

Context Study

Introduction

Concepts and Theories

A major theoretical element that frames this challenge is the “Techno-ecological theory”. This suggests that technology and human ingenuity are the greatest resources available in regards to food security. It links to the importance of adapting agricultural techniques to produce enough food. While considering this approach the limits of food supply can be pushed much higher (Scanlan, 2003).

This is relevant for the project as human ingenuity and technological innovations are concepts not uncommon in the slums of Mumbai. The population living in an informal sector are left to find a livelihood by themselves. The main keys to the prosperous nature of these slums is the innovative and ingenious nature of the people that live there. Mumbai is known to recycle one of the largest portions of their solid waste, this is mainly due to the presence of slums. Usually waste is considered a liability, in the slums of Mumbai such as Dharavi. A different story is told here, waste is more of an opportunity than a liability. “Everything from plastics and car batteries to computer parts, fluorescent lights, ballpoint pens, plastic bags, paper, cardboard boxes, wire hangers and any scrap material. Its economy literally runs on recycling and reusing waste.” Dharavi with its 15,000 mini factories and 250,000 employees recycles and gives a new use to an estimated 80% of Mumbai’s solid waste (Mascarenhas, 2020). Of which there is an approximated 9,400 tonnes.

This highlights Mumbai’s slums link to the Techno-ecological theory through the people’s ingenuity as well as use of technology. It also makes a second relation, one that is even clearer, to the concept of a circular economy.

In an analysis of 114 definitions of the concept of a circular economy made by JulianKirchherr, DeniseReike, and MarkoHekkert (2017). It was summarized that “the circular economy is most frequently depicted as a combination of reduce, reuse and recycling activities.” Furthermore, it was also identified that the main aim for a circular economy is economic prosperity as well as environmental quality. Without the slum’s

recycling industries “Mumbai would choke in its piled-up trash.” (Mascarenhas, 2020). This quote highlights the last point made about environmental quality. Furthermore, this principle of circular economy and repurposing the waste of Mumbai has given a income to a large portion of the slum’s population highlighting its economic prosperity compared to if these activities did not exist.

The low-tech, aka frugal, philosophy is another concept that helps frame this project. Frugal innovations have no specific description, they are relative to the level of technological complexity of the era as described in an article by Aaron Vansintjan, titled, “The Philosophy of Low-Tech: A Conversation with Kris De Decker” (nd). These innovations can be categorized using three main characteristics. Substantial cost reduction, Concentration on core functionalities, and an optimized level of performance. This is relevant to the project as it would be essential to deliver a product which uses accessible technologies, along with the most important functions at a low cost.

Finally, the AYUSH ministry of India provides the essential link to the COVID-19 pandemic. This ministry represents India’s unique focus on alternative medicine and health systems. It groups systems such as India’s age old Ayurvedic medicine, Pranayama, and other naturopathic systems providing one of the world’s only official body of representation of this type of health care system. This is a truly unique occurrence and extremely culturally relevant. It has drawn a set of guidelines that highlight preventative measures such as immunity boosting as well as general bodily and mental health which are thought to be paramount to the survival of India’s population in these hard times.

The Lockdown and its implications.

This challenge focuses on finding a solution to food scarcity and malnutrition in impoverished urban or peri-urban areas of India during times of a pandemic or in this case the Covid-19 virus. The challenge looks at the slums in Mumbai such as Dharavi as a sample to model a solution fitting to this type of context.

The lockdown in India has been referred to as the largest COVID-19 lockdown in the world (The Lancet, 2020). Through further investigation it became clear that the actual lockdown, and enforcement of strict regulations themselves had a big impact on the country and its population.

The main effects brought around by the Corona virus and the circumstances that followed are outlined below. The first and most obvious is of course the impact on people's health. The health care systems in some developed countries were already overburdened due to the pandemic, India with a population of 1.3 billion struggled even more. In rural areas, especially, there is a lack of health care infrastructure and professionals, managing the virus was and still is a big challenge. To make it even worse, 72% of the population lives in rural areas and are served by only 26% of India's doctors. (Thayyil & Jeeja, 2013). India currently has the second largest number of reported cases. Additionally, many people lived in situations which did not allow them to follow the measures due to lack of space and crowded households. According to (Times of India, n.d.) about 8-10 people can live in households or huts that measure 10 square feet, in the slums of India.

The next most significant impact, arguably as important as people's health, was the scarcity of basic necessities such as food, groceries and medicine. This was partly, because transportation of goods was reduced due to the measures. Another reason for this is that a large portion of the population lost their source of income due to unemployment, it is estimated that 400 million workers in India may sink into poverty due to the effects of the lockdown (UN Report - The Economic Times, n.d.). The loss of income and rising prices have had a grave consequence on the poorest in the society. Efforts from the government have been made to counter this, for example by handing out food rations in slums such as Shivaji Nagar, Mumbai. These have mitigated the effects somewhat but not completely as in this case 35% of Shivaji Nagar residents did not have the ration cards needed to get free food. The closing of Anganwadi Centers (AWCs) and schools to fall in with the regulations have led to interruptions in nutrition services. For many children the Mid-day Meal schemes offered by these centers and schools may have been the main source of nutrition in their daily lives (Upadhyay et al., 2020). This highlights the emergency state India was in during the lockdown in terms food security.

To conclude, the phrase « We will die of hunger before we die of Corona » has been mentioned in numerous papers and articles all over the net as people are worried about their survival in these difficult times.

Looking further into the effects of the quarantine regulations it is clear that the virus left a big mark on the Indian economy. The pandemic has already had a big effect on economically strong

countries such as the USA (Foreign Policy Research Institute, n.d.). Additionally, India was already on a downturn. The lockdown, therefore, had a huge impact on India's economy. It is estimated that the lockdown may have cost the Indian economy 7-8 lacs crore rupees (95 billion dollars) during the first 21 days only. (Kundu & Bhowmik, 2020)

Mental health is another important factor that has been impacted by the situation. Survival stress as well as fear of contracting the disease have been major factors playing a role on the mental health of the population. (Mukherjee et al., n.d.)

In the context of India, it is important to understand that the lockdown came to an end and regulations are being lifted mainly because it was becoming too hard to sustain a lockdown that has gone on for so long - economically, socially and psychologically. (BBC, 2020).

Overall, the COVID-19 pandemic has highlighted food security as an important issue. Ensuring a better control over this in the future would aid preparedness for situations similar to the lockdown that occurred earlier this year. It may also directly aid the containment of a pandemic by ensuring better immunity as well as allowing containment measures to be sustained over a longer period of time.

The examination of the important contextual factors above has exposed the scope of multidisciplinary involved in designing and implementing such a solution. This context study will ensure a solution fitting to the context and answering to the issues made evident due to the pandemic.

The Context and Stakeholders

Situation before the Covid-19 pandemic:

Before Corona hit, there were already a lot of problems present as mentioned before. The pandemic worsened these problems and made them more visible. In this section we will have a closer look at the demographics of India and the economic and socio-cultural context.

Demographics and Economic context

Mumbai has 23,5 million inhabitants on approximately 1147 square kilometers, bringing the density to about 20,482 residents per square kilometer and making Mumbai the ninth most densely populated city in the world. About 41.3% of the population, over 9 million inhabitants, live in the slums. In these slums the population density is much higher, it has been estimated to be around 400,000 people per square kilometer.

Despite Mumbai being the wealthiest city in India, with a net worth of 950 billion (12th in the world), a lot of people live in poverty. The per capita income in Maharashtra, the region in which Mumbai is located, is stated at \$2,900 (2020).

In the slums the conditions are very poor. People live in crowded households in really basic houses often made of waste materials. (world population review, 2020) Hunger Currently there are a lot of issues regarding hunger in India which is shown in a research conducted by Concern Worldwide and Welthungerhilfe. The Global Hunger Index is yearly published and lists the countries facing the biggest challenges regarding hunger. The score of a country is based on undernourishment, child wasting, child stunting and child mortality, where a child is defined as someone under five years old. India scores 30.3 on a scale of 1 to 53.6, giving the country a 'serious' tag and placing them 102 out of 117.

India is placed so low on the list because they score low on all criteria, with 14.5% of the population being malnourished and 20.8% of the children are so called 'wasting', meaning their BMI (body mass index, weight compared to height) isn't as it is supposed to be. Even worse, 37.9% of the children are labeled as 'stunting', meaning their height isn't how it should be in regards to their weight.

While people are starving and children are malnourished, India is the largest producer of some agricultural products, with about 25% of the world production. The total grain production in India is estimated to be 275 million tonnes and with a milk production of 165 million tonnes, India is the biggest producer of milk, jute and pulses. Agriculture accounts for 23% of the GDP in India and almost 70% of the rural population depends on agriculture as a primary source for their livelihood. Despite India being a massive producer, a lot of people are still hungry and this is partly caused by the fact that a lot of food goes to waste. FAO (Food and Agricultural

Organization, part of the UN) estimates that almost 40% of the produced food gets thrown away due to inefficient supply chains. Also, a lack of cooling and not enough storage means about 20% rot before arriving at the market.

Furthermore, a paper from 2018 (Hunger, under-nutrition and food security in India, N.C. N.C. N Saxena) says India will probably be having a food shortage in the near future, resulting in India needing to import more, which they can't afford. If India doesn't start importing more, it would either need to improve their agricultural output or more people would be starving. This emphasizes the importance of our project, improving the yield of farming through efficient farming as well as incorporating more locally produced food to reduce loss due to transportation and storage. The paper also suggests the government should take some actions to increase agricultural production. It says the main intervention from the government should be investments in irrigation, power and roads in poorer areas to realize a production surplus in those regions, where most of the poor people live. According to the paper only 40% of cultivated land in India is irrigated, meaning only those areas can be used for farming, therefore the paper suggests better irrigation to increase the percentage of arable land. It also says that the local governing entities probably won't have the tools to solve this problem, so it would need to be solved nationally, but that could take a long time. Our design could be helpful in the non-irrigated areas, since our design will be inspired by hydroponics, and use more resource efficient strategies.

Locale and expenditure class (1)	Undernourishment (per cent)		Malnourishment (per cent)
	FAO norm (2)	ICMR - NIN norm (3)	ICMR - NIN norm (4)
Rural			
Poor	50.0	82.0	50.0
Middle income	21.3	01.3	31.7
High income	7.0	30.0	14.0
All rural	32.3	07.0	30.7
Urban			
Poor	00.7	70.5	50.0
Middle income	33.7	55.2	40.8
High income	10.1	20.7	22.8
All urban	30.5	50.7	43.8
Rural+Urban	34.2	04.8	30.7

Undernourishment and Malnourishment according to the FAO norm and ICMR -NIN norm per income level

The FAO is, as mentioned before, an organization of the UN, monitoring agricultural practices and production around the world. The ICMR - NIN norm is more accurate by taking more variables into consideration and this is why according to the ICMR -NIN norm shows a higher percentage of undernourishment. The ICMR - NIN norm says that half of poor people in rural areas are malnourished, and over 82% of the people in those areas are undernourished - note the difference between malnourished and undernourished- . Even among people with high income there is a surprisingly high amount of undernourishment and malnourishment according to the ICMR - NIN norm. This indicates there is a shortage of good food, not only in the lower income areas, but everywhere in India, stressing the need for an innovative, cheap design to solve this problem.

This was even before corona, during corona the situation only worsened, demanding more initiatives to provide food for the poor, which was somewhat addressed but still not sufficiently to feed everyone.

Socio-cultural context

Another thing to keep in mind are the socio-cultural contexts the challenge should account for. In India, religion is a big part of people's daily life. As the city's name comes from Mumba Devi, an eight-armed Hindi Goddess, Hindu is the most present religion in the city. Two thirds of the inhabitants follow this religion which means that they live according to norms and values influenced by this religion (worldpopulationreview, n.d.). A big part of this is the caste-system, which has dictated a lot of aspects in social life, with each group occupying a specific place in this complex hierarchy. (BBC, 2019) Most of them belong to the lowest two castes; the Vaishyas and the Shudras or to the Dalis (untouchables). Although the caste system got abolished in 1950 and the differences between the castes became less, there is still a great deal of discrimination and this situation worsened during the pandemic. As sources are limited, higher castes look down on the lower castes and feel like they should have priority. There are stories of people who got denied water access by a dominant caste and Dalits in some cases are viewed as 'the' spreaders of the virus. There even are Dalits who claimed that others shouted "corona, corona" whenever they were out on the streets. (Sur, 2020) This shows that the caste system is still very much present in India. Therefore, the design should be accessible for all castes and the Dalits. There needs to be made sure that the design should not be abused by higher castes and it should not be the case that Dalits get denied access to the design.

Other stakeholders

The main stakeholders are of course the inhabitants of the slums in Mumbai. This group of stakeholders is already broadly discussed above and will be further discussed later in this context study. But stakeholders can also be so-called 'third parties' that come into play when you implement your design. For this design there will be no specific collaboration with these third parties. However, we will elaborate a lot on the implementation (and the issues that come with it) in our final report. Therefore a few 'third parties' that can be useful for implementation will be named below.

Schools

One of the main concerns of the people in the slums is the future of their children. An option when implementing the design communally, would be to place it in a school. While farming food for people in the slums, the children will learn about farming, nutrients and construction. It will furthermore provide the skills/knowledge required to provide food to their families later. A design could even make the school environment more appealing with the 'green' they add to the often-depressing looking school buildings. However, these 'schools' are mostly just 'normal' slum houses that have been labeled as schools. There is not a lot of space and light inside. Therefore, a design should be space efficient and working without light or with artificial light.



Slum rehabilitation project

The government of Maharashtra, where Mumbai is a part of, is trying to move the Mumbai slums into flats. The government sells the land relatively cheap (25% lower than the market value) in exchange for free housing for the slum dwellers arranged by the buyer. A lot of companies use this to find a cheap place for their production and in this way create housing for the people in the slums. (Zhang, 2016)

The problem is that there are very few guidelines these companies have to follow in order to build these flats. This often results in very cheap malfunctioning and sometimes even unsafe buildings.

An idea is to collaborate with these companies and NGO's to implement rooftop farming into their future buildings to ensure the inhabitants have a source of food. The design will be provided by us, the NGO's can gather the materials or money needed to build the design and the companies can implement them.

NGOs

Another group of third parties that can be useful in the process of implementation, are NGOs. Some NGOs could support the design and help with implementation on ground level. Especially NGOs with a focus on nutrition will be eager to help.

One organization that is focused on nutrition is POSHAN. This organization has “the goal to enable policymakers, program implementers, nutrition researchers, and other stakeholders to readily access the latest, best evidence to support effective decisions to improve maternal and child nutrition in India”.

Collaborating with NGOs could provide important information about the current situation in the slums and insights on how to implement a certain technology or project in such an area which is contextually valid.

A lot of NGOs are already working in Mumbai to better the people’s quality of life there. The projects they’ve set up differ from emergency packages to more long term initiatives, such as improvement of education and empowerment of the youth and help for disabled people. In times of corona a lot of NGOs are focused more on direct help and providing basic necessities to the people in the slums as soon as possible. A few NGOs have projects that are focused on food supply, such as United Way Mumbai.

This organization is active in over 40 countries working on a wide range of projects. They have, for example, projects to ensure road safety, to replenish the mangroves in Mumbai, but they also work on a COVID-19 response project, providing kits to health care workers, placing hand wash stations and equipping hospitals with medical equipment and awareness materials. (United Way, n.d.)

Project Poshan, is more related to our challenge. In this project United Way fights malnutrition in the rural and urban communities of Maharashtra. They focus mainly on the malnutrition of children, as nearly half of all deaths in children under 5 years are attributable to undernourishment.

Another group of NGOs focuses more on education and development of individuals. They could be of use if the design will be implemented with the aid of schools, which could be handy to ensure everyone gains awareness of the possible solutions and how to gain access to them.

Examples of these kinds of NGOs are ‘MESCO Modern Educational Social & Cultural Organization’ and ‘Community Outreach Program (CORP)’.

Availability of resources and its implications:

Mumbai is a coastal city with a large number of its slums built in marshal areas inferring a low supply of fresh water and being very susceptible to flooding in monsoons. (GCSE - Mumbai Challenges, n.d.). Slums are also found to be built on garbage dumps, in cemeteries and under high tension lines, access to fertile soil is scarce in these contexts. It was found that only 0.1% of residents have access to piped drinking water. (Sharmila L. Murthy, 2020). On the other hand, proximity to garbage dumps means there is high availability of waste material.

This abundance supports the slums main activity which is recycling. There is an abundance of recycling in slums of Mumbai with 80% of Mumbai’s solid waste being repurposed by the 15,000 micro factories that employ 250,000 people in the slums. (The Circular Economy and Recycling of The Dharavi Slum in India, n.d.). This is especially interesting for our project as it makes the repurposing of waste material for the construction of the final design conceivable.

These special restrictions have many implications for the design challenge. In the field of urban farming it would thus be impossible to grow macronutrient crops such as rice and potatoes as this would take up way too much space and resources. A different approach that looks toward faster growing, nutrient rich crops using techniques that use fewer natural resources would be elemental.

Lack of space

Due to population growth and rural urban migration the populations of cities like Mumbai have been rising at extreme rates. Mumbai with a population of 23.5 million people, has a very high population density of about 20,482 persons per square kilometer, making it the ninth most crowded city of the world (Momtaz, 2020). This is even higher in slums and is estimated at 400,000 people per square kilometer (Bombay Pages, n.d.).

Existing initiatives

There are already a lot of initiatives working on improving the living circumstances of the slum inhabitants in Mumbai (Give India, 2019). They are mainly focusing on non-material

improvements, though, like education, or helping sexual assault victims. There are also initiatives which help to inform people and especially parents about the importance of nutritious food, like an app called Saathealth (The Better India, 2019). However, not many focus on improving the physical living circumstances.

The main companies working on urban Farming in Mumbai are UGF farming, Homecrop, and Pindfresh. UGF farming mostly focuses on getting their crops to the customers by working together with supermarkets and restaurants. They are really focused on growing fresh vegetables in the cities with their own vertical farm. They are looking into using every dead space in India for compact farms, ultimately, they are hoping to provide everyone with 'Zero Carbon Food', meaning the process from seed to the consumer's plate doesn't produce a surplus in emissions. They are working on this by farming locally, cutting most of the transportation emissions and farming using organic and sustainable methods.

Homecrop is a company mainly trying to provide people with kits for growing crops in their own houses. Currently they have four kits available, but they are also selling something called a smart grow bag, which is a sustainable bag better for the environment and the plant.

Pindfresh is selling modules in which you can plant crops for indoor and outdoor use.

Although this somewhat addresses the problem identified above, it is not focused on the lower-class populations as they are built as companies with the aim of making profit. A collaboration could be made by providing instructions to build similar growing kits out of waste materials to be accessible and economically viable for the slum's populations.

Urban farming using hydroponics is a solution as well (Orsini et al., 2015). There have been projects doing this in Peru, Egypt, Senegal and Italy that used rooftops to create farms in crowded areas. The main problem that urban rooftop farms experience is the tap water. The tap water often contains high concentrations of chlorine, which is not good for the plants. On top of that, it can be quite expensive and make up for up to 80% of the cost of the farm. Orsini et al. (2015) suggested that rainwater might be a good solution; however, a good way to store the water needs to be found. Especially within our context, in which there are only three months of rain a year, this would be important.

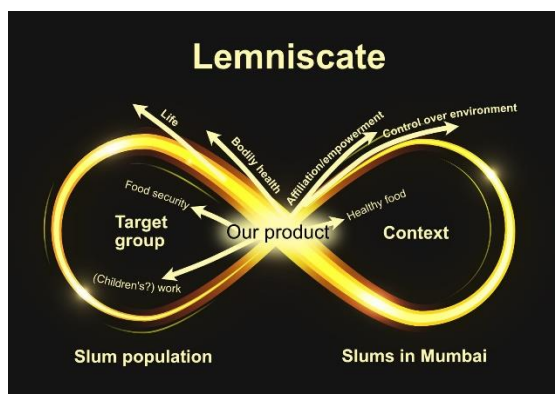
A feasibility study in Peru focused on people living in the slums in Lima (Orsini et al., 2010). The circumstances of those people were very similar to the circumstances of our target group; many of the poorest had to struggle to get their basic needs met. Normal urban farming was difficult due to the lack of fertile soil in the urban areas. Therefore, the project coordinators

looked at the concept of hydroponic communal farms. Earlier projects found that this could indeed be a very good solution, due to a decreased dependence on soil and pesticides. Because of the low physical effort, this was also very suitable for women and elderly people. The people, which consisted mainly of women, could be helped by the main goals of this project: improving nutrition, generating income and creating social networks. The downside was that it cost \$2 a day per household, already a lot cheaper than other technologies in this field, but still quite expensive for poorer slum inhabitants (Orsini et al., 2009).

To solve this problem of price, an initiative called “Low-tech lab” set up a website with technologies that everyone can make out of cheap materials. The concept of providing people with information about technology and letting them build it themselves really appealed to us. They have a tutorial on a hydroponics system as well; based on European prices and if all the material were to be purchased rather than reclaimed the budget was calculated at 50 Euros. (Low-Tech Lab, n.d.). Looking at the list of materials most can be salvaged from garbage dumps and if we consider the prices in India (for screws etc.) it would be up to five times cheaper.

Based on all this information, we think it would be good to investigate the possibilities of low-tech hydroponics, since this might be very suitable for our stakeholders. Our team member Luuk Winters will do his deepening about hydroponics for this reason, while Perceval Fayon will investigate frugal innovations.

Defining an Appropriate design.



Design Ethics

Eden or Utopia?

From the first hand axe to a modern-day smartphone, humankind has been finding ways to modify its environment in such a way that it benefits us. However, what we are just starting to realize is that the more technologies we bring into this world, the more we are creating a new world – and that world has a big influence on who we become as individuals. In this day and age, with a mass influx of new technologies, the power of the creators is growing rapidly. This raises the question of what kind of world we want to live in, and what the role of humans will be in the new world.

Because the environment influences the actions of the people living in it, the people who shape the world have some ethical responsibilities for the results of those actions. In our case, we are focusing on the mediation of technology in human-world relationships. There are two main ways in which technology influences people, called experience and praxis. Experience is about the way technology influences our perception of the world. Praxis is how technology influences our actions (2006, Verbeek).

The aspects of praxis/action that will be invited are buying (seeds, nutrients), gathering building materials, arranging the building of something and maintaining plants (watering, harvesting). These are mostly behaviours that people already have. They do not seem to have significant moral properties. However, the way people experience the world might change significantly. A big cause for that might be contact with nature. This offers people unique views on beauty and life in general. In our opinion that has a big existential value. Besides this value, it might make people more conscious of the immense beauty that exists on this planet; they might see that life in every form is incredibly precious. This might make them more grateful (which is healthy) and more inclined to protect nature. Our product will not only give them visual beauty, but also the feeling of earth on their hands, the freshness of water and the smells of flowers. That might just be something good in the lives and minds of people who have spent their whole life surviving. Also, in general, there can be something hopeful in seeing things grow and flourish. The product could transform an environment of waste into something green and flowering.¹

Another important aspect of people's experience that is co-shaped is the absence/presence of survival stress. When technology reduces this, there is more space for other experiences. We assume that the people themselves will look for experiences that they regard as positive to fill

¹ *On the other hand, it might also sustain the idea that nature is a means to an end. This might lead to more exploitation of nature.*

this extra space. However, this advantage is accompanied by an increase in work. Since our target group has a limited amount of time and energy, the product might decrease the number of alternative things people could do². In other words, the product might inhibit the freedom to act and amplify the freedom to experience .

Since we are still in a very early stage of the project, we don't know what our product will be. For the sake of clarity, we will assume that it is a box that produces food in exchange for a certain amount of work. The main script that we want to put into our product is that of planting, maintaining and harvesting food. Those might have other scripts as a consequence; for example, people will need to buy seeds or nutrients, and they will cook, eat or sell their produce. These scripts are mainly focused on the individual.

It is harder to predict what influence our product will have on the society in the slums. Since we are giving people a source of power (in an environment where food is scarce, a farm is power), the power structures in the community might change. According to the interview we conducted with the experienced developmental workers (see the appendices) and other initiatives (IFAD, 2019) (SM Sehgal Foundation, 2018) sometimes vegetable gardens can empower women. In India, men are the primary income earner, providing for their families; there is a lot of gender inequality (Seguino, 2011). This means that women are the only ones with time available for the garden. However, when women get their own source of income, it will have an influence on their social status. What the developmental workers saw was that women started behaving more confident and freer.

However, this completely depends on what kind of work the farming module will require. If we make it very easy to maintain (say, 5 minutes each morning) the effect will be small, since the contribution of women will not be perceived as significant. Maybe even the men themselves could take care of it. However, as the needed maintenance increases, say to three hours spread over the day, the role of the women increases. We can ask ourselves if we should delegate this moral choice to our product, by making the maintenance higher, thereby increasing the chance that it will empower women.

There could be some ethical constraints to that, though. From our Western perspective, empowering women is of course amazing. A few of our most important values are freedom, equality and independence. However, in the Indian culture, other values dominate. For women, for example, it is important to be a good wife for their husband, and honor Brahman by living

² *Although eating healthier can give people more energy and generally has mental health benefits as well.*

a diligent life in the place (in the caste system) that has been given to them (Narini Narayanan, 2014). Forcing them (in a situation of food shortage) to be more independent might distance them from their religion, since the acceptance of your life and detachment from suffering is very important in Hinduism³. How can we just declare our Western values to be more important than their own?⁴ Whether empowering women is a good or a bad effect really depends on the perspective taken.⁵

This clash between religion and human rights is too complicated to dive into in this report. Luckily, other people have thought about this before. The United Nations are actively working to empower women in India specifically (United Nations, 2017) and one of their 17 sustainable development goals for 2030 is gender equality. In our design we will trust this authority to guide us on which path to follow regarding gender inequality.

Coincidentally, Martha Nussbaum has developed some thoughts on this as well. This conflict between equality of opinions (or freedom of opinion) and equality of position (and of course any moral point of view that intuitively seems very important to us) is complicated and extensive because it goes back to the very basics of moral philosophy. The approach of Martha Nussbaum proposes is actually the Capability approach mentioned earlier. In this, she tries to give a general benchmark to help ethical decision-making while leaving space for every person/religion to pursue his own points of view (instead of imposing a “superior” Western way of thinking on people). It seems quite sensible; however, we will not go into it here because of a lack of space and time (it is hard to get a full grasp of the discussion for the procrastinating student) and because Loes will be doing her deepening about women empowerment.

There might be other unforeseen possibilities. If the boxes are easy enough to maintain, and mothers are busy with the households and their four toddlers, and fathers are out working the whole day, older children might actually be forced to take care of them. However, according to UNICEF (2020), children aged 5-14 can work for a maximum of 21 hours a week on unpaid household chores. So, even if the farming module needs three hours of maintenance a day, this will probably not lead to child labor. However, it should be considered that this could burden the child with a big responsibility, since failing would mean the family doesn't get to eat.

³ The specific role of women actually includes providing food for their husband and family, so for each individual woman, having a vegetable garden is probably perceived as a very good thing. Here we are purely talking about the effect of empowerment, and that effect on its own might not be seen as positive.

⁴ Given, on a side note, that they might equip people to transcend suffering (Whitman, 2007)

⁵ We have considered the fact that this can enable women to choose themselves what they want to believe and who they want to be. Again, from our Western perspective, this is very good, but Hindu Indians might not find this as valuable. In their eyes, we are alienating women from their cultural and religious heritage, while we call it 'empowerment'.

Based on all these considerations, there seem to be no significant ethical constraints. The ideal script would be that women work on the maintenance of the farm for a small amount of time each day, thus obtaining food and getting empowered. We could delegate this to our product by making the maintenance time not too short.

If, however, the product were to be a communal property, there would be more complications. These complications mainly include making sure that the food gets divided in an honest way or making sure that everyone does their share of work. This is of course important, but it is impossible for us to incorporate all of this into our design, since most of this is up to the people living there. Therefore, for this project, we will leave social justice to the people who will actually implement or use it. We will keep it in the back of our minds, though, and if our product turns out to be a communal project after all, we will delve deeper into the ethical problems this brings.

There is one problem we want to mention, though. In the context study, it was revealed that there is a lot of corruption in the slums. This might give the wrong people the power to manipulate innocents. To solve this, we could think about other contexts where the farming module could be implemented. Some ideas include schools, or the slum rehabilitation project, like we mentioned earlier. However, these environments might require a different design. Like we said, we will keep it in the back of our minds.

Assessment of capabilities

In order to gain a better understanding of the context, our stakeholders and other variables we need to take into account when designing our product, we used the capability approach. When using this method you write down the so called capabilities (there are 10 capabilities who all influence other things) that you want to design for. They describe what your design will be helping your stakeholders with. Further in the process they will function as a set of guidelines for your product



design. Martha Nussbaum has been a big contributor to the capability approach, centering individual human dignity in her interpretation. Although Nussbaum's original goal of the capability approach was to design capabilities for every person, meaning the ten capabilities are meant to relate more to individuals than groups, we are relating them to groups, since there are too many individuals in the slums to relate them to all the individuals.

As mentioned before, food security has been an issue in the slums before the COVID-19 pandemic even started. Setting up steps to help solve the lack of food and malnutrition will have a positive effect on the following capabilities. We try to address the following capabilities with our solution based on the capability approach developed by Martha Nussbaum (Nussbaum, 1999).

Bodily health

Food is the supply of energy for our body. If you stay well-nourished you will have enough energy to function, work, learn, live. A well-nourished body generally also develops a better immune system, which is very important, especially during a pandemic. The AYUSH Ministry (Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy) and Ministry of Health have released dietary guidelines to help boost immune systems as a preventative measure towards the coronavirus.

Life

Since we will try to provide people with a decent supply of food, we will increase their life span and allow them to live a “normal” human life. The quality of their lives will also improve, since we will be taking away survival stress that most people in the slums have and their health will improve, as described in “Bodily health”. Considering the design will be implemented in a communal setting, this will promote communal contribution and collaboration in the capability of affiliation, which will also have an effect on the capability of life by resulting in closer relationships and communal warmth that will have an impact on the happiness and wellbeing of the individuals, increasing the quality of their life even more.

Affiliation

Communal contribution, Self-esteem, Independency, Less conflicts (because basic necessities are better fulfilled)

As mentioned above, the design will aim for a solution that promotes communal contribution. A solution implemented in a household or within a close-knit community results in more independency, relying less on an outer source to feed the end users. Independency is defined here and further on as a stakeholder being able to provide for him-/herself better. Independency ensures more stability and certainty, mainly during unsure times caused by external factors (a pandemic, bad yield, job loss, etc.). More independence often results in a higher self-esteem and, most importantly, the confidence of being able to fend for oneself.

Conflicts evolving around a lack of food will also be reduced as households will already have some basic food supply. Also lack of food often has an impact on the mental health of people making them act out frustration and anger, resulting in violent conflicts. That's why solving the issues around lack of basic necessities can reduce the amount of conflicts and domestic violence present among people in the slums.

Control over one's environment

In the political sense we are not giving people control over their environment, since our design will not give people more rights. By giving people in the slums their own source of food however, we will give them a material control over their environment, since they own the farming module. Furthermore we give them work and more equality among people in the slums, since most of them will probably use our farming module.

Appropriateness

For a lot of designs nowadays the considerations are taken towards a general stakeholder, this makes it easy for the designers as they can take the 'general' human being as their target group. But in reality, nobody completely fits this general profile of a stakeholder, meaning, the design doesn't work effectively for all end users. Even though most people will not differ that much from the 'general' stakeholder, and therefore not have a lot of problems using the design, there will still be a large number of individuals that struggle to use it.

This is where ‘appropriateness of design’ comes into play. The main definition for appropriateness is quoted below.

“Any object, process, idea, or practice that enhances human fulfillment through satisfaction of human needs. A technology is deemed to be appropriate when it is compatible with local, cultural, and economic conditions (i.e., the human, material and cultural resources of the economy), and utilizes locally available materials and energy resources, with tools and processes maintained and operationally controlled by the local population”.(Hazeltine, 2003)

This concept builds the foundation on how to make a solution fitting for all its users. A design fitting for all genders, all ages, all cultural groups, all physical abilities or disabilities and so on. Making a design that is perfectly appropriate is impossible, but a designer should strive for the design to be as appropriate as possible for the context in which it is applied. To ensure a feasible yet appropriate design, a designer makes a priority list of requirements based on the context and the intended stakeholders.

In the case of Slums in Mumbai there are a lot of important variables to consider. Age, for example, is a really important one. Maharashtra has the highest population of children living in slums of the whole country. (Deshpande, 2011). From an early age on, these children are expected to work in the households and are often forced to take up a job to pay for medical fees or sudden debts (Nagaraj, 2016). Therefore, the design should be appropriate for adults as well as children in the context of Mumbai’s slums. This is an example of a design requirement that can be formulated based on this factor of age. The structure of gender roles in the society is also important here.

In terms of appropriateness, level of education is another important factor to consider in this context. In Mumbai, the secondary school drop-out rate is 33.4% (Moya 2017). And this is an average number for the whole city, the drop-out rate in the slums themselves are estimated to be much higher. This is because a large amount of the youth is expected to drop school and take up jobs to provide income for their family. Even if a child manages to complete school, their educational level is still below the average, because of the low quality of education provided in the slums. To make a design appropriate for all educational levels a requirement can be formulated; “the design should be easy to understand and implementable by individuals with different levels of expertise”. Although the literacy rate in Mumbai is 89%, this number

is not as high in the Slums, it is even lower for literacy in English. The design should therefore be understandable without the use of a written manual; this is a good example of how to formulate more specific requirements from a base concept.

Furthermore, when looking at the food security issue most households are concerned with having enough to eat and often disregard the nutritional value of what is offered on the table. This is especially important during pandemic situations as outlined by the AYUSH ministry and ministry of health which describe preventive, immunity enhancing diets in times of Covid-19. It would thus be important to include these guidelines into the solution.

As mentioned earlier, in India, Males are caretakers of resources, performing the functions of earners, on the other hand, females are family caretakers performing the functions of child nurturing, caring for the aged, running the household and putting food on the table (Chowdhury & Patnaik, 2013). This dynamic is important to consider, providing a solution which simply addresses food supply may encourage women to accept the technology, but if it can be a source of income as well, both genders will be likely to implement the technology. Furthermore, this could give a more important role to the women in the household and empower them in their social standing as well as allow for them to express themselves better as independent individuals. Therefore, the design should be appropriate for women to use it. Of course, the design would be best if all genders can work with it, but women have priority. Refer to section on design ethics for more information on women empowerment.

Culture is also an important variable. As the cast system creates a great deal of discrimination, the product would be appropriate if it is accessible for people of all castes including Dalits, the access must not be denied to individual in the lower castes/Dalits (by higher castes). Furthermore, it should not cause conflicts or break boundaries that are still strongly held in the culture. If certain groups of people are not supposed to interact it would be wrong to force them into interacting with each other. This would be an unintended interaction or behavioral mediation of the product.

Other relevant appropriateness factors to be considered would be, for example, pregnant women or people with different handicaps, this is essentially people with different abilities of capability profiles.

The definition of appropriateness also states that it is important to think about the materials being used. To make the design appropriate in the context of Mumbai's slums, It is important to consider its resident incomes and economic backgrounds. The design should therefore make use of cheap materials that are present locally, the import of materials would add costs. The design would ideally make use of waste materials, lowering the costs further. This is appropriate to the context of this challenge as recycling of waste materials is one of the main economic activities in these slums.

It is easy to check whether the design is appropriate for all these groups with the use of the relevant capabilities (affiliation, life, bodily health and control over one's environment). To make the design appropriate, the formulated requirements for the solution should account for all four relevant capabilities. The design should for example provide nutrients and contribute to the immune system for end users (bodily health). The design should also take away the survival stress of end users (life). The design should also create independence for all end users (affiliation and control over one's environment) and should lower conflicts between all end users (by lowering survival stress for all end users) (affiliation). See elaboration in the design script.

Our responsibilities within the project

When designing a product, it is important to take into consideration the cultural differences that are present in Mumbai, making sure that the technology will not be disapproved due to religious or cultural reasons. The caste system which is a big part of the Indian society should be taken into consideration, as well as religious diets and disabilities. It is important that the design is accessible to people of all social classes and backgrounds.

A lot of inspiration was taken from urban farming and hydroponics, but since that is pretty high-tech and thus quite expensive and inaccessible, inspiration is also being taken from the low-tech philosophy and the low-tech-lab to be more precise. The design will try to implement a good balance of both. Since the focus is on using dead space and as little resources as possible, as well as cheap and easy to use, which is why inspiration is also being drawn from the low-tech lab, which is an organization trying to simplify technologies so they can be made from waste and used by everyone.

Analysis of Inspirational technologies and design elements.

A large amount of Innovation has been carried out in the field of hydroponics and urban farming. A large part of this is high tech, although there have been some low-tech innovations that we can rely upon, we also draw inspiration from hydroponics concepts and general ideas in the field of food production.

Part of this is the low-tech lab, this is a group of engineers travelling the world to compile a database of low-tech innovations that are developed directly in collaboration with the stakeholders in the various countries they travel . These innovations are then tested on a low-tech sailing boat on which a selected member of the group attempts to survive solely with these innovations as a source of food, water, energy and so on. This provides a reliable source of low-tech innovations that are already tested in real life. (*Le Low-Tech Lab*, 2020)

The context study has highlighted a set of solution spaces involving hydroponics, frugal innovations and permaculture. Here are some technologies and design elements that have been used as inspiration in the process of ideating a design.

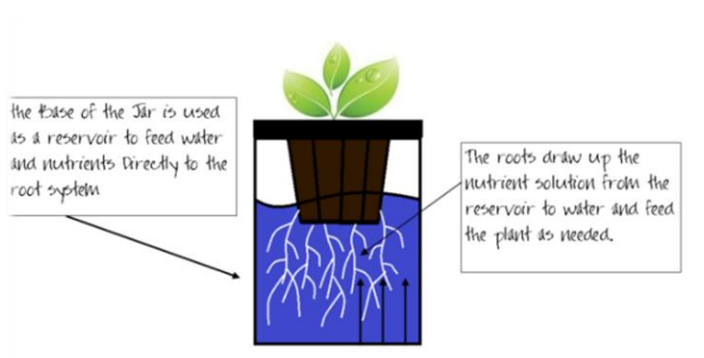
Hydroponics

Hydroponics comprises of a number of systems that all use nutrient solutions in varying ways through a range of growth media, or none at all to provide a required environment for the growth of plants.

Here are some of the main Hydroponics systems that give insight and inspiration for the formulation of a design:

Passive Hydroponics (aka semi-hydroponics):

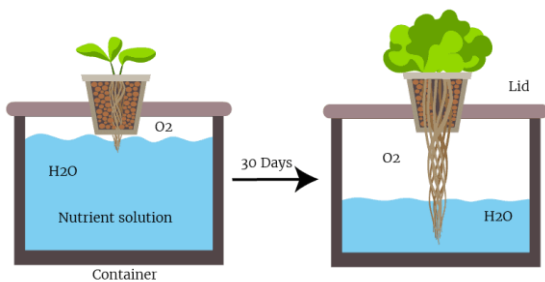
This differs from true hydroponics as it uses wicking systems instead of a pump to transport water from the nutrient solution store to the plant. (*Gigi Belle Plants*, 2020)



Credit: Grow Jar / kickstarter

This concept is very beneficial for the situation in the slums as it uses a small amount of water, can be built out of waste material and therefore is easily adaptable to the slums. Furthermore, it requires little maintenance and doesn't use any expensive piece of technology such as a pump.

The Kratky Method:



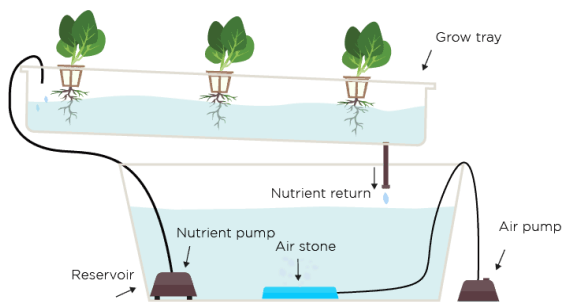
Credit: Frugalpersonalfinance.com

This method is a variant of the deep-water system true hydroponics, the main difference is that, like passive hydroponics, it doesn't use a pump. All plant's roots require oxygen to respire which is why they must have contact with air. The Kratky Method Partially submerges the plants roots in the nutrient solution. As the nutrient solution is used up and its level decreases, the plants roots grow. The ratio of the root system that is exposed to the solution and to air remains constant. For short cycle plants this means one might not even have to re-fill the water container until the plants are ready for harvest.

This means very little maintenance is required. It also improves on the simple passive system mentioned above by allowing for a larger number of crops to grow in the same nutrient solution.

The medium used can vary but are all inorganic material that have a low effect on the pH of the water. Media can include expanded clay pellets, coconut husk and rock wool. The basic Passive hydroponics unit is shown below.

Nutrient Film Technique (NFT):



Credit: Trees.com

The NFT system is one of the more complicated true hydroponics systems that can easily be adapted to be more low-cost.

It stores the nutrient solution separately, then transports it (with the help of a pump) to the top of a slanted tube containing the growing plants before coming out the other end of the pipe back into the container.

This has been easily adapted to a non-pump system that you can see below.



Credit:

Oldstreettown



Credit: Stephane Fayon

This adaptation of the NFT system uses plastic bottles instead of tubing as the plants containers. Instead of using a pump it uses two Buckets. One bucket contains the nutrient solution and is placed at the level of the highest part of the plant tubes (water bottles). The other is placed at the bottom to recover the surplus solution. This can then be reused by lifting it up to the higher bucket by hand.

This system has the benefit of allowing for larger plantations, it is very effective at oxygenating the roots as the water is never static, furthermore it can be built again using waste materials and requires little maintenance.

Vertical Farming

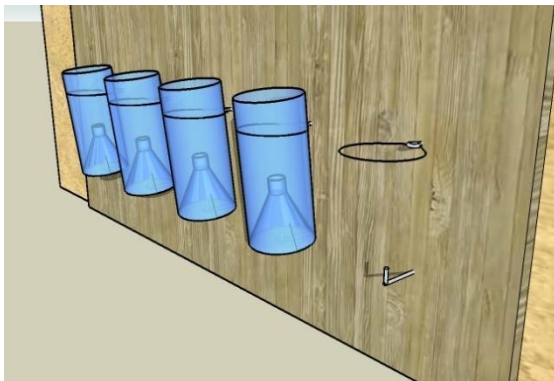


Credit: Kashyap Vyas

Vertical Farming is the concept of stacking plants in a vertical system to take up less space, it can be applied to Hydroponics, Aquaponics and Aeroponics.

In this case a low-tech version of hydroponics developed by Willem Van Cotthem (2010).

This system uses a plastic bottle technique that reduces water loss through evaporation, it is inspired by the inventors research on desertification.



Credit: Oldstreettown

These can then be placed on a vertical partially shading board which reduces evaporation further by reducing exposure to the sun thus cooling the system down.

This is very relevant for the context as India is known to have very dry summers and the slums specifically have scarce access to water.

Urban farm

Urban farming is getting more and more popular. It is based on the idea of farming in the city, on rooftops, walls, even inside and every other available space. Different methods can be used in urban farming, hydroponics, normal farming techniques, etc. It is a collection name for everything that gets farmed in the city. It is something we are trying to do of course, farm in the city, but in itself it isn't a solution.

Rise against hunger

This is an initiative trying to feed the hungry. Rise against hunger is more an initiative trying to soften the problem than a solution. It is an initiative that tries to feed the hungry by giving away food, but this is of course not sustainable and a long-term solution.

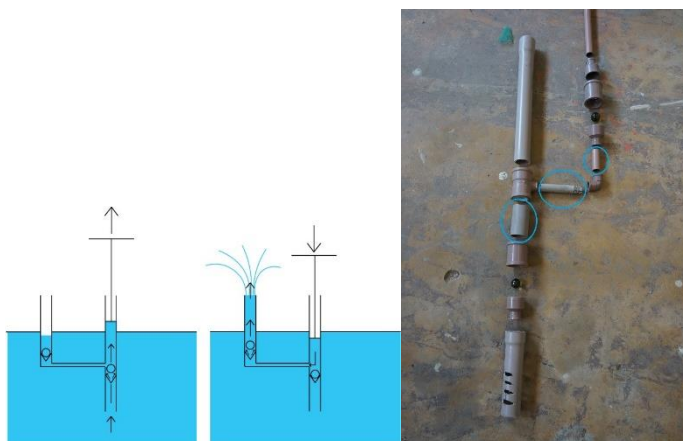
Other food system

Low-tech edible cricket farm

Crickets and other insects are good sources of protein and easy to farm, making it an amazing source of food for people in the slums. However, they do require some more maintenance than the hydroponic system, since you have to feed them manually and raise the babies, but the maintenance is still low. Also, the setup requires a couple hours of work, which people in the slums might not want to invest in something they don't know much of. Furthermore, it would require a heat source, which is not that easy to get in the slums. Most of these points are applicable to every insect farm. (*Low-Tech Lab*, n.d.)

Low Tech Lab

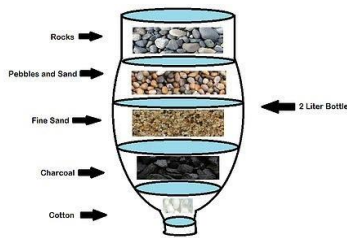
Low-Tech Vertical Pump



Low-tech lab

This is a low tech hand pump designed by the low-tech lab which can be fitted to small wells as well as other water containers. Built out of PVC parts it is a simple to build, cheap alternative to using an electrical pump. It works by creating pressure differentials when one pushes on the handle to drive water vertically upwards.

Sand and Gravel Filter



reddit.com

Filters large particles as well as basic filtration of bacteria and chemical substances by charcoal, use of activated charcoal amplifies this process.

Activated charcoal is charcoal that has been heated or otherwise treated to increase its adsorptive power.

Low-tech Liquid Compost Maker



Low-tech lab

This low-tech innovation made by the low-tech lab uses a number of vertical modules to convert organic waste into a liquid compost rich in nutrients suitable for growing plants with.

Low-tech Biofilter



Low-tech lab

A biofilter is used to activate nutrients that exist in liquid compost to be usable for plant growth and would be the final step in providing a nutrient solution for a hydroponic system.

Learning outcomes

In conclusion, many of these existing technologies and initiatives have been of inspiration for the final design of this challenge. However, the main learning points taken from these technologies are as follows. Hydroponics is one of the most efficient farming strategies when it comes to urban farming. It uses very little water which can even be reused in multiple cycles. Some of its systems use up very little space as they can be set up vertically. Furthermore, the use of non-organic substances as media for the roots to grow in is advantageous as no fertile soil is required for the plant growth. In particular the NFT hydroponics system is of great value for this challenge as it can be set up vertically, water can be reused and it can be set up in a

way that no pump is required but watering is still automatic. This could serve as a great model for the start of this design.

Furthermore inspiration is taken from the low-tech lab with their vertical hand pump, to move water to higher containers, their liquid compost maker to generate nutrients for a nutrient solution and their sand and gravel filter to reuse grey water from the surrounding households. This has inspired autonomy in the water component of the design as. Water would be the most important as well as most scarce resource in the slums. Autonomy with regards to water would give a great advantage to the design.

The use of plastic water bottles as pots or tubes from various designs around the world has demonstrated how hydroponics can be built using waste material lending to the idea of building the complete design out of waste available in the slums.

In conclusion hydroponics is the most important farming system to take as inspiration here, with applications of hydroponics in low-tech showing what is possible, to which extent one can take hydroponics. Finally combining a number of existing technologies and innovating a little would allow for a very versatile design which can function in complete autonomy which is the goal of this challenge.

Principles and regulations that shape the niche of Indian Slums.

Our niche is the slums of Mumbai, the design challenge is to battle the food insecurity problem the stakeholders are facing on a daily basis. This will be done by trying to implement a design which will provide them with food. The design should be space efficient and fit in the slums to ensure people are able to use it. There are more factors influencing the design, those being political and economic rules and regulations. However, there is an ongoing project to move the slums into apartment buildings, which will influence choices made during the design process. The apartments will probably be bigger than the space they have now and they may get access to a more reliable source of water, which is a different context than the slums. The design could be a bit bigger and more dependent on water, although it will still be as space- and water efficient as possible, since the original context is still the slums.

The Government of Maharashtra has set a goal to make Mumbai slum-free by 2022 (Zhang, 2016). However, due to the slow rate with which the transits occurs, this is unlikely to happen. Still, we should take into account that in the next decade, a big part of our target group might be moved to apartment buildings. Therefore the design should be easy to either move or recreate.

In September of this year (2020), three new bills got introduced in India, giving farmers more power and they were meant to increase farmers' profits. The bills loosen rules around sale, pricing and storage of farm-products, rules that were meant to protect the farmers from the free market. This doesn't influence our design directly, but it may help our stakeholders when they want to make profit with our design, since it will be easier to enter the market and make a small profit. Furthermore, it could lower the interest in our design, because food will be cheaper, so the design should still be useful, despite an increase in food security. Therefore, the aim of the design could change to be a supplement for diets or a source of income, rather than a source of food. Before these bills, farmers could only sell their yield to government-controlled markets, acting as a middleman between farmers and buyers, cutting the farmers profits. Now, farmers are able to sell directly to private players, which will drive down prices due to competition.

However, some farmers are not happy with the new bills, since it is not clear how this will work out in reality. Farmers are mostly scared these regulations will end the assured prices and wholesale markets, taking away their back-up for when they can't sell their products. When the farmers will sell to the players, the governmental markets will pack up and eventually the players will start exploiting the farmers, since farmers can only sell to those players. In the regions Punjab and Haryana the protests are the worst, since production there is so high, only the government is able to buy such quantities at the set price.

Conclusion

In conclusion, the study of the food security problem in India before the context pandemic and the effects of the lockdown on this focuses the challenge on food security and malnutrition. It will continue to threaten the health of the lower-class populations in India even outside of a pandemic situation. A solution that focuses on this issue, would design for a product that would

be useful in similar pandemic situations in the future, as well as in daily life during the normal state of affairs. The context study frames all the considerations to be taken into account when ideating a design solution.

The theories and concepts such as the Socio-Ecological Theory, the circular economy, the low-tech philosophy

as well as the health guidelines drawn by the Indian government specifically the AYUSH ministry have helped frame the direction in which to look for solutions.

Furthermore the analysis of existing technologies and innovations in the niche as well as the field in general has brought the solution within grasp.

Finally, the analysis of the stakeholder and analysis of design ethics and appropriateness of design have helped draw up the requirements for a possible design solution that can be seen in the script of the design below.

All these considerations will insure the designing of an innovative and efficient design which is ethically and contextually framed in the context of Mumbai's slums and all this thanks to the in depth study of the context above.