic type

- Plastic is not just plastic, there are several types with very different attributes.
- The melting temperature is different in each plastic type.
- There are several methods to check the plastic type from the plastic waste.
- The Precious Plastic website provides methods to identify plastic types and their attributes: https://preciousplastic.com/en/videos/plastics.html

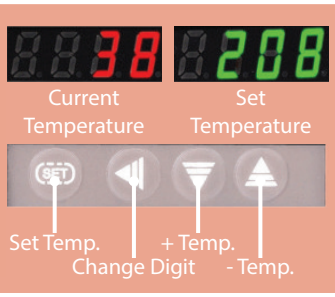


4) Prepare for melting

- The specific plastic, which you want to use, has to be prepared and cut into flakes before melting.
- The Shredder machine by Precious Plastic is an effective tool to prepare the plastic. If the Shredder machine is not available, simply hand-cut the plastic into small pieces.
- After shredding, put the plastic into the mould and put the whole mould inside the oven.

5) Set the temperature

- Before melting, the temperature of the plastic type you have chosen has to be determined.
- The temperature of the oven can be set on the control panel in the control box.
- Start setting the temperature with the *Set-Temperature* button, press *Set* again to start.
- The oven will heat up automatically after the temperature has been set.



6) Wait (and be patient)

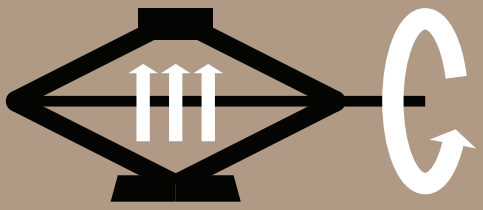
- After the oven has been started, it can take 20 minute or more, for the plastic to be fully melted, depending on the product, mould shape and plastic type.
- It is safe to check inside the oven, if the plastic has melted yet, or not.

7) Take the mould out

- To take the mould out, proper protection is required as the mould can get as hot as the temperature inside the oven, especially for steel moulds.
- Put the mould on the pressing stand immediately to compress the product. If the plastic gets cold before compression, the quality of the product will be lower.

8) Press the product

- Try to align the carjack and centralize the mould to the pressing stand.
- Spin the carjack to compress the product, stop only when it is not possible to spin anymore.



9) Cool down the mould

- Wait for the mould to cool down.
- Splashing cold water onto the mould can quicken the cooling down process.

10) Take the product out

- After the mould has completely cooled down, the product can be taken out of the mould. Great job!

PBL EAST AFRICA

PROBLEM-BASED LEARNING in East Africa brings together multidisciplinary student teams from four universities to develop sus tainable solutions to community challenges in 2017–2020.

aaltoglobalimpact.org/pbl-east-africa

Up-plastic Kampala

The Up-plastic Kampala project (Upcycling plastic waste in Kampala) is a joint project of two student teams from Makerere University and Aalto University, who collaborate to work on a real challenge from which the students can learn from and th rough another, while also aiming to support larger scale impact.

The project aim is to contribute to underlining environmental and social issues in Uganda, part of which are solid waste problems and youth unemployment.

The goals of the project is to support the Makerere community to upcycle plastic waste, create awareness in waste management by launching a workspace as a community hub for plastic-reuse innova tions, as well as to prototype low cost building units from recycled plastic and steel wastes.

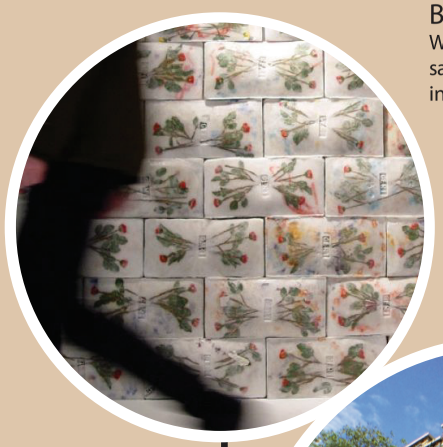
Makerere University

Aalto University

up_plastic

Figure A2: PBL East Africa and Up-plastic Poster

OTHER PRODUCTS CREATED FROM PLASTIC WASTE



RECY-BLOCK
Partition blocks made out of plastic bags.

BOTTLE MASONRY WALL
Whole plastic bottles filled with sand and layed down like brick into mortar.

PLASTIC BOTTLE VILLAGE
A new initiative in finding solutions to the invasion of PET plastic bottles in Colon Island, Panama.

BYBLOCK
ByBlocks are created with the ByFusion Blocker, a recycling machine which super-heats and compresses any category of unsorted and unwashed plastic trash.

Recycled Plastic Sturdy Bench

Recycled Plastic Bags into Purses

Green Tea Chandelier

Figure A3: Reference projects poster

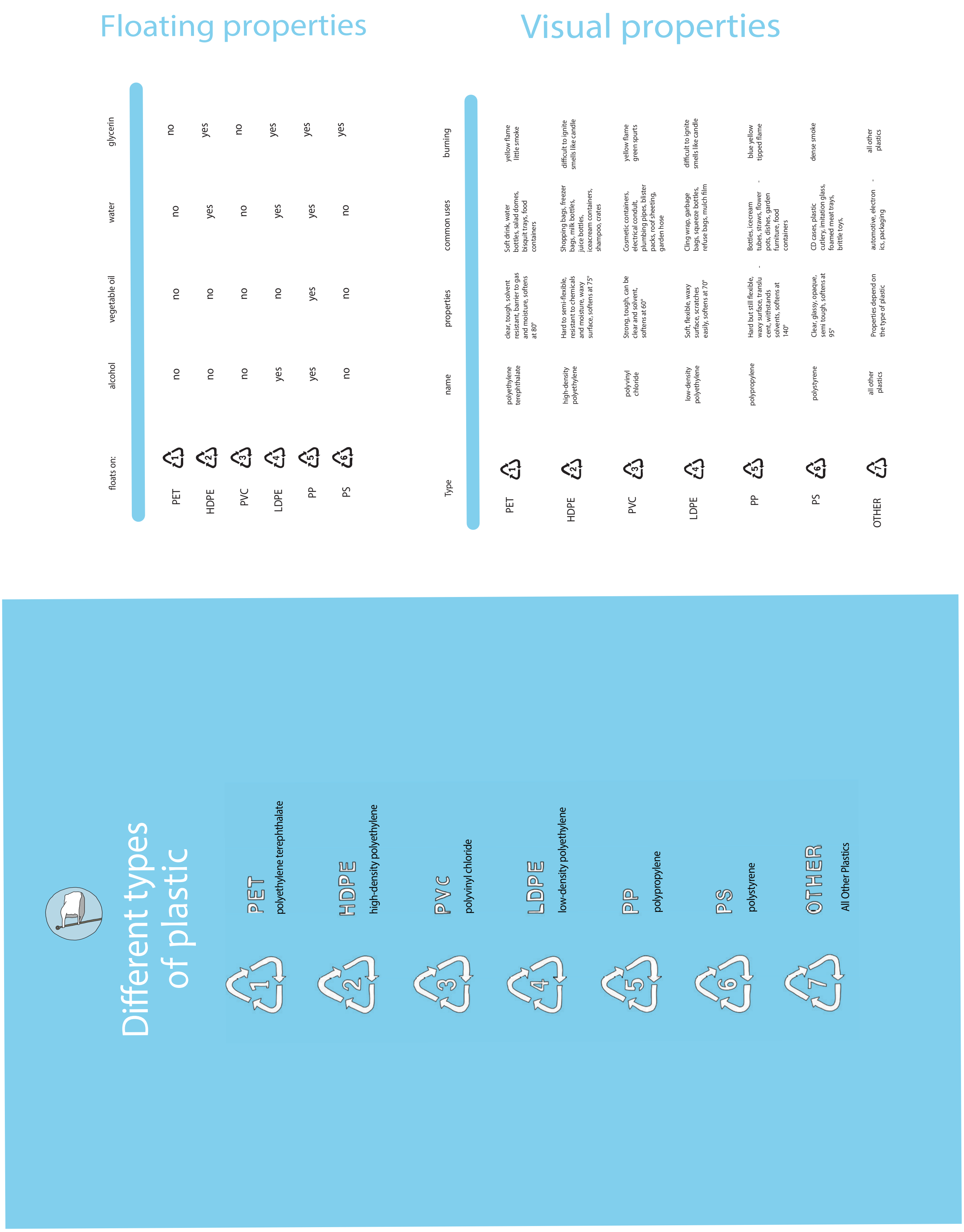


Figure A4: Plastic properties poster (From Precious Plastic)

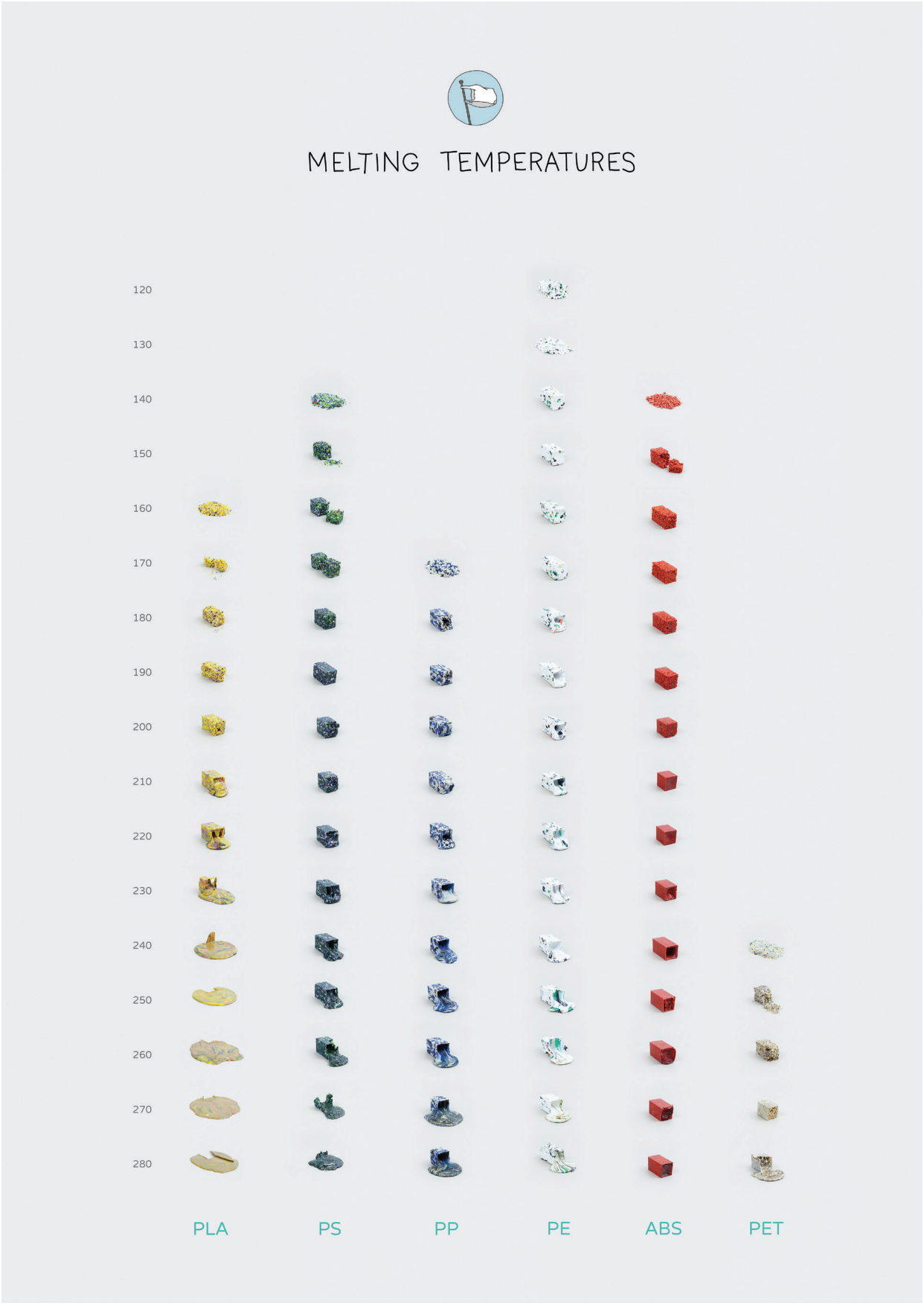
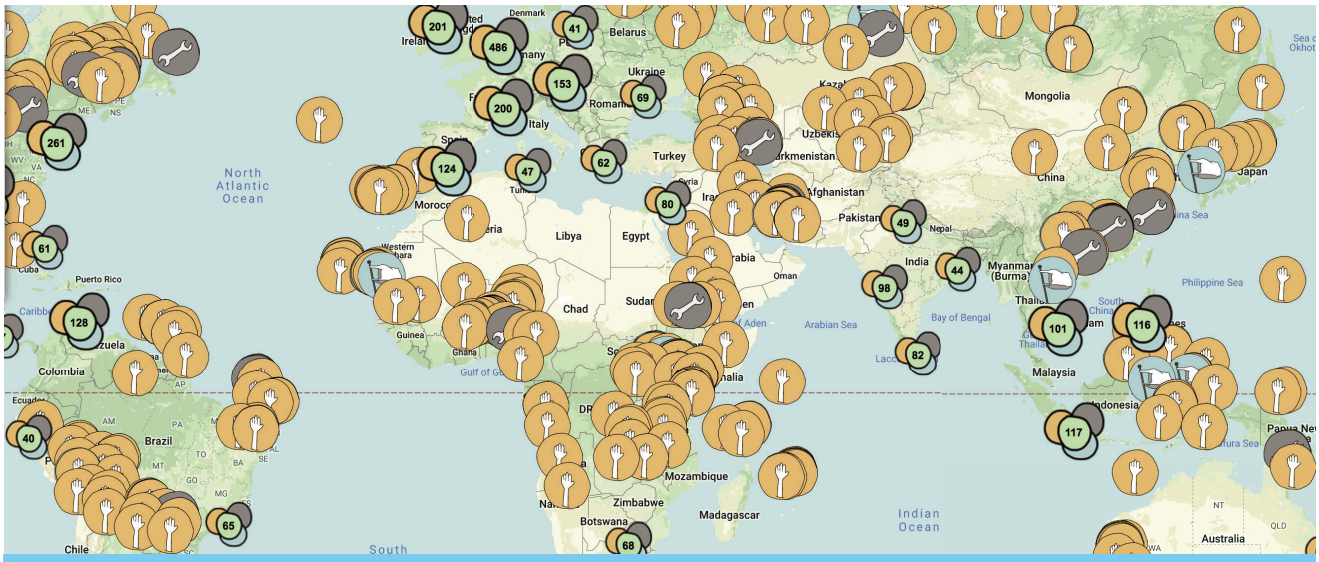


Figure A5: Plastic Melting temperatures poster (from precious plastic)



PRECIOUS PLASTIC

Started by Dutch man Dave Hakkens.

Since 2013.

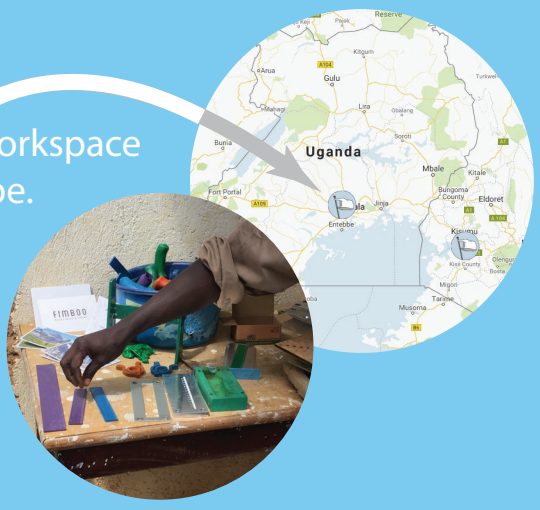
Precious Plastic community all over the world!

More than 140workspaces.

A global community of hundreds of people wor king towards a solution to plastic pollution. Knowledge, tools and techniques are shared online, for free.

preciousplastic.com

FimboWorkspace in Entebbe.



What to make out of recycled plastic?

Bowls

Bottle caps, Tiles

Flower pots

Figure A6: About Precious Plastic poster (from precious plastic)

LCB UNITS

Low Cost Sustainable Building Units

LCB Units are modern structural building components produced from plastics, steel slag and sand.

For these LCB Units, we concentrated on one specific type of plastic known as PET, under which almost all water and soft drink bottles fall.

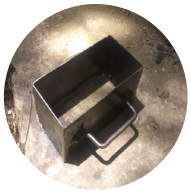
The plastics are melted in a pan, then they are mixed with the sand and steel chippings.
This is poured into the mould.
Below is an image of the finished LCB Unit.

With time, we are planning on producing a number of other building units for example tiles, pavers, blocks, etc.

RAW MATERIALS

Sand

Steel chippings



Mould

Plastic

However,
this project is continuous because there are a lot of pending tests still to be carried out.
Plus, a lot of research is being carried out on plastic recycling for the production of a more effective prototype.

Figure A7: LCB-Unit poster(Designed by Jaura)

COMMUNICATION

The most essential tool in project execution where there are multi-disciplinary and multi-cultural teams is communication. Both the Aalto team and Makerere team used different channels of communication that included setting up the blog where all activities done were posted, Google drive account where all documents and photos were shared between the teams and mentors, Instagram and whatsapp.
To ensure radiant flow of information between the student teams and the mentors, each team selected a contact person through which any notifications and information was linked to the coordinators and mentors.

Internally:

This is the way information is shared between our Makerere team, mentors and coordinators from both team and the Aalto team. The team uses online platforms which are; **Google drive** where we created 3 folders, 1 for us the Makerere Team, another for the mentors and another for both teams (MAK and Aalto). The drive is mainly used to share all kinds of documents, photos and any other useful information between both teams as mentors. The team also uses whatsapp share information that is casual and for quick updates and notifications between student teams only. We also found Skype convenient so we use it to make video calls between both teams as we share progress all activities when we are all in our respective countries. Emails are also used to share information and documents to mentors from both teams.

Within us, the Makerere team, we designated Bruce as the main contact person between the Mentors and Coordinators and also with the Aalto team. This was done to avoid over lapping and exchange of inconclusive information. This also enabled to efficiently coordinate with our mentors.

Externally

To ensure that project information and progress well reaches the outside world such as to stakeholders, public communities, possible partners, NGO and to both University communities. The team created a formal **blog with Tumblr** where all project activities and content is uploaded and this has been used since the start of the project. The team also created an **Instagram** where ongoing activities with photos are uploaded informally. YouTube account is also taken up to share videos of the activities and personal experiences of the project.

As way of reaching stakeholders and possible partners, final reports will be issued and distributed to different offices and online platforms so that whoever is interested in the project can access it wherever he/she might be. As a wrap up, media releases will also be another channel to inform and involve the public.

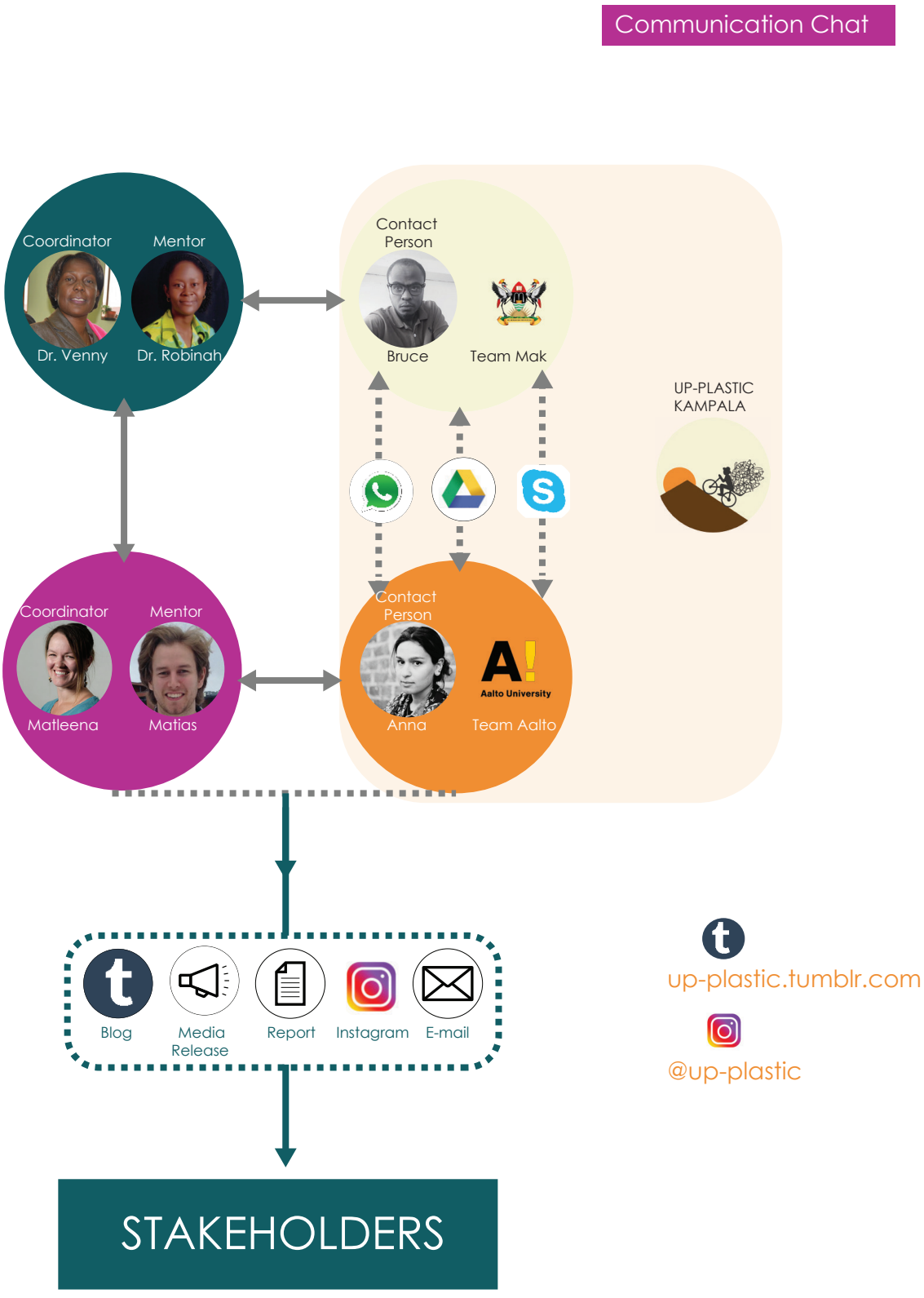


Figure A8: Communication Chat

CHALLENGES

The scope of the project broadened suddenly as the team worked together notably due to acquisition of new ideas about recycling and plastics. The project could hardly be limited to making low cost sustainable building units only and this lightly caused us to peruse undefined goals contrary to those in the proposal.

Having 2 weeks of hands on work with full team both from Makerere University and Aalto University limited our possibility in terms of time. Much progress was registered however the time was limited to achieve everything as planned on paper. This was further noted in the overall project duration, time allocation was insufficient for the project to reach its full potential.
The two teams, one located permanently in Uganda and another in Finland left the communication between the teams at the edge. Some few skype calls would be cancelled due to network and other communication barriers. This in turn occasionally decreased the morale blurring the expectations of the project.

Stakeholders expected as laid out in the project proposal were not so easy to link up with as initially expected thus the boast of the project slowed down a little bit. More ways of the team linking with these stakeholders can be studied far the next time.

TEAM BIOGRAPHY

Makerere University

Bruce is 3rd year student at Makerere University soon graduating with a Bachelor's Degree in Construction Management in 2019. With extreme interests in Engineering and design,

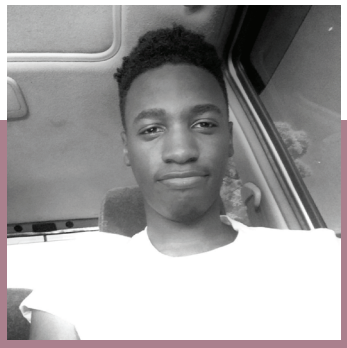
He has worked on quite number of projects including concept development at Kiira Motors Corporation, a car manufacturing company in Uganda. He is a tech enthusiast and is passionate about exploring many opinions on which technology can be embedded into projects sustainably. Fromthis experience, he learned the value of hard & team work, efficiency, and communication.

Following the fields of study, Bruce is good at cost engineering, design, management and documentation. When he is not in class, he is surfing, designing websites and executing other freelance jobs.

Within the Up-plastic Project Kampala Bruce juggles between planning and documentation and in-depth research on the project sustainability.

Jessica is a student at Makerere University offering a Bachelor of Science in Construction Management. She is curretly the president of Makerere Association of Construction Management students (MAC), an association that brings together all the students studying Construction Management in Makerere University.

Jessica is passionate about innovations and she has been involved in a number of innovative projects at Makerere University, one of which was ranked fourth in the whole country in 2017. She is also passionate about landscaping and gardening. She supports the Up-plastic project in creating awareness of the project to the community and also ensuring that the project is innovative in all aspects.



Jaura is studying a Bachelors of Industrial and Fine Art at Makerere University. He is good at Graphics and Logo Design where he has won a couple of awards in National Design competitions.

His passion is to be able to communicate and send messages to the public through vectors and illustrations by creating art in relation to everyday life so that people can relate.

Within the Up-plastic Kampala project he supports the team in design

Joseph is currently pursuing his Bachelors of Science in Construction Management at Makerere University. He is enthusiastic about building engineering. Joseph has recently participated in projects that are driven by use of innovation as a means to solve society's challenges.

Besides his interest in the built environment, Joseph is fascinated by technology, working with computers in particular, and spends some of his free time creating websites, mobile apps and graphics designs. Joseph has experience in planning, developing and maintaining internet products from the ground up.

As a member of the Up-plastic Kampala project, Joseph is interested in ensuring quality and safety of the end products. He is also keen on exploring the various possible applications of plastic and steel waste as construction materials.

Agnes is a third year student of civil engineering at Makerere University and passionate about working with other people, learning and exploring new things.

Us

nder the Up-plastic Kampala project, Aggie is responsible for quality control and the scientific practical aspects of the final product as well as ensuring that the product suits the standards by developing sustainable machine

Clare is an undergraduate student pursuing a bachelor's degree in Construction Management at Makerere University. She has formerly volunteered with The AIDS support organization and the DREAMS project to asses community needs for development and stability in Uganda, and currently serves as the on campass project coordinator for the association of construction managers. Clare loves traveling, meeting new people and sharing their perspectives on life in different societies.

Within the Up-plastic Kampala project, she supports the prototyping team majorly testing and analyzing the product's suitability in the community and the environment. Her interest lies in seeing a cleaner, waste-free environment which is influenced by the construction industry.

Aalto Team

Anna is a Creative Sustainability Master's student in Architecture at Aalto University. Originally coming from Georgia (the country, not the State) she finished her thesis about transformation of Soviet sleeping district - Microrayon - and graduated from Kaunas University of Technology in 2016.

Before joining Aalto University, she has been working as a junior architect in JDWA, an architecture office based in Rotterdam, The Netherlands, focusing on urban and architectural transformation projects and social housing.

Within the Up-plastic Kampala project she is supporting the team both with her architectural skills and knowledge of participatory methods of design. She is especially interested in the multidisciplinary approach to problem solving and design as a tool for collaboration

Beam, or full name Bergpob Viriyaroj, is an architect from Thailand. He has been studying in Creative Sustainability in Architecture programme at Aalto University since 2016.

Formerly, Beam graduated from Chulalongkorn University with a Bachelor's degree in Architecture. Prior to his studies at Aalto University, he has been working in building design for 6 years, in real estate projects and private housing in Thailand.

His parents are managers of a plastic packaging factory, which gives him basic knowledge in plastics. Apart from architecture he is interested in science, films, animals and metal music.

Beam supports the Up-Plastic project in strategic planning and visual communication. He is interested in hands-on approach and contribution to larger scale impacts.

Sara is currently studying her Master of Arts in Collaborative and Industrial Design at Aalto University and has a German Bachelor's degree in Digital Media. She is trained and experienced in human centered design as well as in management and technology related topics.

If asked, her biggest passion is to study and understand human nature and the human mind as well as finding touch points for intervention to efficiently improve people's (emotional) well-being. In the future she strives to become more of a strategic designer, some type of coach, or an established artist, or none or all of the just mentioned. Sara also likes to hug trees, get up early to greet the sun and find humor in the paradoxes of life.

Within the Up-plastic Kampala project she supports the team in design, communication and management matters and is especially interested in capacity building and team dynamics.

Olga is a Creative Sustainability Master's student in Aalto University. She started her studies in Aalto University in 2013, with a Bachelor's degree from Business Technology.

She is trained and experienced with business operations and information management and more recently she has been involved in various NGO projects. Olga is passionate about exploring alternative ways of living and organizing society while questioning how we understand the quality of life. She loves to spend her spare time with boards; snowboarding, surfing and longboarding.

Within the Up-plastic Kampala project she is supporting the team by ensuring that the project is sustainable in all dimensions and she is especially interested in community involvement and the development of the project in the longer run.

Enni is studying Water and Environmental engineering in Aalto University and soon a Master of Science in biology from University of Eastern Finland. She is trained and experienced in environment biology and pedagogy and more recently focused on ecotoxicology and topics related to sustainability in water management. Enni is passionate about exploring and understanding people's relationship with environment and nature. She loves to spend time in the forests, just walking or picking berries and enjoying the fresh air and sounds of nature.

Within the Up-plastic Kampala projects she supports the group with life-cycle aspects and with her knowledge of pedagogy. She is especially interested in creating awareness about sustainability and using sustainability thinking as a resource.

MENTORS

AALTO UNIVERSITY

Matleena Muhonen
Cordinator

Matleena is the coordinator of the Sustainable Global Technologies Programme in Aalto University. She is responsible for managing PBL East Africa in Uganda. Matleena loves snow, snowboarding and mojitos. Matleena supports the Up-plastic team as a project manager.

Matias Heino
Mentor

Matias is a doctoral student at the Water and Development research group. He is studying climate impacts of food production in the global scale. Matias is passionate about playing floor ball and listening to the rap music. Within the Up-plastic Kampala project Matias supports the team as a mentor

MAKERERE UNIVERSITY

Arinaitwe Henry
Chairmman BOD PBL-East Africa

He is current the principal of the College of Engineering Design Art and Technology. He is a Civil Engineer with a PhD in Engineering from Lund University, Sweden. He has published a lot of books in Civil engineering and has worked on a lot of projects including the design . In the up-plastic project, he is the Chairman Board of Directors PBL- East Africa

Venny Nakazibwe
Cordinator PBL East Africa

She is currently the deputy principle of College of Engineering, Design Art and Technology. She is an Industrial Designer with PhD in Art History at Middlesex University, London UK. In the up-plastic project she is Makerere University PBL-Project coordinator

Robina Kulabako
Direct Mentor

Nsereko Raymond
Mentor

Nsereko Joseph Raymond is a Lecturer at the College of Engineering Design, Art and Technology (CEDAT), School of Industrial and Fine Arts Makerere University, Depart ment of Visual Communication Design and Multimedia. He has been involved in proj ects like designing the New Family of Ugan dan Currency Banknotes. In the Up-plastic project he acts as mentor. He was also a mentor in the UNIWASH and UNICOM project

Antony Gidudu
Mentor

He is a lecturer at College of Engineeering, Design, Art and Technology in the Department of Geomatics and Land Management. He currently works on Gasification,Environmental applications of remote sensing,Cartographic visualization, Machine Learning and holds a PhD in Geomatics, Land Cover Mapping Through Optimizing Remote Sensing Data for SVM Classification. In the Up-plastic project, he is the mentor.

Kwesiga Philip
Mentor

He is an Associate Professor of Art and Design at the School of Industrial and Fine Arts and currently he is the head of department of visual communication, Design and Multimedia at Makerere University Kampala. He is a professional in Industrial ceramics with a PhD in Art and Design from Middlesex University. In the Up-plastic project, he is mentor

Mukiibi Stephen
Mentor

He is currently the Head of Department of Architecture and Physical Planning at the College of Engineering, Design, Art and Technology. He is an Archtect by profes sion with a PhD in housing policy from University of Newcastle upon Tyne, (U.K). In the Up-plastic project, he is a mentor.

Compressive Strength test on LCB-Units

Sample	%ges	Weight(g)	Load(KN)	Load(N)	Area of the unit(mm2)	Compressive strength(N/mm2)	Av Compressive strength(N/mm2)
1		535.1	19	19000	5000	3.8	
2	100% steel, 0% sand	571.3	21	21000	5000	4.2	3.7
3		495.5	16	16000	5000	3.2	
4		555.5	29	29000	5000	5.8	
5	75% steel, 25% sand	548.3	23	23000	5000	4.6	6.5
6		568.7	46	46000	5000	9.2	
7		620.4	54	54000	5000	10.8	
8	50% steel, 50% sand	570.6	23	23000	5000	4.6	7.1
9		508.4	30	30000	5000	6	
10		514.7	31	31000	5000	6.2	
11	25% steel, 75% sand	534.5	21	21000	5000	4.2	5.3
12		647.8	27	27000	5000	5.4	
13		432.4	18	18000	5000	3.6	
14	0% steel, 100% sand	438.6	18	18000	5000	3.6	4.3
15		459.9	28	28000	5000	5.6	

Table 4: Compression strength test results

Items	Detail			Compressor						
Steel Bars		Quantity		Estimate Price	ACTUAL THINGS	20.02 UPDATE	21.02 UPDATE	22.02 UPDATE	PRICE PAID
Round bar	25mm	45	cm						
Round bar	26mm								
Round bar	30mm								
Angle profile	30x30x3mm	260	cm						
Hexagon bar	27m								
Tube	34x26x4mm								
Square tube	30x30x3mm	1,500	cm						
Strip	20x3mm								
Strip	30x3mm						x		40,000.00
Strip	30x4mm								
		ALL	IN	UNIVERSITY					
Sheets Metal		Quantity		Price					
3mm	1.2m x 2.4 m								
5mm	1.2m x 2.4 m								
6mm	1.2m x 2.4 m								
Sheet metal	1mm	1	sheet						
Sheet metal	25x25x3mm	1	sheet						
Mesh	150x180x1.5mm								
Electronics		Quantity		Price					
PID Controller	0-400 Degree	1	piece	72000	FIMBOO				none
SSR	2-24 V	1	piece	16,000.00	FIMBOO				none
Thermocouple	Type K	1	piece	23,000.00	FIMBOO				none
Power switch	220V	1	piece	35,000.00					
Led indicator	220V	1	piece	36000					
Powercord		5	m	36000					
heat sink					250000		40,000.00	x	60,000.00
Contactor				130,000.00		130000	x		140,000.00
wires				???		?	x		64,000.00
Heating coil				60,000.00	50000	60000	x		60,000.00
Bandheater	35x45mm								
Bandheater	40x45mm								
		SUM		218,000.00		190,000.00			
Misc		Quantity		Price					
Oven	45x45x55cm	1	unit	180,000.00	Done				100000
Car jack				180,000.00	Done				40000
Bearing									
Drill	26x600mm								
Motor	+/- 2kw								
Wooden base	18mm								
Labour								x	150,000.00
SUM		TOTAL SUM		578,000.00		844,000.00			654,000.00
		TOTAL EUR		132.94					150.42

Table 6: Compression Machine Budget

Up-Plastic Kampala

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