CLIMATE RESPONSIVE URBAN PLANNING

in EL GAMALEYA, CAIRO

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IN
ARCHITECTURE
AND
PLANNING

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INTRODUCTION

written by Lisa Harseim

Fig. 1: Panoramic view of the city of Cairo

The Master of Science Resource Efficiency in Architecture and Planning (REAP) is graduate programme offered by the HafenCity Universität Hamburg (HCU) since 2009 which focuses on sustainability and the efficient use of resources in architecture and urban development in different geographic and cultural contexts. The third and last coursework semester culminates in the combination of gained skill and knowledge through the undertaking of an international research project.

Fig. 2: The multi-layered city of Cairo

This brochure documents this research project's scope, methodological approach, theoretical analysis and results, as well as their translation into urban interventions as proposed by the 7th generation of REAP students. The participants' variety of professional, academic, and cultural backgrounds finds expression in diverse, interdisciplinary, English-speaking teams bringing together specialized experiences for the greater benefit of project work.

Hence, this publication represents an overview of this unique work process portrayed through the condensed perspective of architects, civil engineers, social scientists, interior designers, anthropologists and urban planners.

Fig. 3: A glimpse of REAP students diversity

Owing to bonds on different levels between the Architectural Department of Cairo University (CUFE) and HCU, a cooperation was established in 2016 and the overall task for the international project could be set: generate concepts for sustainable climate responsive development in a historic urban area in Cairo, Egypt.

Fig. 4: REAP and Egyptian students at Cairo University

Thanks to the invaluable financial and organisational support offered by the German Academic Exchange Service (DAAD), a workshop with members of both universities specialized in the field of sustainability could be held from 4th until 10th of November, 2016. A vast amount of theoretical information and useful insights on Egypt's situation have been provided during lectures, project presentations followed by Q&A sessions, and evening events at the Cairo University and the DAAD headquarter in Zamalek. Excursions and trips to contrasting sites of attraction such as Cairo's crowning citadel - the green pearl of Al-Azhar park, the bustling Khan-el-Khalili area, tranquil mosques, and ancient heritage of the pyramids provided a lively and holistic view on the soul and character of the city.

In preparation for the trip to Cairo, six groups of 4-5 REAP students each compi-

Fig. 5: Marvelling at the city

led and presented background knowledge about Cairo in general and on key topics specific to the REAP master course: water, energy and material cycles, and urban development (see chapter *REAP Topics*).

Upon arrival to the study area, groups

Fig. 6: Al-Azhar Park contrasting with its urban context

were intermixed with students of CUFE in order to incorporate insights of local experts and apt guidance during site visits and urban analysis. Points of interest, building materials, urban patterns, open and green spaces, and land uses were mapped and documented through photographs and surveys of local residents. These shaped a more realistic impression and served as scientific groundwork for the following urban intervention proposals. Preliminary research results were presented at the end of the Cairo workshop and further perfected into more complete sets of recommendations following the return to Hamburg.

The 7th generation of REAP Master students would like to thank the professors and staff of the cooperational partners of HCU and CUFE for their tireless efforts, especially Prof. Wolfgang Dickhaut and Prof. Sahar Attia. We thank our instructors Sonja Schlipf and Annegret Repp for organizing the project coursework, showing support, and offering constructive criticism.

Additionally, we would like to recognize our project tutors Mostafa Abd El Atif and Mahmoud Hussein for guiding our steps in their mysterious yet fascinating home country. Finally, we thank all student partners in Cairo for their warm welcome and continued support throughout the entire project period.

FIG. 8: PARTNERSHIP OF REAP AND CAIRO UNIVERSITY VIA DAAD

M.Sc. (REAP) Year 1		M.Sc. (REAP) Year 2		
Semester 1	Semester 2	Semester 3		Semester 4
Project I (5 CP)	Project II (10 CP)	Project III (10 CP)		Thesis Project (30 CP)
Methods of Integrative and Urban Planning (5 CP)		Plus 2 Modules from each block		
		Block 1: Resources, Technologies and Environment	Block 2: Resources, Institutions and Instruments	
		Climate Responsive Architecture and Planning (5 CP)	Economics and Planning of Technical Urban Infrastructure Systems (5 CP)	
Facets of Sustainability (5 CP)	Urban Material Cycles (5 CP)	Technologies for Sustainable Water Resource Management (5 CP)	Decision Support and Project Evaluation (5 CP)	
Legal and Economic Instruments (5 CP)	Urban Energy Flows (5 CP)	Urban Traffic and Noise (5 CP)	Material Flow Analysis and Life Cycle Assessment (5 CP)	
Research Methods and Statistics (5 CP)	Urban Water Cycles (5 CP)	Technologies for Sustainable Material Cycles (5 CP)	International Development: Institutions and Policies (5 CP)	
Studium Fundamentale (5 CP)	Studium Fundamentale (5 CP)	or instead of one Module General Elective		

Fig. 7: Structure and key topics of M. Sc. REAP

BACKGROUND

written by Defne Yener & Fernando Miramontes

Fig. 1: Cairo cityscape from the top of the citadel

CLIMATE

Cairo's climate can be labeled as BWH under the Köppen climate classification - an arid desert type with warm or hot days, and cool nights. On average, the city only receives one centimeter of rain per year but has high humidity due to its proximity to the Nile River. Summer temperatures are around 35 °C on average. Cairo and Egypt as a whole are particularly vulnerable to climate change, with increased drought rates that put pressure on the food supply and the already suffering Egyptian economy [1].

A HISTORIC, POLITICAL, AND ECONOMIC FOCUS ON CAIRO

Aside from the rise and fall of the ancient Egyptian civilization since about 5000 year BC and a coptic era, Cairo was the center of four major political and economic periods which shaped the city into who and what it is today. For about a thousand years, the Islamic, Imperialist, Arab Socialist, and Transitory Capitalist eras each have had a distinct impact on the city in many different built forms which convey much of the social structure that is echoed from the unpredictable economy, turbulent politics, and the arid landscape [2, 3].

The city itself was founded in 969 AD by the Fatimid Caliphate, an offspring of the powerful era of Islamic rule characterized by a productive time period for city-building. Upon its foundation, it took Cairo four years to be built and serve as the capital of the Fatimid. This significant Islamic period was also known as the Islamic Golden Age, where Cairo started its contribution to Islamic enlightenment with the Al-Azhar University from 970 AD, which still stands and serves today. After the Fatimid dynasty, Cairo was the center of the Ayyubid Caliphate, ruled by the infamous Saladin against European Crusaders, who laid the foundations of the largest monument of Cairo: the Cairo Citadel, walls that surround the old city [4, 5].

A hundred years after Saladin and the Ayyubids, Cairo was seized by the Mamluks. During this period, Cairo had already a population of almost 500,000, had established a stronger and adequate city infrastructure, and was an important academic and economic center. Eventually, the city lost its allure during the Ottoman rule (1517-1867) as alternative routes for the spice road were found and Cairo became a mere province. However, the city kept on growing outside the walls of the Citadel towards the south and the west, eventually becoming the second largest urban concentration in the area, after Constantinople. As its decline years were approaching, French and British occupations were influencing the urban structure as well as kindling internal political turmoil [4, 5, 6].

Modern Cairo was found thereafter, with the leadership of Muhammad Ali Pasha under the British occupation of Egypt. His British backed rise subsequently ignited an era of western modernization which introduced Egypt to British Imperialism under the rule of Isma'il Pasha, wherein Cairo was equipped with dashing maidans and avenues which are still standing today in downtown area, including the notable

Fig. 2: On the way between Old and New Cairo, Citadel Mosque of Mohammed Ali, and Tombs of the Mamelukes

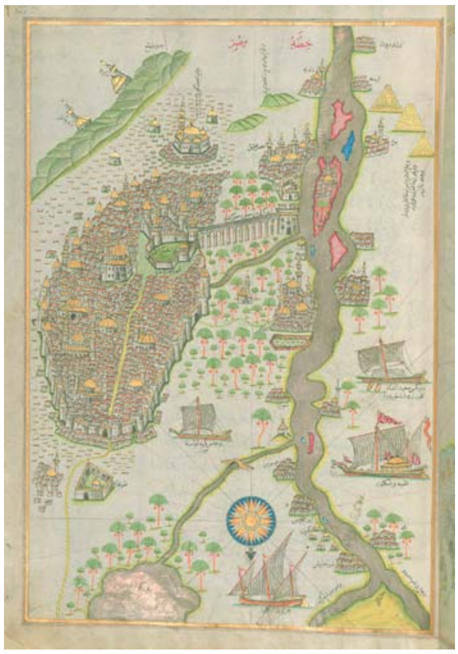


Fig. 3: Map of Cairo under Ottoman rule

Fig. 4: Tahrir Square on November 18., 2011

Tahrir Square [7].

The endeavours of modern Cairo had put Egypt in additional debt and forced capitulation to and de facto rule of the British occupance. Its economy was then dependent on European forces such as Italy, France, and, of course, Britain, leading the administration of major agricultural lands and precious cotton fields in the outskirts of Cairo into colonialism. Nonetheless, the rapid Europeanization of the city had also given birth to a new intellectual class which was inseminated by European philosophy and socialist doctrine, in particular [1, 8]. The intimate relations with the monarchy of the United Kingdom had taken its toll on the people of Egypt, dividing the country on social, political, and economic aspects, with results depicting symptoms of a colonized territory.

Some 60 years after Muhammad Ali Pasha, on the 26th of January, 1952, Cairo survived what is known as the “Black Saturday”, a day of riots and looting as well as killing of 10 British appointed soldiers [9]. This internal unrest was merely a hint of what was to come; on July 23rd, 1952, military officers Muhammad Naguib and Gamal Abdel Nasser led a military coup, famously known as the July 23 Revolution, causing the abdication of King Farouk, the last sovereign from the Muhammad Ali Dynasty [1, 10].

Fig.. 5: King Farouk and Frank D. Roosevelt at Great Bitter Lake in Egypt on February 13, 1945

Fig. 6: President Muhammad Naguib (left) and Prime Minister Gamal Abdel Nasser (right) during the second anniversary celebrations of the 1952 Revolution

URBANISM

written by Defne Yener

Fig. 1: From left to right: Cairo in Egypt; El Gamaleya in Cairo; project site in El Gamaleya

LOCATION

El Gamaleya (the name was most probably derived from "Al Jamali" meaning *aesthetic* or *beauty*) is a Qism (meaning *section*) partially bordered by the historic city walls and located on the eastern side of the Nile in downtown Cairo. The district encompasses 1.16% of the entire Cairo population [1] and it hosts the historic Khan el-Khalili Souk (meaning *open-air marketplace* or *bazaar*) with its handcraft shops, perfumeries and herbalists, as well as gold and copper work ateliers, all of which are open around the clock throughout the year.

In fact, life in this part of El GAmaleya starts relatively late during weekdays when coffee shops quickly fill up with various people, keeping the area up and running at all times. As this southernmost sector of the district is greatly conveyed as a tourist attraction, northern sectors harbour a micro-cosmos made up of dusty, narrow streets, waste filled open spaces, ascending semi-formal buildings, large jerry-built pigeon cages, and cramped neighboring houses.

Amidst this complex urban space, the project site sits on the western side of the Qism, consisting of an approximate total of 670 lots and 13,216 inhabitants who live in severe environmental and urban conditions, decidedly under the poverty line [1].

URBAN FABRIC

Various structures of historical, semi-formal, and under-construction buildings are woven together, towering over the narrow streets that meticulously connect the four busy roads which environ the sector.

The semi-formal constructions in the area are unambiguous, since the government is tolerating these settlements as long as they regularly pay for infrastructure services. Unfinished facades, new storeys, and occupied open spaces are common [2]. This pattern appears omnipresent as the buildings are adjoining and open spaces are considerably less common compared to the built-up space, representing only about 4% of the total area of El Gamaleya [3]. Vacant lots that stand dwarfed under the 5-8 storey buildings are predominantly used as waste disposal areas often overflowing onto the narrow streets.

Fig. 2: Street vendors in El Gamaleya

In comparison to the south of the Qism, the research area is predominantly residential; however, a striking number of artisan workshops and kiosks are found on all the main streets as well as branching roads. Mosques are common gathering spots and quite numerous in the area.

ACCESSIBILITY

The study area is encircled by four busy streets and avenues which also demarcate its' limits. The Al Banhawi Avenue lies on the northeastern line, joining the Port Said/El Gaish Avenue on the northwest.

The two busiest roads are densely occupied by motor vehicles and ensure accessibility for any external services that are provided for the location. To the southwest lies Amir Al Gyosh Al Goani Street, which is quite narrow but also highly congested during daytime - a route accommodating important daily commute and service by means such as waste collecting donkey carts and small private motor vehicles.

In addition, the Amir Al Gyosh Al Goani Street is quite significant for connecting the busy El Gaish Avenue and the Al Moez Ldin Allah Al Fatmi Street to the southeast, which is the extending street for the Khan el-Khalili Bazaar. Both streets to the south are densely flanked by local shops, workshops, cafes, and mosques while heavily affected by congestion leading to frequent conflict amongst vehicle drivers and pedestrians.

The streets inside the study area are similarly dense and exceedingly narrow, in some cases the street width not exceeding 1.5 meters. This significantly restricts motorized mobility in the area, causing vehicles to use to wider streets and leading to a heterogenous traffic distribution.

BUILDING MATERIALS

written by Gema Nugraha & Petrut Ababei

Fig. 1: Informal conversion of a balcony into an additional room

The study site in El Gamaleya presents several building uses such as residential, commercial, and even industrial, with the dominant building type being the multi-story apartment block.

Lower levels often host corner stores or cafes catering mostly to the locals, as well as small shops producing shoes, furniture, and metalwork further distributed to local merchandisers around Khan Al Khalili area. For the most part, building materials reflect cost-effective solutions for high density residential area with inhabitants of lower socio-economic status.

Fig. 2: Typical building

STRUCTURES

Most buildings in El-Gamaleya feature a reinforced concrete structure with a brick fill. As exceptions, buildings with a wood structure and concrete facade were also observed in this area. Building heights vary to accommodate 5 to 8 storeys and flat roofs. Some of these roofs are used as mounting points for TV antennas or to host bird cages.

Open and enclosed balconies are present on each level and refurbishment status of facades reflect varying inhabitants' economic potentials. In an area with a fair share of informal constructions, the urban fabric of El Gamaleya is characterized by a high average ratio of building height to building distance.

Particularly in older or informal buildings, load bearing walls are constructed out of larger than usual bricks. Many of these structures appear badly damaged or seem to have reached their end of lifespan (figure 3).

The narrow streets are often in poor condition due to damaged or inexistent pavement.

Fig. 3: Load bearing walls

WINDOWS

Window opening types reflect a mix of cultural norms, climate constraints, and availability of modern construction materials. A *trellis* wooden window (figure 4) is typical for El Gamaleya. Lacking glazing, the window features adjustable shutters protecting from direct sun and helping create natural ventilation for the indoor spaces.

Non-traditional window structures with rectangular wood or metal frames and glazing are also irregularly adopted as options for refurbishment of openings or enclosed balconies (figure 2).

AD-HOC TECHNICAL SYSTEMS

Wastewater pipes and water supply lines, electrical cables, or auxiliary technology such as pumps or generators can be observed on building facades (as shown in figure 5). Some of these systems either replace or compensate for the inadequacy of formal building infrastructures and municipal levels of service for water and electricity supply. Such improvised informal additions present various levels of deterioration, with leaking pipes being a major cause for localized deterioration of exterior walls.

Fig. 4: Typical window openings

Fig. 5: Typical infrastructure for water supply and wastewater seen in El Gamaleya

REAP TOPICS

Sustainable Urbanism

Water

Energy

Waste and Material

SUSTAINABLE URBANISM

written by Sibel Sarper, Maria Jose Mujica von Seggern & Annika Stein

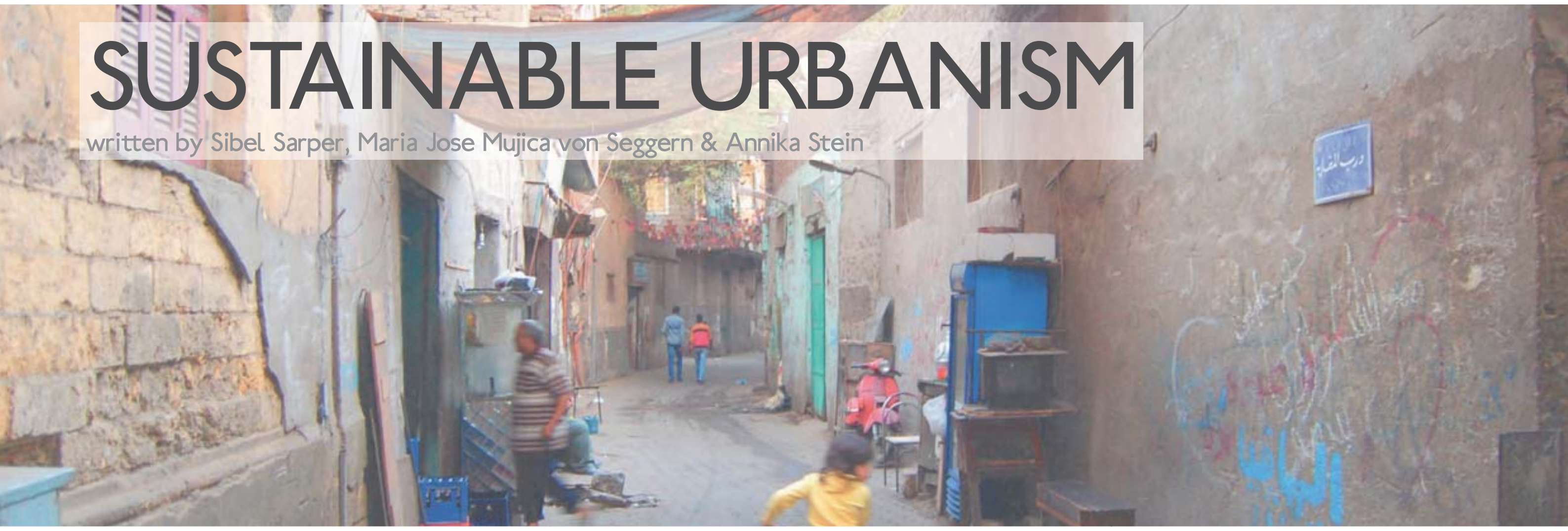


Fig. 1: Street in El Gamaleya

Sustainable urbanism is comprised of the interconnections between different aspects such as the cultural, social, and economic situation specific to an urban context. There are several goals of sustainable urbanism in order to achieve a high liveability [1]. Several of these goals are discussed below with reference to the study area.

Regarding traffic, El Gamaleya is surrounded by several large streets with micro, mini and larger busses as part of the public transportation system. Due to the size of the district and its narrow streets, there is no public transport within the district. People mostly walk or use scooters. Bikes are rather uncommon. To avoid speeding, improvised traffic calming devices made of tires have been installed by the inhabitants. For large and heavy goods transport, small trucks and carriages which are sometimes pulled by donkeys, are used.

Fig. 2: Open space in front of Al Jame' Al Anwar

To improve lifestyle and reinforce tradition, a goal of sustainable urbanism is to create and interconnect green and open spaces. Since El Gamaleya is a very dense area, there is a general lack of open space and only little greenery. The largest open space is located right outside the district in front of the mosque Al Jame' Al Anwar. It is very well used by inhabitants as well as tourists. In the narrow streets of El Gamaleya, trees are very rare, but in some cases some greenery has been planted and maintained by the initiative of the residents. The government has also implemented a larger green park space in front of the great wall, surrounded by trees and a fence. However, this area is not well-utilized by residents.

Another goal of sustainable urbanism is employment to guarantee a source of income. There are several small industries in the district, such as bakeries and metal or wood works. Women also sell local goods to people passing by. Still, many residents of El Gamaleya struggle to find a job to make enough money to meet their basic needs. Some are even forced to cut down food consumption because of their fragile financial situation.

A sustainable city should offer a certain comfort level while keeping its identity. Since El Gamaleya has been an informal settlement, building standards were not followed. Neighbourhood industries are not regulated, streets are designed too narrow and only little room is left for open space, impairing a healthy microclimate. These conditions lead to poor air quality and the heat island effect. High indoor air temperatures contribute to the decrease in comfort level as well. In addition, safety is endangered when houses do not have emergency exits, lack fire truck and emergency service accessibility, or the structure is unstable.

In El Gamaleya, the goal to create a relationship between the community and the government is not fulfilled at all. The government struggles to accept the informal settlement and to take responsibility for the residents, while the inhabitants have a strong distrust in any intervention planned by the government. There is a constant fear that buildings will be taken down and people relocated.

Despite all unfavourable circumstances, there are two potentials for further projects. First of all, the use of available space resources can still be improved. There are several vacant lots and roof tops, either empty or filled with materials from demolished buildings or waste. If cleaned up, they could be used for new projects, although it is important to consider ownership issues, if any.

The second potential of the district is the well-developed social harmony and interaction. Residents meet on a regular basis within a community board and have a designated community leader. These strong ties between locals can help with implementing and supporting new community projects.

In El Gamaleya, most goals of sustainable urbanism are not yet achieved. Although one of the main challenges for meeting such goals is the lack of space, there is still great potential to improve liveability.

Fig. 3: Roof tops in El Gamaleya

WATER

written by Nikita John

Fig. 1: Manhole for accessing water pipes in El Gamaleya

FRESHWATER MANAGEMENT

The river Nile has been more than just a source of water for the Egyptian civilization, with its yearly flooding producing some of the most fertile land in the world; the locals consider it a blessing from the gods. However, since 2005, Egypt has been classified as a water scarce country by the United Nations. With only 18 mm yearly rainfall (1.8 bn. m^3) in Egypt, the Nile currently provides 98% of the water used by the country (55.5 bn. m^3 yearly), crucial for the intensive agriculture that supports the economy [1]. Of the total water consumption, 15% can be attributed to industrial and municipal use [1], and, with the growing urban population, this demand is projected to rise rapidly [2].

Fig. 2: Dense urban settlements leave little space for improving infrastructure

In Cairo, the Ministry of Water Supply and Sanitation Facilities supervises the formal water supply and sanitation services, along with the Cairo and Alexandria Potable Water Organisation (CAPWO) and the National Organisation for Potable Water and Sanitary Drainage (NOPWASD). According to official statistics, the current coverage of water supply services has reached 97% for urban population [3]. However, for the 65% of the Egyptian population living in informal areas, the numbers are a little different, with 40% receiving water for 3 hours or less per day and another 30% having no access to formal supply [4].

El Gamaleya is part of a historical area that was designed to have infrastructure to support formal supply of water; however, in time, these systems have experienced significant deterioration due to little or no maintenance. While the price of the water in Egypt is one of the lowest in the world [5], this does not seem to affect the prevalence of illegal and therefore unmetered connections.

The cost of water does not reflect its value but, given the country's precarious economic situation, the government fears that a hike in prices could spark another revolt amongst the common people [2]. Meanwhile, high operating costs of water treatment plants cannot be balanced by supply revenues and seriously threaten the quality of water supplied.

While water is frivolously used for daily chores, safe drinking water is another serious challenge. Residents opt for alternative sources, often risking unsafe conditions of storage and high prices.

Fig. 3: Street watering carried out by a water truck or manually, is a common practice in Egypt

WASTEWATER MANAGEMENT

Cairos wastewater is channeled through its crumbling sewer system to the 6 operating wastewater treatment plants serving the Greater Cairo area. These plants discharge the treated water back into the Nile. Despite stringent laws, lack of monitoring leads to situations where, yearly, 125 m. m^3 industrial wastewater from factories is discharged with little or no treatment [6].

El Gamaleya's situation displays the neglect suffered by the city's system. Leaks from the existing system contribute to unhygienic conditions on the streets and infiltrate the groundwater. In certain areas, this leads to increased groundwater levels causing damage to buildings, both residential and historical.

Fig. 4: Damage caused to buildings by rising groundwater levels

With an intent to improve the status quo, water treatment plants have been planned for this area. With plans of using treated wastewater for irrigation, increasing efforts are made to reform the efficiency of the freshwater and wastewater management systems.

ENERGY

written by Ziva Hanzic & Fano Sutrano

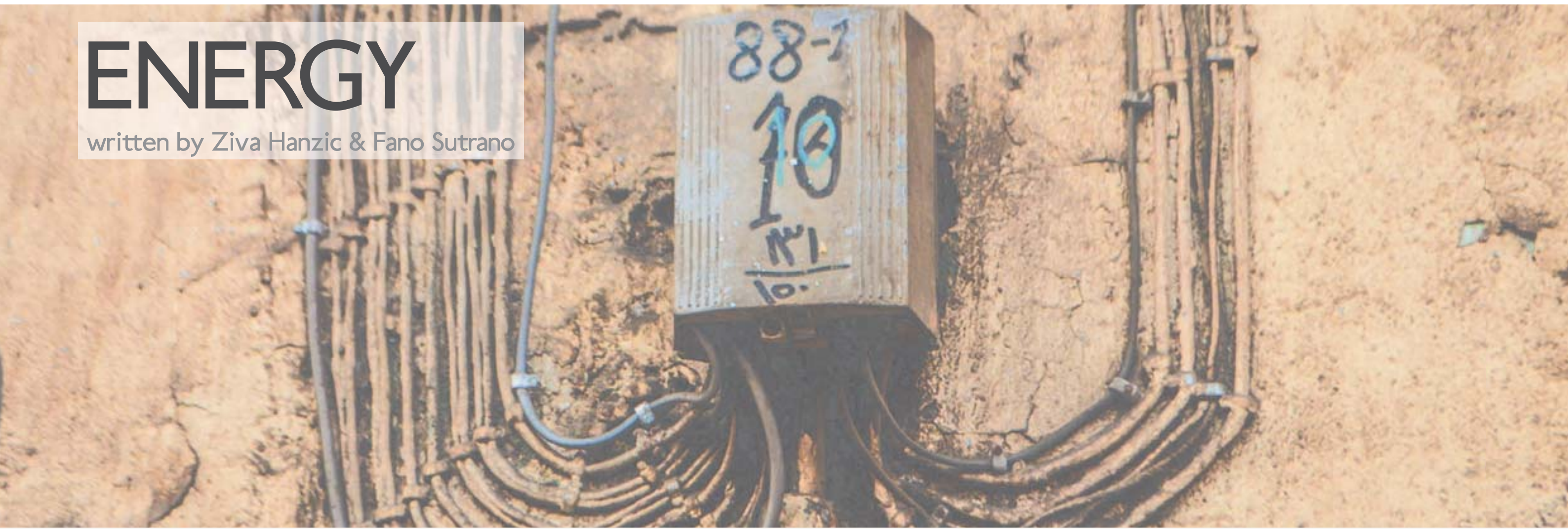


Fig. 1: Old electronic distribution box fixed on an external wall in El Gamaleya

Once an exporter of oil and gas, Egypt is now struggling to meet its own energy needs. With a current population of 94.5 million [1] which is rapidly becoming urbanized, substantial energy supply is needed to support demographic growth and relocation into the cities. The amount of energy needed for production of a GDP unit in Egypt is the highest in the region and four times higher than the energy intensity in industrialized countries - 1,742.91 kWH/ capita in 2011 [2].

Since the end of the Mubarak era in 2011, the steady energy production has been compromised. In fact, Egypt has experienced several occurrences of load shedding during the past years, and is predicted that by 2022, it will suffer a severe electricity deficit of up to 6 GW [3]. This has pressured the government to confront the problem in two ways by seeking for additional power generation options and better managing the demand for electricity.

The country currently generates 95% of its energy from natural gas and oil [4] as shown in figure 2. In the context of a growing population, the increasing price of gas and oil extraction adds pressure on the energy supply system. As the prices for renewable energy become more competitive, an increased focus on developing the specific infrastructure may result in a shift away from fossil primary sources. Presently, the share of renewables is 4% of total energy produced [4] and the government's goal now is to increase it to more than 20% by 2020 [5]. The improvements in the projected energy mix in the future can be observed in figure 3.

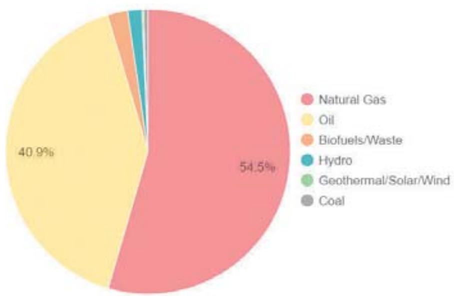


Fig. 2: Share of total primary energy supply in 2014

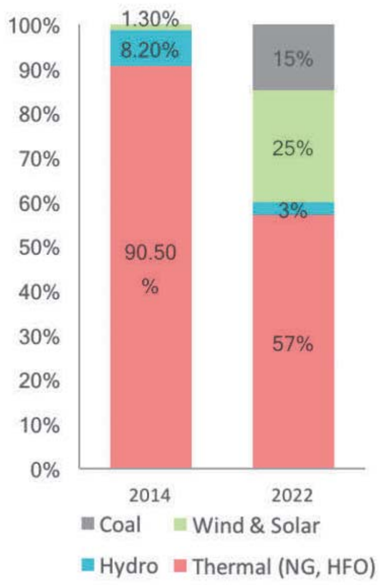


Fig. 3: Electricity mix: 2014 data vs. 2022 projection

The country's future development strategy is looking to ease the electricity demand on share produced by the Nile river. Anticipating the increase in oil and gas price, Egypt intends to promote the development of solar and wind energy for its future energy structure. The initiative is further supported by the government through the introduction of a feed-in tariff regulation for electricity generated from renewable sources. Additionally, there is an intention of addressing constraints on land access and financing related to the exploitation of clean energy [3].

From the perspective of energy efficiency, Egypt has made several notable initiatives that were encompassed in the 2010 National Energy Efficiency Action Plan (NEEAP) under the guidance of the Minister of Electricity & Renewable Energy. These include the implementation of efficient lamps for street lighting and commercial purposes, labeling and standardization program for various home appliances, and the setting of energy efficiency codes for residential, commercial and public buildings, among other measures [6]. Despite these actions, further development is inhibited by challenges such as lack of public awareness and project financing [3].

During field visits, El Gamaleya exhibits the characteristics of a residential or mixed-use informal area. The resident population appears to have low electricity consumption, most of which would be spent for cooling purposes, lighting, and home appliances. However, the actual energy consumption patterns are difficult to map due to a mix of user behaviour, buildings condition, and economic activities. Addressing energy issues in this area would require more detailed studies and effective regulatory institutions.

WASTE & MATERIAL

written by Beatriz Campos, Jovana Pavlicevic & Mehul Khoont

Fig. 1: City of bricks, a view of Cairo from the citadel.

BUILDING MATERIALS

The historic district of El-Gamaleya is located close to the bazar Khan el-Khalili - a major tourist attraction - and adjacent to the remains of the historic city wall. Within the area, many buildings appear neglected, abandoned, or on the verge of collapse. Subsequently, a lot of plots are under-utilized [1].

Fig. 2: Degraded buildings in El-Gamaleya

One of the jewels of old Cairo, Al-Moez Street, was founded in 969 AD by the Fatimid dynasty and restored in 2014. Along the street, one can observe traditional house types made of stone, wood, and brick.

However, along the adjacent smaller streets connected to the lively Al-Moez, buildings inside the El-Gamaleya district are predominantly in contrast with traditional typology and materials, many being erected on a concrete frame structures with an infill of bricks [2].

Fig. 3: Al-Moez Street

The combination of historic urban fabric with buildings in a precarious state of conservation and unplanned informal multi-storey concrete and brick structures poses significant difficulties for urban intervention proposals.

Fig. 4: Degraded buildings in El-Gamaleya

WASTE MANAGEMENT

Cairo is known to have serious waste management problems. Cairo's municipal solid waste generation is approximately 16,000 tons/day, accounting for 1.80 kg/cap/day, while most lower middle income countries produce 0.79 kg/cap/day. The waste is composed of 50-60% organic waste, 10-15% plastics, 8-12% paper, 1-3% metals, and 13-21% as other type of waste. The western zone, where our site is located, produces 2,550 tons/day [3].

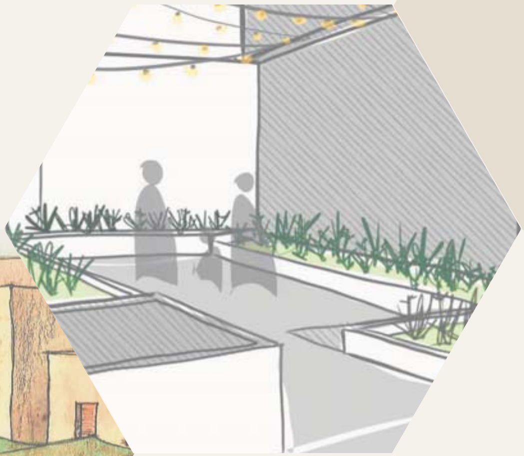
Waste management is partially fulfilled by formal actors, who collect around 51% of all waste. Informal collectors also play an important role in waste collection. The Zabbaleen are one of the major informal collectors, handling about 1,500 tons/day. These traditional informal collectors began their activity during the 1940s as they settled at the edge of the city; they currently sort and recycle about 80-85% of recovered materials [3].

Fig. 5: Fraction separated Informal waste collection

As Cairo grew, the traditional Zabbaleen waste collection system could not keep up with the pace and a formal collection system mainly controlled by the AMA Arab Environment Company (AAEC) was introduced. The AAEC are a local subsidiary for AMA International and are now one of the largest companies in Egypt in the field of solid waste management, focusing on street cleaning, container collection, treatment and disposal [4]. Currently, the formal sector collaborates with the informal sector for material recovery from the collected solid waste to achieve a higher rate of waste recycling in Cairo [5].

FEATURED PROJECTS

Decentralized Greywater Recycling



Urban Agriculture

Passive Cooling & Shading Methods

Local Energy Generation

Waste 2 Knowledge

Sustainable Community Niches

Decentralized Greywater Recycling

written by Petrut Ababei, Lisa Harseim, Lucy Henriques & Nikita John

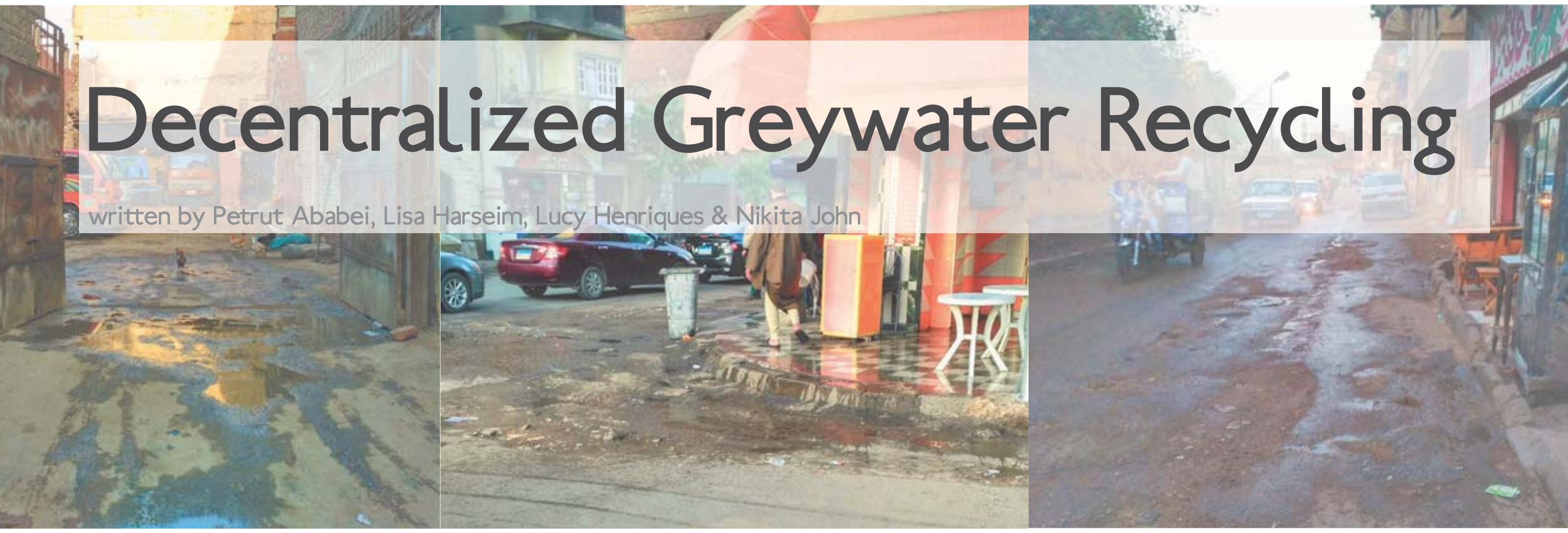


Fig. 1: Images showing use of potable water for the common practice of street watering

THE EXISTING SITUATION

For a civilization that grew knowing the abundance of the Nile, a lifestyle constrained by acute shortage of water seems unimaginable. Cairo is dependent on a government controlled water supply and has one of the lowest municipal water tariffs in the world. While it makes the resource accessible to its growing low-income population, the pricing approach does not reflect the water shortage or cost of treatment and maintenance of infrastructure.

By contrast, the islamic faith considers water the source of life and condemns the waste of water. In a country plagued by political turmoil, military control of social life, and economic crisis, citizens and communities may not have much of a choice. In El Gamaleya, the water supply and sanitation infrastructure has suffered long-term deterioration, contributing to the problem of seepage of untreated water into the groundwater and the inefficiency of the entire system.

Since any improvement would require overhauling the entire existing infrastructure, decentralised solutions may prove quite successful as the next best approach. Reducing the community's dependence on the decaying municipal water system and engaging local stakeholders to gain and transfer water management knowledge could make for a more realistic solution under such circumstances.

Fig. 2: A public water cooler by the road side with a quote from the Quran

The objective of this project is to create a local, renewable, and high quality source of water using low-cost, small-scale, and low-impact technologies to treat greywater from residential sources. The focus of the research is to understand the feasibility of a decentralized greywater management in improving the environmental and social quality of life in El Gamaleya.

METHODOLOGY

Firstly, the project aims at the practical implementation of a decentralized greywater treatment system appropriate for the urban context of El Gamaleya and developed in line with socio-economic constraints and cultural characteristics. A second and arguably more critical aspect refers to the continued functioning and maintenance of the water treatment system, as well as the potential for replicating the pilot project onto additional locations. This second project objective has been identified as the *institutionalization of the community-based approach* in El Gamaleya and has as a more tangible outcome in the establishment of a civic foundation. Within these two objectives, the project aims to create added value for the locals by regenerating vacant plots and urban pockets in the area through the active engagement of the local stakeholders .

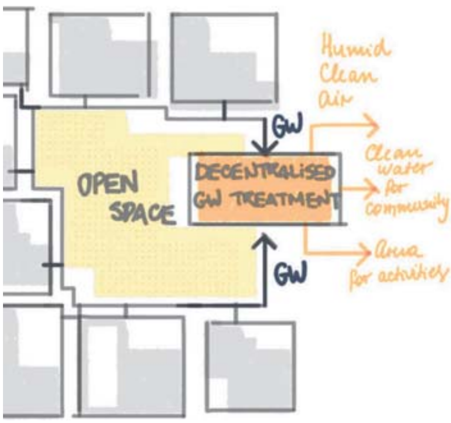


Fig. 3: Concept for El-Gamaleya

In addition, the production and use of recycled water enables the creation of a green, flexible use open space and better microclimate for the surrounding area as a result of evapotranspiration.

A technical analysis of the various wastewater treatment technologies and the available vacant plots was carried out, allowing for a selection of technology and space for pilot project based on relevant criteria. The resulting design method catered to all aspects described within the two project objectives. Requirements of a suitable technology include the ability to treat water with high levels of grease, fat, and oils, fitness for arid and hot climates, cost-effectiveness in terms of energy consumption, maintenance, and material requirements, as well as scalability.

MULTI-CRITERIA ANALYSIS

The concept of this project is to treat the greywater generated by the residents of El Gamaleya and recycle it with the aid of adaptable and decentralized wastewater treatment technology. The treated water will be used to cover a share of water demand in the area yet it will not be intended for domestic consumption. The target demand mainly includes watering of

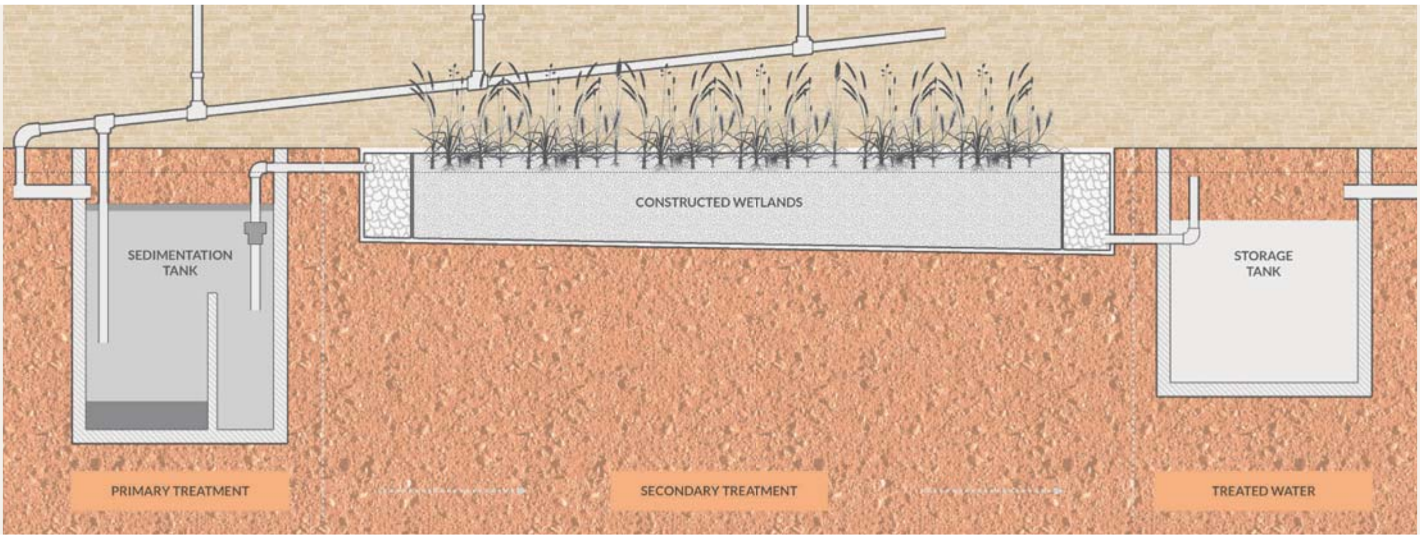


Fig. 4: Components of greywater treatment system for pilot project in El Gamaleya

the streets (an activity frequently practiced and currently making use of potable water supply) and greenery or other common non-potable public uses. Implementing the treatment system in the vacant lots makes it possible for the entire community to benefit from the water, a prerequisite for motivating various stakeholders around the concept.

Six treatment technology options were identified as generally eligibile for the given conditions and project goals: constructed wetlands (CW), upflow anaerobic sludge blanket reactor (UASB), compost filter (CF), trickling filter (TF), sedimentation tank (ST), and bio-sand filter (BSF). The multi-criteria analysis involved 10 criteria scored on a scale from 1-4, proportionally referenced to to their calculated minimum and maximum values. Higher scores are more advantageous; for example, a score of 1 is assigned to more complex technologies requiring expert installation while the simplest, least demanding ones were assigned a score of 4. The result of the multi-criteria analysis (figure 5) led to the proposed use of a combination of sedimentation tank for the primary treatment and a constructed wetland for the secondary treatment (figure 4).

The next step was to analyse all the vacant plots available for the project and the various opportunities of each plot. The preliminary study resulted in an outline of 24 plot boundaries and details regarding the type and scale of neighbouring activities, ownership, as well as details on building heights and access (figure 5). These indicators were used in calculations to estimate greywater supply specific to each vacant lot.

Fig. 5: Mapping and analysis of the vacant plots

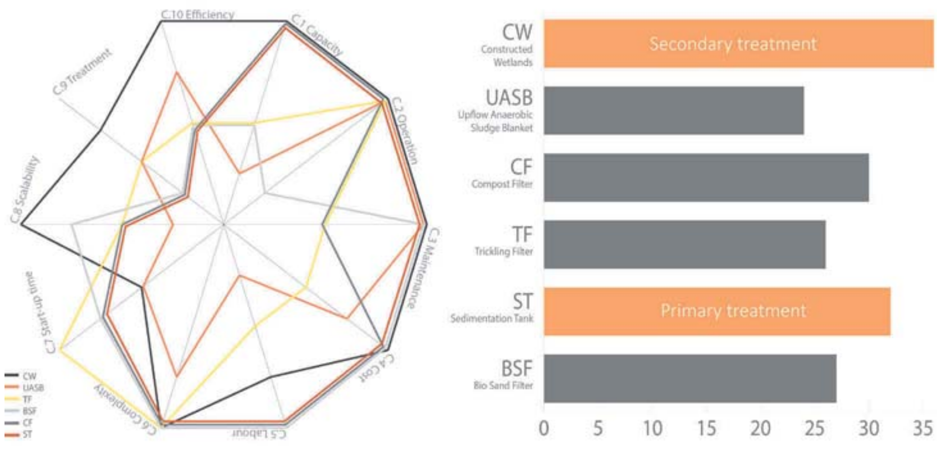


Fig. 6: Result of the MCA of technologies

DATA CONSIDERATIONS

Estimating the quantity and quality of the greywater influent is critical for further system sizing and overall development of the treated system. According to research, a household of approximately 5 people consumes around 1,000 liters of water daily, around 80% of that amount returning as greywater [1]. The kitchen is the main contributor to that amount, resulting in a high share of organic load and total suspended solids (TSS), both of which are critical when sizing the system.

For the purpose of further calculations, we defined a single floored traditional dwelling unit as an area of 90 sq. m inhabited by 4.9 people [2]. Daily water consumption producing greywater per dwelling unit is 995 litres/day [1].

TREATMENT TECHNOLOGY SIZING

Several different methods exist for the sizing of constructed wetlands for greywater treatment. Specific characteristics of the greywater influent as well as cultural, economic, and location context considerations led to choosing

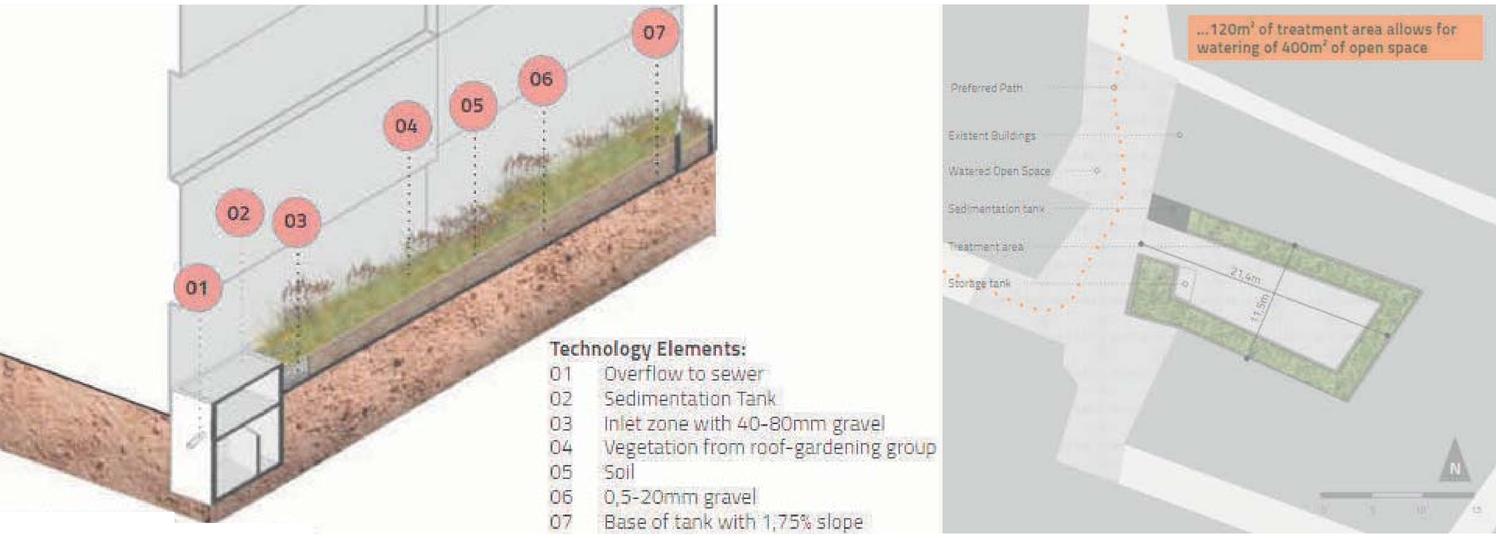


Fig. 7: Cross section (left) and plan (right) of the constructed wetland for the pilot project

a method based on rate of BOD5 removal.

The method's equation, also known as Kickhut's formula, returns area needed for treating influent of certain characteristics for a system operating at a certain temperature and expected to deliver effluent set according to legal standards for treated water.

Most lots suitable for CW technology implementation offer limited area for treatment. In addition, available space needed to be considered as a valuable resource for multiple aspects of urbanism. As such, the surface area dedicated to the wetlands was approximated as an acceptable compromise between competing areas of interest. Kickhut's formula was further used to determine the maximum greywater inflow and, therefore, the number of households that could be connected to the treatment system.

Several key variables were determined as universally applicable to pilot project and further applications. First, effluent BOD5 concentration was set to a maximum of 20 mg/l in order to meet Egyptian regulations for water treatment [3] and achieve a 90% treatment efficiency (CW influent BOD5 concentrations were calculated to be around 200 mg/l). CW bed depth varied between 0.6 and 0.8 m and the bottom slope was designed with a 1.75% incline in order to achieve gravitation-aided water flow. For a medium porosity of 35% and an operating temperature of around 20°C, the hydraulic retention time was determined to be about 4 days. Other variables such as bed surface and inflow/outflow daily capacity varied depending on the size of the vacant lot hosting the implementation.

APPLICATION

Baseline criteria constraining the urbanism proposal in general were identified with regards to functionality, maintenance, cost, scalability and efficiency. However, several non-technological factors such as design elements, risks, and, social potential were considered as well. The proposed design involved a careful evaluation of appropriateness for space entry size and location, shape, historic conservation and cultural sensitivity, as well as recreational potential in the macro urban fabric of El Gamaleya.

As a first implementation phase, one plot was chosen to showcase a pilot project. The arrangement of system technologies to border the plot (figure 10) aimed at leaving the center flexible for use by the community. It is critical to highlight that the chosen design was intended in accordance with the cultural aspects of the community and incorporates specific design elements of the arabic culture to it.

According to calculations, the 120 m² dedicated of treatment area on the specific lot can meet the demand for about 400 m² street watering (approx. 6 m³ of treated effluent).

STAKEHOLDER INVOLVEMENT

All project planning and implementation stages envision community involvement for developing, constructing, and operating an effective system, while the educational component aims to materialize into the basis of a civic foundation. A stakeholder involvement plan allows the project team to identify and effectively engage those parties with the highest degrees of power and interest. A

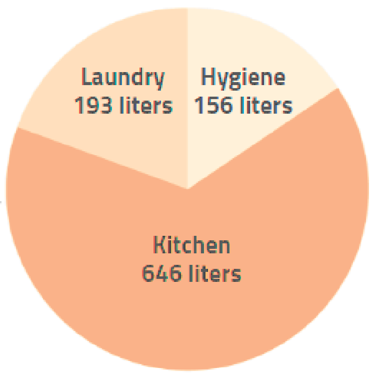


Fig. 8: Daily water consumption per household in El Gamaleya

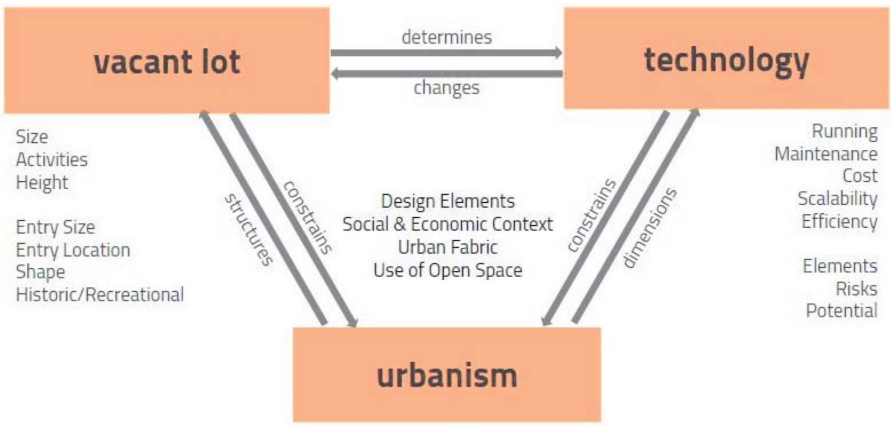


Fig. 9: Decision criteria used for the the design of the concept

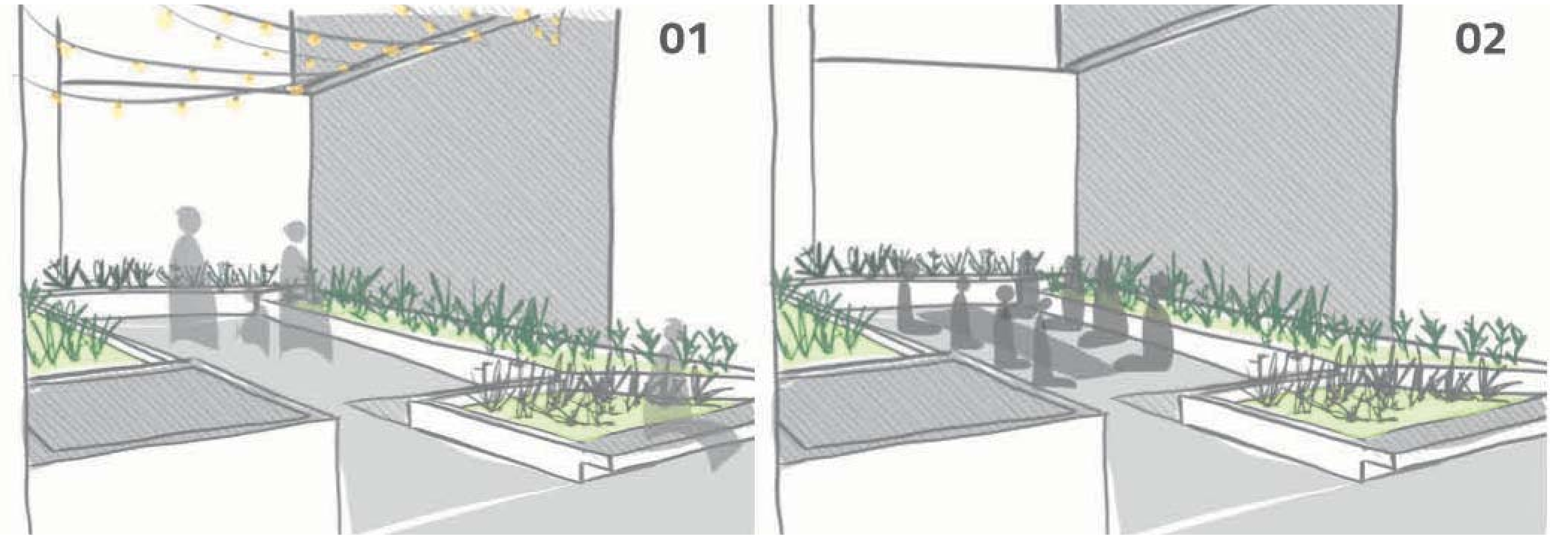


Fig. 10: Envisioned space designed to offer maximum flexibility for user activities

particularly important role will be played by mosques, shop owners, and potential NGO partners.

The feasibility of the project depends largely on local and regional conditions highlighting the importance of stakeholder involvement. In light of the the new draft law declared in 2016 regulating activities of NGOs and more control exercised by the government, the requirement of increased initiative from the locality was considered to be a priority in this project [4].

PROJECT OUTCOMES & CONCLUSION

This project aimed at exploring the feasibility of a decentralized greywater treatment solution and its potential to improve quality of life in El Gamaleya. While there is no unique definition for "quality of life", the concept is known to comprise several aspects of human well-being including ecological, economic, political, and cultural considerations. Figure 12 provides an overview of the direct and indirect benefits induced by the implementation of the treatment system and making recycled water freely available to the community.

With regards to energy, the low-tech treatment system allows for the reduced consumption of formal water supply, leading to reduced energetic cost for water treatment. The mainly passive character of the treatment system also improves the energy consumption pattern over the traditional wastewater treatment options. By improving the design of vacant plots and outfitting them with amenities that offer flexibility of use for the community, a practical motivation for taking care of the area is created. Further, development of appreciation for open space may hinder activities related with littering and more responsible usage of the urban area.

In terms of air and noise pollution, it is expected that the green space created can function as an air filtering device and the resulting evapotranspiration as microclimate regulator, while the vegetation wall around the plot can provide for a more comfortable, less noisy social gathering area. Simultaneously, the new space might bear a sense of local pride and ownership while also promoting the empowerment of men and women in the community by strengthening their organisational power and political voice.

Through a semi-public open space design utilizing a natural greywater treatment solution as a functional medium and aesthetic enhancer, the project aims to create a space adapted to its location within the neighbourhood and increase the awareness towards long-term maintenance of the public areas with tangible benefits for the community.

DIRECT EFFECTS	INDIRECT EFFECTS
Reduced energy cost due to use of recycled, local material Near-zero energy consumption for operation	Reduced overall energy consumption for water treatment processes Reduced cooling demand due to evapo-transpiration
Reduced consumption of potable water for uses that do not require drinking water	Less dependence on the centralized treatment system More efficient water use in the area Decreased overall water demand
Motivation for clearing waste from empty lots Use of recycled material	Environmental and social benefits while reducing carbon footprint Increased appreciation of open spaces
Shared urban space Integration of bottom-up, participatory approach Improved comfort through reduced heat and noise stress Recreational relief	Reduced vulnerability by strengthening community bonds Support of traditions by maintaining space flexibility Contribution to liberalisation of women and community Community empowerment & independence
Reducing costs for water use Potential papyrus harvesting Support of local economy	Improved atmosphere leading to increased attraction for consumers Increased resilience to market changes

Fig. 12: Project outcomes

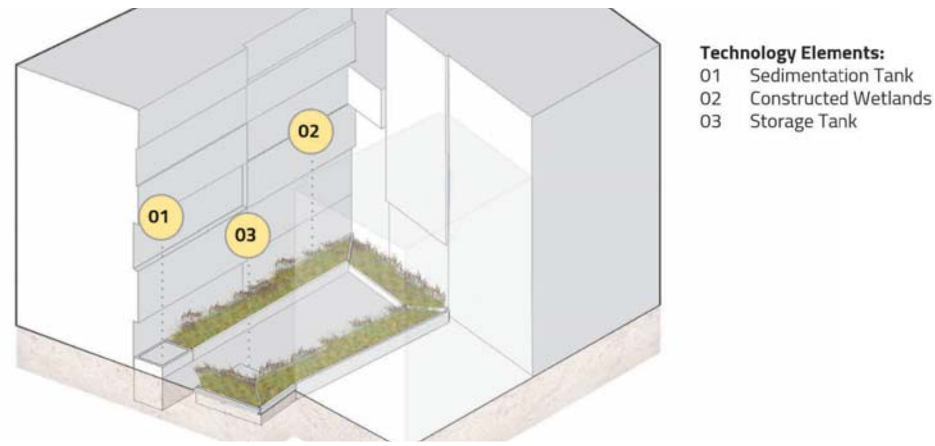


Fig. 11: View of proposed constructed wetland elements

URBAN AGRICULTURE

written by Sibel Sarper, María José Mujica von Seggern, Annika Stein & Andrea Vergara Bernal

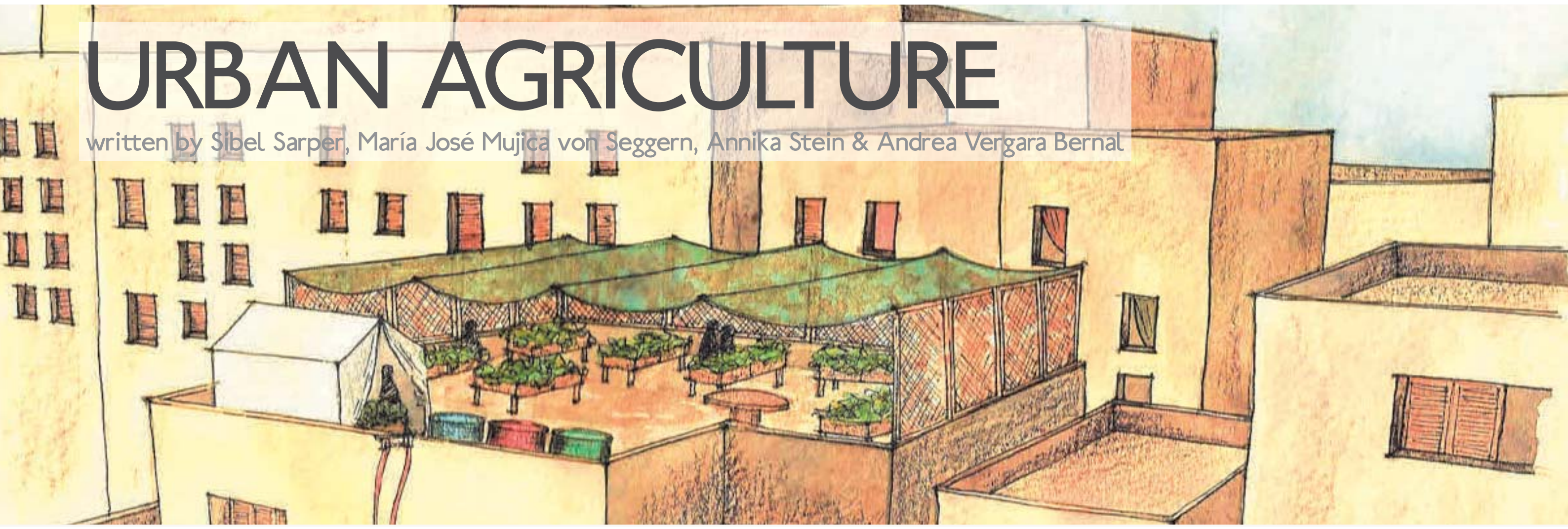


Fig. 1: Rooftop gardening proposed in El Gamaleya

PROBLEM IDENTIFICATION

During the site analysis and on-site interviews, it was discovered that residents of El-Gamaleya do not have enough means to meet their basic needs, particularly lacking adequate food supply to meet nutritional needs. Within the greater global context, this issue is projected to be exacerbated by the decline of agricultural productivity resulting from the effects of climate change. It is expected that 49 million additional people will be at risk of hunger by 2020 and 132 million by 2050 [1]. Maxwell and others [2] state: "Urban and peri-urban areas are similarly impacted, as natural causes such as storms, floods, or constraints on water availability can lead to increased (temporarily or sustained) higher food prices, food shortages, epidemics, and sudden settlement of those displaced by the shock." To make matters worse, natural causes of food crises are often cyclical, repeatedly affecting the same regions or agro-climatic zones.

Agriculture is one of the most important economic sectors in Egypt, as it is in many other developing countries around the world. It is a major source of income, food security, nutrition, jobs, livelihoods and export earnings. The strain on the agricultural sector and rise in food prices would be most pronounced in lowest-income households, who spend as much as 60 percent of their income on food [3]. Therefore, urban agriculture will play an important role in how cities respond to climate change and in helping combat projected food shortages in the future.

Considering the current and projected needs of El Gamaleya, the objective of this project will be to increase the availability and access to food in the neighbourhood by promoting urban agriculture. In turn, this will contribute to sustainable urban development and urban poverty reduction by functioning as a source of livelihood and income.

Rooftop locations in El Gamaleya will be identified where residents can grow fruits and vegetables for their consumption and as an additional income source through selling or trading. Sustainable practices such as greywater reuse and redirecting organic household waste for fertilizer amendment are incorporated in the system.

SUSTAINABILITY CONCEPT

Environmental

- Productive reuse of water that would have otherwise been wasted
- Reducing greenhouse gas and noise emissions by reducing environmental costs from food transport
- Improving the microclimate by reducing the heat island effect by providing shade and enhanced evapotranspiration to clean and cool the air
- Reusing and reducing household waste by diverting food waste to create compost for the gardens
- Sound insulation and noise absorption

Economic

- Providing an additional income source for families by activating women near their home or an additional income stream for those underemployed
- Improving food security by increasing local food production and sale
- Providing healthy and organic foods at an affordable cost
- Opening up new economic opportunities for materials and goods related to food production
- Reducing building cooling costs and energy use

Social

- Inclusion of urban poor and women
- Active community participation
- Improved aesthetics of the neighbourhood
- Providing additional green space and increase the utilization of existing open spaces
- Providing agricultural and environmental sustainability education
- Local economic development
- Improved health and nutrition through better access to nutritious food

METHODOLOGY

The output of the research is comprised of a series of analyses that helped identify how the project will achieve its objective. The first step included an analysis of the history and context which informed the subsequent site analysis. The site analysis consisted of surveying a sample of residents from Cairo and conducting on-site interviews with residents from El Gamaleya. Coupled with a logical framework problem tree analysis, this process helped define the problem and strategic approach in addressing the problem.

Next, a multi-criteria analysis was performed to identify the most suitable urban gardening technique to use. Eleven gardening techniques were analyzed and, based on criteria such as level of investment, density of plants that can be accommodated, adaptation flexibility and weight, *square-foot gardening* in the form of wooden planter boxes was the most desireable. To help select

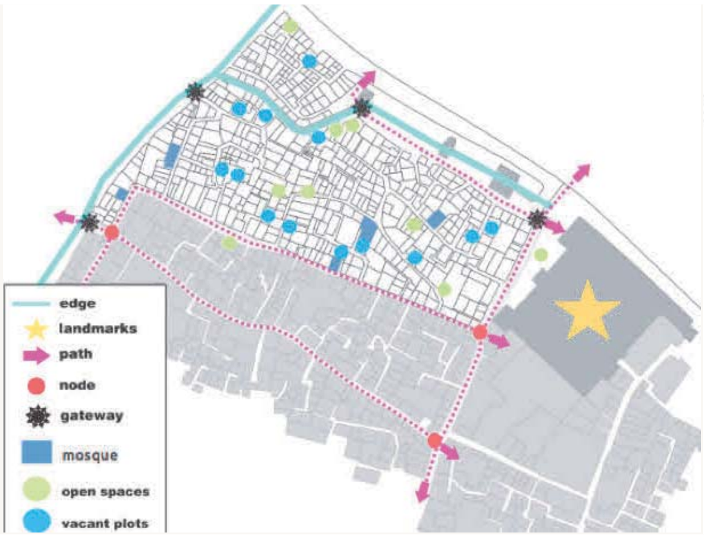


Fig. 2: Urban analysis map

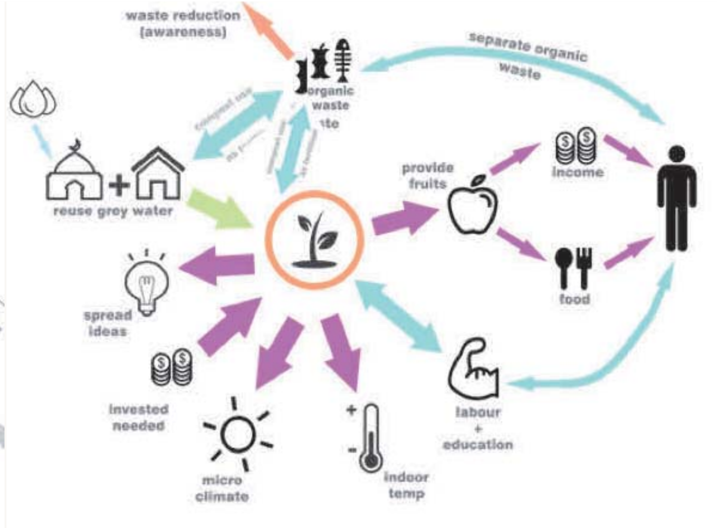


Fig. 3: Concept diagram

which plants to grow, several plant varieties found in the local Egyptian diet were assessed based on criteria such as amount of water consumed, sun requirements, and value.

To help identify the locations where a rooftop garden would be most feasible, the following rooftop selection criteria were used:

(1) Accessible rooftops with adequate roof space
(2) Within 250m of mosques (greywater access)
(3) Structurally able to support gardening equipment

ADVANTAGES OF SQUARE FOOT GARDENING

- Can use locally-sourced materials for planters and a lightweight soil mixture
- Low maintenance and conserves water when utilizing drip irrigation [4]
- Only very basic tools are required and is easy to construct
- High yield by maximizing the vertical and horizontal growing space

PROPOSED CONCEPT

The project begins with the implementation of a pilot project on a chosen site that meets all the necessary siting requirements. The pilot project will allow the program to be put to the test, allow for evaluation, and for any necessary changes to be implemented before resident urban gardens are established. It will also be used as a marketing strategy to showcase the benefits of the rooftop garden to get residents interested in the program and provide some initial education and training.
The design of the urban garden structure (figures 1 and 8) has been inspired by local Egyptian features and ornamentation. For instance, semi-permeable wood panels with muslim cultural details have been proposed as shading devices that also serve as a trellis to facilitate vertical plant growth. Green translucent fabric hanging from the roof is incorporated to imitate the surrounding street characteristics by creating a semi-private space and providing shelter from the sun, rain or cold. The garden structure, pulley and irrigation system were

designed to be as low-tech as possible (figure 4). The idea behind this is to give inhabitants the assurance that an urban garden is something that can be done by anyone and with inexpensive, local materials. There is no need for previous knowledge in construction or farming and simple, square-foot gardening training is given to those who want to establish a garden. Since the residents of El Gamaleya are part of a tight-knit community, this project takes advantage of friends and families in helping each other construct and volunteer in each other's urban gardens to cut down labour expenses.
The produce to be harvested in the urban gardens has been carefully selected based on a typical Egyptian diet. Moreover, the different selections of harvests are meant to fulfill each user's specific needs. A family of eight might need one for their own consumption, whereas a household of one might want it for commercial use. Additionally, the irrigation needs are also meant to accommodate to the users' needs. A woman in her fifties might have trouble transporting water from the mosque, so she might choose to have a low water consumption garden. The long-term

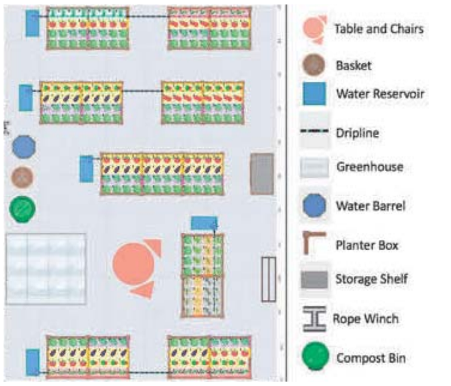


Fig. 4: Rooftop layout proposal

	Cherry and full-size Tomatoes	Peas	Iceberg Lettuce	Colored peppers	Eggplants	Cucumbers	Zucchini	Spinach	Green Beans	Herbs (Sage, parsley, oregano, thyme
Space requirements	XL	S	L	XL	XL	L	L	S	M	S
Water requirement										
Value	$$$	$$	$$	$$	$$$	$$	$$$	$$	$$	$$$
Planting Season (Summer or Winter)										
Climbing (C) or Horizontal (H)	C	C	H	H	H	C	C	H	C	H
Light requirement										
Heartiness										

Fig. 5: Plant analysis table

Fig. 6 & 7: Architectural local characteristics used as concepts

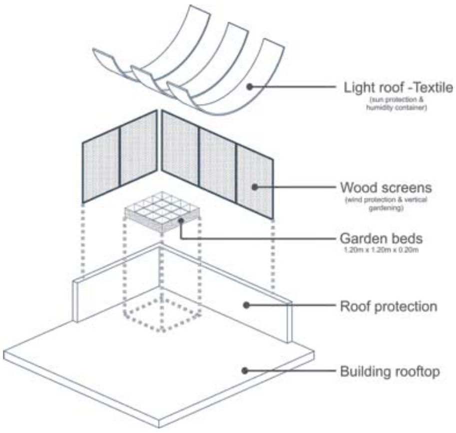


Fig. 8: Urban gardening structure

plan for the program is to become self-sufficient and sustainable. In time, the program will spread out and trainees will become trainers and prepare new trainees. We believe this project has the potential not only to generate a food source but also an extra income for households and overall improve the living conditions in El-Gamaleya.

PLANTING PLAN OPTIONS

This planting plan modeling exercise was done using an online square foot garden planner [5]. This planner provided the opportunity to identify the growing season of each plant, specific to Cairo's climate, the number of plants that can be grown in each square foot, harvest frequency and the yield.

Different planting combinations were then analyzed to model three planting scenarios that met specific user objectives. These are:

(1) *Family Garden*: Growing a diverse mix of vegetables and herbs to supplement a family's diet.

(2) *High Profit Garden*: Growing five varieties of the highest-profit plants for mainly selling or trading.

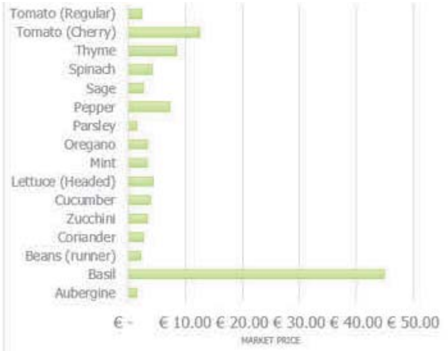


Fig. 9: Plant cost analysis

(3) *Low-Water Needs Garden*: Growing five varieties of plants that require the least amount of water.

For each plant variety, the yield potential for each square foot of space was calculated and based on the market cost in Egypt for the produce (converted from Egyptian Pound to Euros), the most profitable ones were determined (figure 9). Scenario 1 was modelled to include a balanced, diverse mix of vegetables and herbs with less consideration of profit. The highest profit plants were then selected as the plant choices for Scenario 2 - High Profit planting plan model. Scenario 3 was then planned with the plants that were identified in previous analysis as having a low water requirement (e.g. deep-rooting plants) and high profitability.

Providing different planting plan models helps with the promotion efforts by clearly illustrating the income potential from different rooftop garden configurations and the trade-offs for having less water-need plants or more plant diversity. This can help the user decide what option is most suited for them based on their objectives for having a rooftop garden.

FINANCIAL OVERVIEW

The following section goes through the financial outcomes of each of the three modelled planting scenarios. Each garden user is provided with a micro-financing loan to cover the construction costs of 428 €, with a payback period of 6 months at about 70 €/month.

As illustrated in figure 10, Scenario 1 - Family Garden planting plan has a projected profit of 1,310€ in the first year with 428€ goes towards paying back the micro financing loan, for a net profit of 882€ in the first year. Comparatively, Scenario 2 - High Profit garden has a potential

Garden Type	Typical Family Garden	High Return Crop	Low Water
Crop Type	Diverse Mix of Crop	Basil ▪ Lettuce ▪ Pepper Thyme ▪ Cherry tomato	Basil ▪ Zucchini Cucumber ▪ Beans ▪ Thyme
Average overall market price	0.87 €/kg	1.73 €/kg	1,39 €/kg
Yearly Yield	2,165 kg	2,227 kg	2,058 kg
Yearly Profit	1,310.20 €	3,852.48 €	3,614.56 €
Investment Costs	427.88 €	427.88 €	427.88 €
Net Financial Benefit (first year)	**882.32 €**	**3,424.60 €**	**3,186.58 €**

Fig. 10: Financial overview of all three scenarios

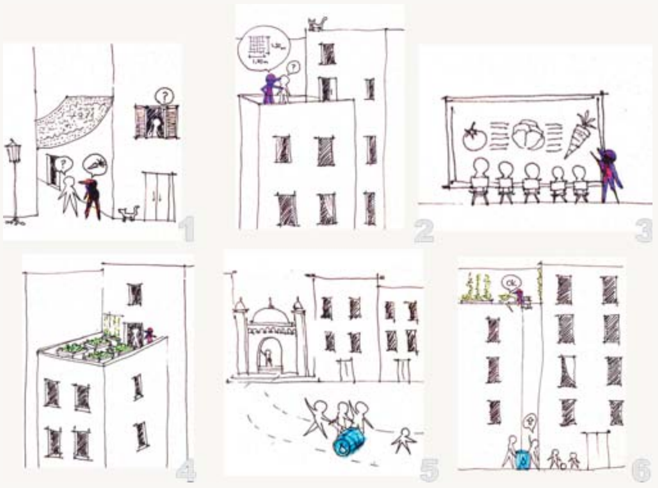


Fig. 11: Six steps for communal ideas spreading

Fig. 12: Project zoning on a 5 year timeline

net profit of 3,424€, nearly four times that of the first scenario. Scenario 3 - Low-Water Needs remains profitable with a net profit of 3,187€, more than three times the profit as compared to Scenario 1.

The key objective of using the square-foot gardening method is to maximize the production to optimize the yield and therefore the net benefit. When analyzing the failings in other community rooftop garden projects, many cite the gap between the net financial benefit from a garden's production and the energy and money invested into constructing and maintaining a garden. Through this project's financial analysis of comparing different planting models, it is suggested that the rooftop gardens are able to be greatly profitable, have a short pay-back period and strong net benefit.

IMPLEMENTATION STRATEGY

The project team consists of a project manager, a planning team, a construction team, and a trainer. The planners are responsible for organizing, promoting, assessing and monitoring events such as workshops and trainings. They also select and purchase crops and design the gardens on roofs. The construction team works together with local community workers. Together they build square-foot gardens and adjacent structures such as building rooftop accesses or pulley systems for water transportation. The trainer carries out workshops and guided tours, compiles documentation, and conducts the assessment and monitoring of project activities.

The implementation success of the project is defined by several outputs. The first output is the public awareness campaign, which takes about six weeks. During this phase, surveys are carried out, residents are interviewed, advertising and promotional information is distributed and consultation with religious leaders help spread the idea. The second output relates to the pilot project, which is estimated to take about 15 weeks from the feasibility analysis to the day food production begins. The steps to be taken during this stage are the analysis and selection of a suitable roof, negotiating with the landlord, crop analysis, selection and purchase, planning and designing of garden, improving access, installation of a pulley system, building and preparation of planters, installation of info charts and eventually clean up. Urban gardening can then begin, which will be monitored by the planning team. The pilot project serves as example for future urban gardens and will host guided tours in preparation for every new project implementation. The facility will also be used during workshop trainings, which are defined in output three and begin during the construction phase of the pilot project.

Every nine weeks, two new projects are implemented following workshops that help raise public awareness and train new groups of gardeners. Finally, output number four concerns the implementation of resident urban garden projects. The process is similar in length to the pilot project, taking about 15 weeks for each project. After a program length of five years, 46 projects can be implemented. For the long-term sustainability of the project, a fifth output was created called "Train the Trainer" education. Local leaders are trained to teach other interested members of the community how to install urban gardens and grow food. This way, the idea and process of implementing urban gardens on rooftops in El-Gamaleya can continue to spread after the project is completed.

MEASURING SUCCESS

To measure the progress of our project in meeting our objective, several indicators will be monitored and evaluated including:

(1) Increase in household income or reduction in food-related expenses (in Egyptian Pounds)

(2) Number of successful urban farms installed in the rooftops within the site area

(3) Increase in market activity (i.e., number of traders within the project area)

(4) Increase in amount (kilograms) of local food produced within El-Gamaleya.

CONCLUSION

Agriculture exhibits one of the highest level of vulnerability to the effects of climate change and, since it is a larger threat to the poorest of communities like El Gamaleya, it needs urgent attention and preparedness. We believe this project provides a viable solution to preparing for the risks faced by changing climatic conditions, food scarcity and unemployment in the neighborhood of El Gamaleya. Our program presents residents with an opportunity for secure food production, an extra income, and a reduction of their current expenses. Furthermore, the project has been designed to provide climate resistant crops and sustainable agricultural practices such as greywater reuse and the use of organic household waste as fertilizer for the urban gardens. These practices will cut down on costs that would normally add on to the costs of an urban garden, making it an even more favorable opportunity for the community.

Passive Cooling & Shading Methods

written by Rafael Dobbs, Gema Nugraha, Kalpesh Makwana & Fano Sutranto

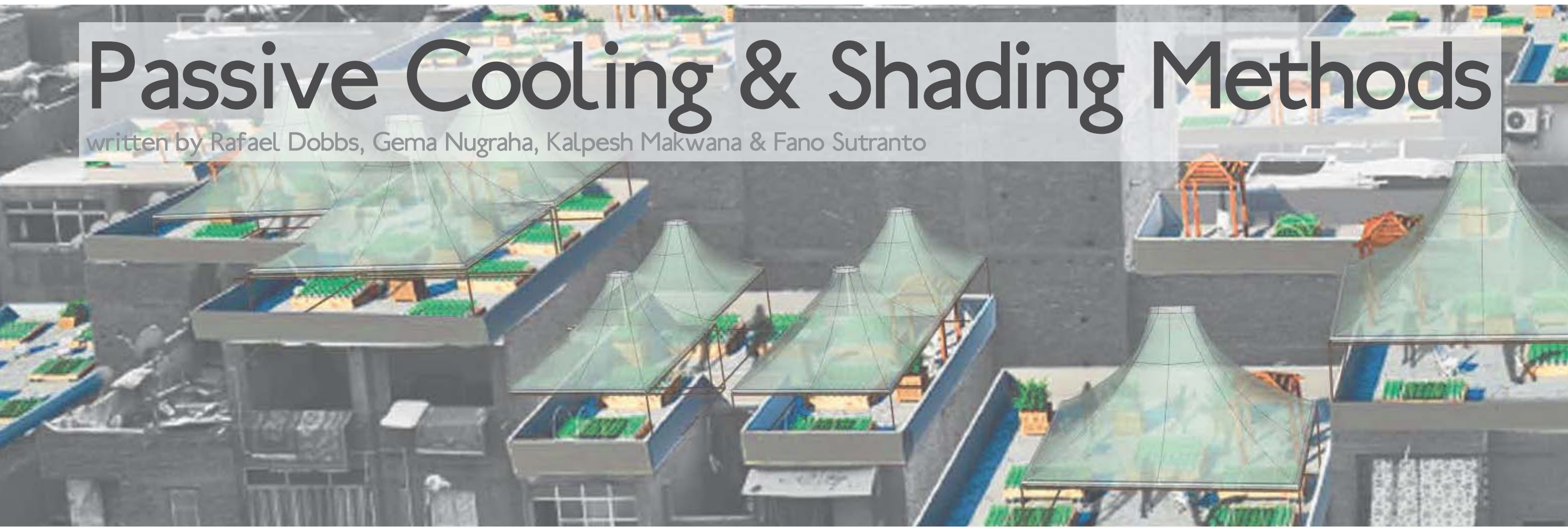


Fig. 1: View of proposed solution in El Gamaleya

ENERGY SECTOR OF CAIRO

Along with the increase of population in Egypt which currently amounts to 94.5 million people, large energy supply needs to be provided to support and sustain the value generation activities as well as the constantly growing population. Since the end of Mubarak era in 2011, the energy security has been compromised, which resulted in Egypt experiencing several occurrences of load shedding and blackouts during the past years and is predicted to suffer from severe electricity deficit in 2022 as high as 6 GW [1].

An immediate solution to the prevalent condition of energy sector in Cairo is necessary; however, to effectively address the situation, a root cause analysis is required in order to better come up with proper interventions that could be impactful in leveraging the conditions in the sector.

As per relevant research, 4 major factors contribute towards future electricity deficit: supply vs demand lag, aging infrastructure, fuel sourcing complications, and an unstable political environment (figure 3, right). This research will focus mainly on addressing the supply-demand lag factors as it is believed that by addressing this sector, a more significant impact on the overall improvement of the electricity sector is possible.

When it comes to energy efficiency, Egypt ranks quite low, with the amount of energy needed for the production of a GDP unit being the highest in the region (1,742.91 kWH/ capita in 2011) [2] and around four times higher than the energy intensity in industrialized countries. Considering this information, it is clear that the potential of energy saving is abundant and tackling the efficiency issue will be pivotal for the sustainability of the energy sector. Therefore, further research on the dynamics of energy consumption will be vital in determining the focus of the project initiative.

FOCUS AREA

Research on the energy consumption dynamics lead towards identification of residential sector cooling demand (based on the high need of air conditioning) as one of the main contributors of high electricity consumption in Cairo (figure 2). Therefore, a similar condition is assumed for El Gamaleya area.

Based on the findings, it was concluded that a sustainable initiative that would help in reducing cooling demand would be best suited for managing the majority portion of electricity demand generation.

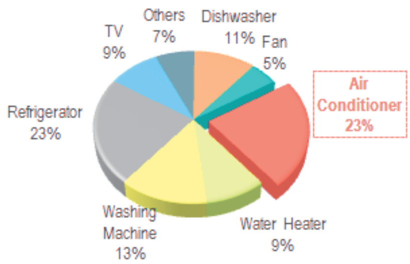


Fig. 2: Domestic shares of electricity consumption

The challenges first lie on generating a concept that would be best for creating a reduction of cooling demand in El Gamaleya context and, based on this thought, the research question was formulated: "How can energy demand be minimized through the reduction of building solar heat gain by using passive cooling methods in El Gamaleya?" With such question in mind, the research is executed and should reflect the process of determining and elaborating the solution within the upcoming sections.

An analysis on current condition of El Gamaleya's residential sector and the existent opportunities for optimization was conducted to identify the characteristics of the right approach suited to the need. In order to appropriately identify the most suitable characteristics of an intervention that would effectively address high cooling demand in El Gamaleya, a SWOT analysis was carried out to ascertain the complexities of introducing the solution in the context (figure 3, left). The SWOT analysis helped with the identification of ideal characteristics of a concept solution that could be applied particularly in the focus area. Such characteristics are as follows: cost efficiency, low maintenance, suitability to general building condition, light-weight, low degree of complexity, ease of implementation, and little or no energy consumption. As a preliminary general concept, a passive cooling or shading device that could fit all such requirements was proposed for further investigation and development.

TENSILE MEMBRANE AS A SOLUTION

After the ideal solution's characteristics were known, the comparison between possible solutions is done to select which would fit best into the needed set of characteristics. From a certain range of passive cooling and shading methods, the following options appear to be amongst the most suitable methods for the climate and socio-economic conditions in El Gamaleya. These options are explained below for a brief overview on each kind of passive cooling method.

Tensile membrane

One of the biggest concerns during the project development was to come up with improved material solutions for shading devices. Shading is a powerful resource for cooling and it was believed

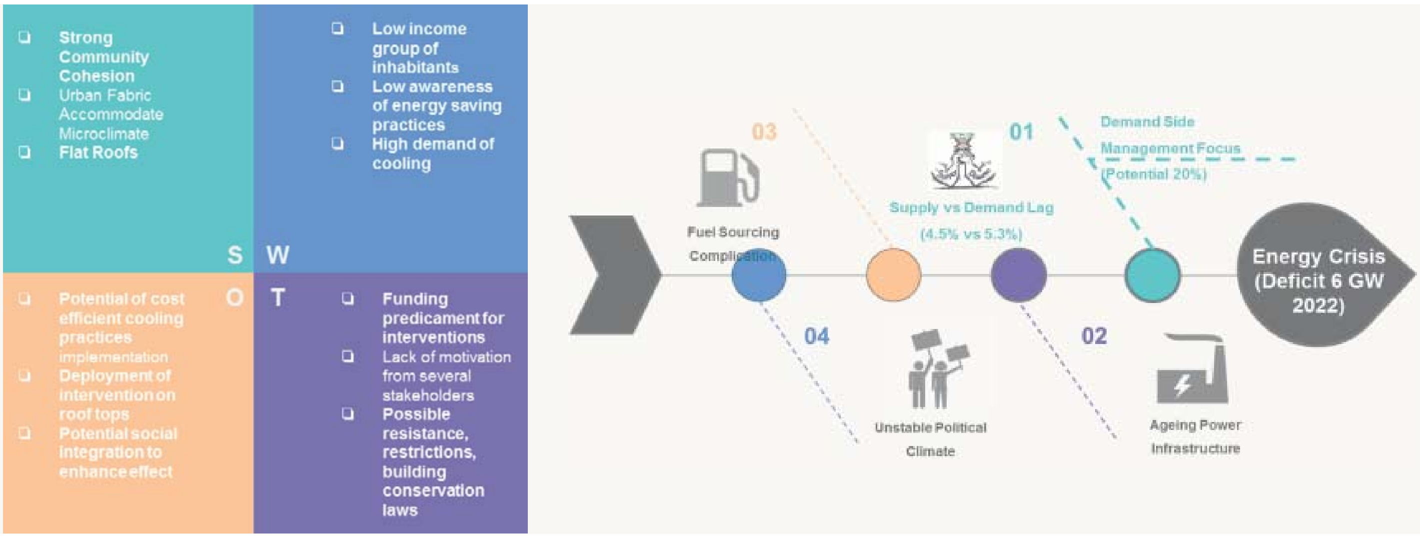


Fig. 3: SWOT analysis (left) and fishbone diagram (right) leading to the research question

that there was potential to upgrade the fabric shading system commonly used in the Cairo urban context. As such, the tensile membrane material and its technology to cool down spaces was proposed.

One of the main advantages of using tensile membranes is the flexibility that it generates in the project application space. In addition, other benefits include the speed of construction, light conditioning, thermal behaviour (fit for hot climates), and low costs.

Hanging membrane structures

These structures are hanging from cables and masts and they work together to provide the structural and shading solution. This means that if any of the elements was to be removed, the whole structure would collapse.

This type of structure could have lead to a very interesting solution and built form in response to our research question. However, due to the nature of technology and cost calculations, it was regarded as not the best method for the context of El Gamaleya.

Membrane as a skin

These are the membranes that are used as an exterior skin and which are not part of the structural solution. This one was a preferred solution for the project as it was mixed with another type of structure described in the next topic.

Self-supporting structure

This kind of structure does not transmit any structural forces to the ground, working as a module or a hat on top of the existing building.

Ground-supported structures

These support structures transmit forces to the ground through cables and masts.

Upon comparing available options, it was decided to combine the skin membrane system along with the self-supporting structure. The conclusion of the analysis indicated it was better to use the skin type due the flexibility needed for the structure and the self-supporting structure because it allowed for the model to be replicated in slightly different contexts. This solution will allow the avoidance of further complex structural calculation. Also, the flexibile structure will have a larger upper overture for better environmental behaviour by increasing the wind velocity of the semi-closed space.

Thermal behaviour

The membrane has a high thermal conductivity (5.59 W/m2), although recent technology has been developed to answer this matter. Since more technology means more cost, the other option is to use two layers of regular PVC membrane, creating an air cavity and decreasing the thermal conductivity. The external-internal transmission of heat on a opaque membrane is not significant due to a low solar factor (less than 20%). The membrane has low heat absorption of radiation which means that it does not irradiate the solar heat gain and does not become hot like metal solutions that can reach peak temperatures of 70 °C during a sunny day.

As a consequence, it was strongly recommended to use the shape of the membrane itself to take advantage of the thermal qualities of the material. In addition, the cone shape along with the semi closed shading materials on the lower bottom of the module would allow the air to circulate in a more natural way.

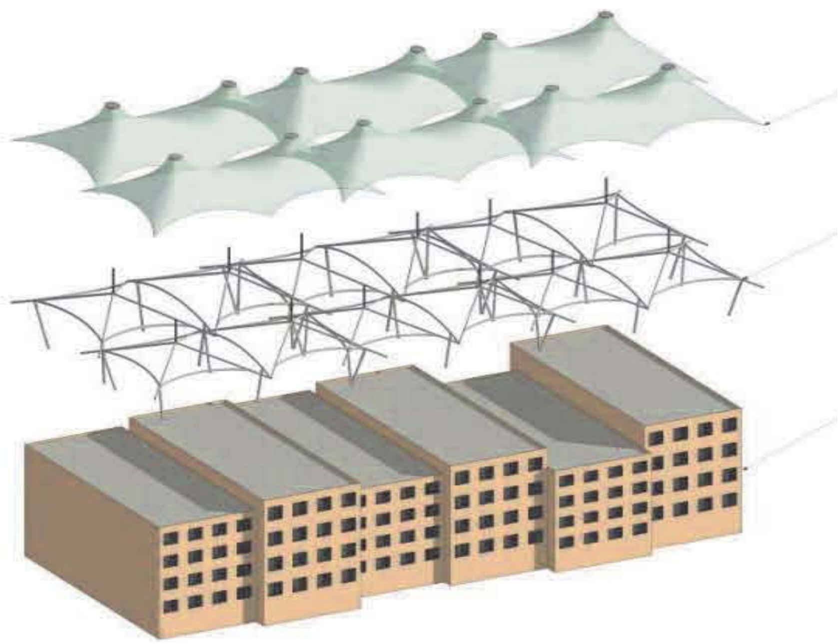


Fig. 4: Solution applied to class 1 buildings with heights up to 4 storeys

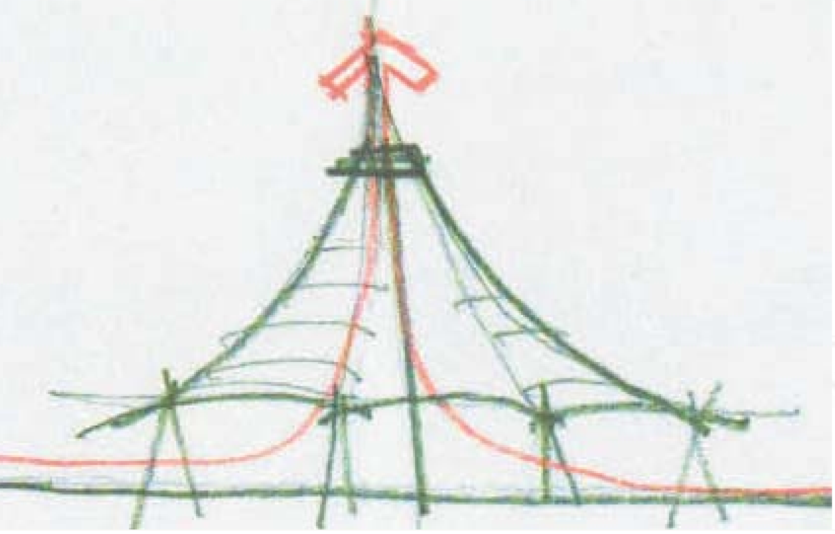


Fig. 5: Sketch showing airflow under shading device

Fig. 6: 3D visualisations of proposal

Membrane fabric material selection

Upon determining structure, the material selection for the membrane itself followed. As the fabric material would be crucial in allowing the solution to achieve the expected result, a comparison between strengths and weaknesses of various type of membrane fabric that currently exist was conducted and a preferred material was chosen (figure 7). This material, known as PVC coated polyester, is made of a synthetic tissue layer forming a net. This tissue is covered by two layers of either PVC, PTFE, or silicon as a protection from external elements. This gives the membrane impermeability, fire proofing, and anti-mold protection. It is possible and potentially recommended to add some external treatment to the external layers in order to upgrade the quality of the product such as anti-dirty additives, anti-condensation dripping, and better durability.

DISTRICT ANALYSIS

The given site in El Gamaleya has a variety of building uses although the site is dominated by residential buildings which represent 52.3% of total site area. These can be a suitable target area for the project as they have potential rooftop spaces for the membrane shading implementation. In addition, creating a rooftop shaded area may result in the establishment of an alternative social gathering space.

As a resultant of analysis of the given site, some of the desirable characteristics for candidate buildings were outlined: (1) potential area on rooftop of residential building for multiple uses; (2) can be facilitated into passive cooling technology; (3) can improve social life by providing additional community places.

Segregation of focused area

As a result of district analysis, a fundamental obstruction for the proposal was identified. The building heights are not homogeneously distributed on the site, which can be a challenge for the project. The major differences in building heights have been identified through a more in detail site study and buildings were classified in two groups of up to four storeys (class 1) and between four and eight storeys high (class 2).

Buildings in class 1 offer the opportunity to design a larger single structural shading membrane covering the cluster of adjoining buildings. This approach can facilitate a larger space on rooftop and ease of access for inhabitants due to lower building heights. The larger area can facilitate alternative social activities which can strengthen the socio-economic ties within the community.

By applying a single structural shading membrane the buildings of similar heights can all benefit from the shading device while minimizing costs and complexity. The cluster can be identified and the larger shading membrane can be provided to facilitate larger community place on rooftop (figure 4).

Class 2 buildings (4 to 8 storeys high) have given an opportunity to design a small sized modular shading membrane covering a single building. This approach offers increased flexibility but also a smaller space on rooftop which will be mainly available to building inhabitants (figure 8).

Both class 1 and class 2 solutions consists of lightweight shading material and supporting lightweight steel structure.

CHOSEN MATERIAL

FABRIC MATERIAL	PVC COATED POLYESTER	PVC COATED GLASS FIBRE	PTFE (TEFLON) COATED GLASS/PTFE	TENARA
Lifespan	10 – 15 years : Acrylic lacquer 15 – 18 years : Weldable PVDF lacquer 18 – 20> years : Non-weldable PVDF lacquer	35> years	35> years	35 > years
Pricing	Very Cost-effective	Approx x2 of a rolled PVC	Approx x4 of a rolled PVC	Approx x10 of rolled PVC
UV H12 Resistance	High	Excellent	Excellent to High	Excellent
Translucency (gm/m2)	8% of Grade II (1000gm/m2)	0 – 30%	12% (800 gm/m2)	Up to 40%
Frequent Application	Standard systems; temporary, movable and permanent structures	Standard systems and permanent structures	For interior application, protection from sun, used for billboards and other visual ads	Standard systems; temporary, movable and permanent structures
Environmental	All harmful phthalates and heavy metals removed	All harmful phthalates and heavy metals removed. Can be used for sand bags and ground stabilization	Recyclable and has no Chlorine or Bromine content. Can be shredded for landfills	Unaffected by pollution

Fig. 7: Comparison of materials for tensile membrane

PILOT PROJECT

A detailed analytical approach led to the identification of buildings potentially suitable for the pilot implementation (figure 9). For the selected site, the proximity to the wider street can be beneficial as it offers increased exposure, resulting in community awareness and potential funding for subsequent implementations. Three proposals were identified as fitting to the pilot location in line with site charactersitics and project objectives.

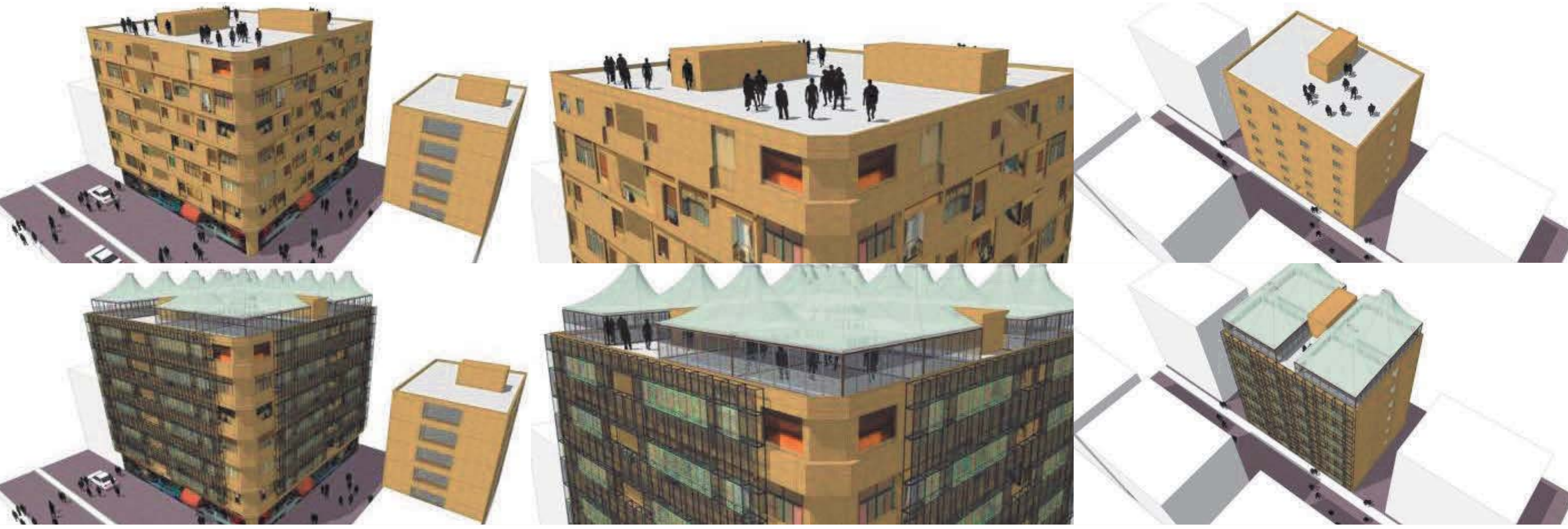


Fig. 8: 3D visualisations of class 2 buildings before and after proposal 3 implementation

Proposal 1: Vertical perforated screen for facade shading

A large share of solar radiation is usually absorbed by the building facade and results in a higher cooling demand. For reduced cooling demand, facade should be shaded with appropriate functional and aesthetic elements. Perforated screens can prevent direct solar gain for facade as well as increase the wind velocity and induce higher ventilation rate.

The screen design should be realized differently for openings and built facade as the requirements

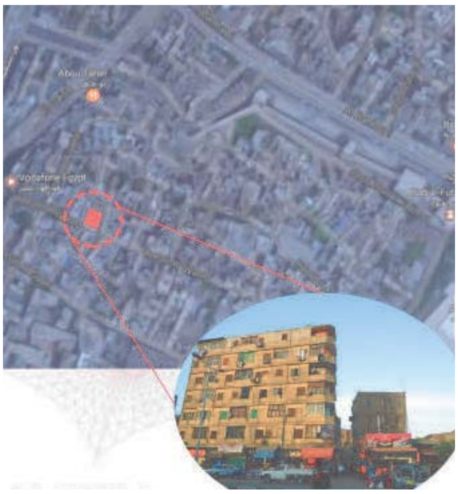


Fig. 9: Pilot project location in El Gamaleya

for each are different. Figure 10 illustrates both types of perforation and also the cavity between the wall and the screen. The perforation depends upon the desired shading but, in the Cairo climate context, built facade should benefit from maximum coverage to reduce heat gain. In addition, openings should be shaded in such a way that it does not obstruct the natural air flow. For optimized results, it is proposed that 40% perforated screens are used for window openings in order to allow daylight and ventilation while for facade, 10% perforation is proposed to eliminate direct solar radiation on walls and resulting heat gain.

Proposal 2: Insulation for inner wall

While solar heat gain and indoor temperature can be reduced by facade shading, an additional reduction in heat gain can be achieved by the use of insulation material. However, in the Cairo socio-economic context dominated by informal construction, the users may not cannot afford the high cost for purchasing and installation of traditional insulation material.

The collaboration with other projects groups working on material and waste management in the area has presented the opportunity to reuse paper waste. With a share of 10% of total waste, paper products have the potential to be converted into insulation material for the inner walls. by means of primary recycling. This option can facilitate low cost insulation material which also has a simplified installation procedure.

Proposal 3: Rooftop shading membrane

The maximum solar heat gain for buildings in Cairo is absorbed by the rooftops. To reduce this heat gain, the lightweight shading membrane previously discussed has been proposed for the building. Aside from the improved thermal properties of the buildings, the shading membrane can facilitate additional recreational area for inhabitants and can provide for a first step towards improved socio-economic sustainability. The reduced heat gain can decrease the cooling demand and energy consumption for the building. In addition, the creation of a comfortable semi-public space on building rooftops can constitute in a valuable resource for the densely built El Gamaleya district where open space is in scarce quantities.

FUTURE PROPOSALS

For future development, the intervention will focus on addressing social aspects by utilizing the space created by the roof shading system. One consideration could be to develop synergies with the roof-top gardening project, which would alleviate the visual condition of the area and also could provide a mean to empower the local inhabitant. An additional opportunity would be to partner up with already established local organizations focused on empowering the local inhabitants through education or skill development such as sewing, craftsmanship, tapestry, etc. The additional rooftop space would allow such community workshops to expand their activities and reach a larger share of the population. In conclusion, beyond the energy saving benefits, the passive cooling devices proposed in this project aim at he improvement of the community's long term resilience by improving social ties and the creation and transfer of new skill and knowledge.

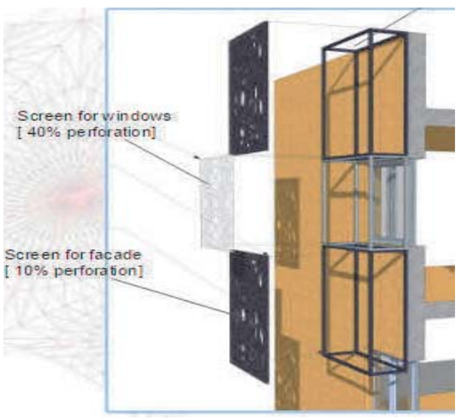


Fig. 10: 3D visualisation of proposal 1

Local Energy Generation

written by Kevin Becerril, Beatriz Campos, Joel Ferran, Ziva Hanzic & Jovana Pavlicevic

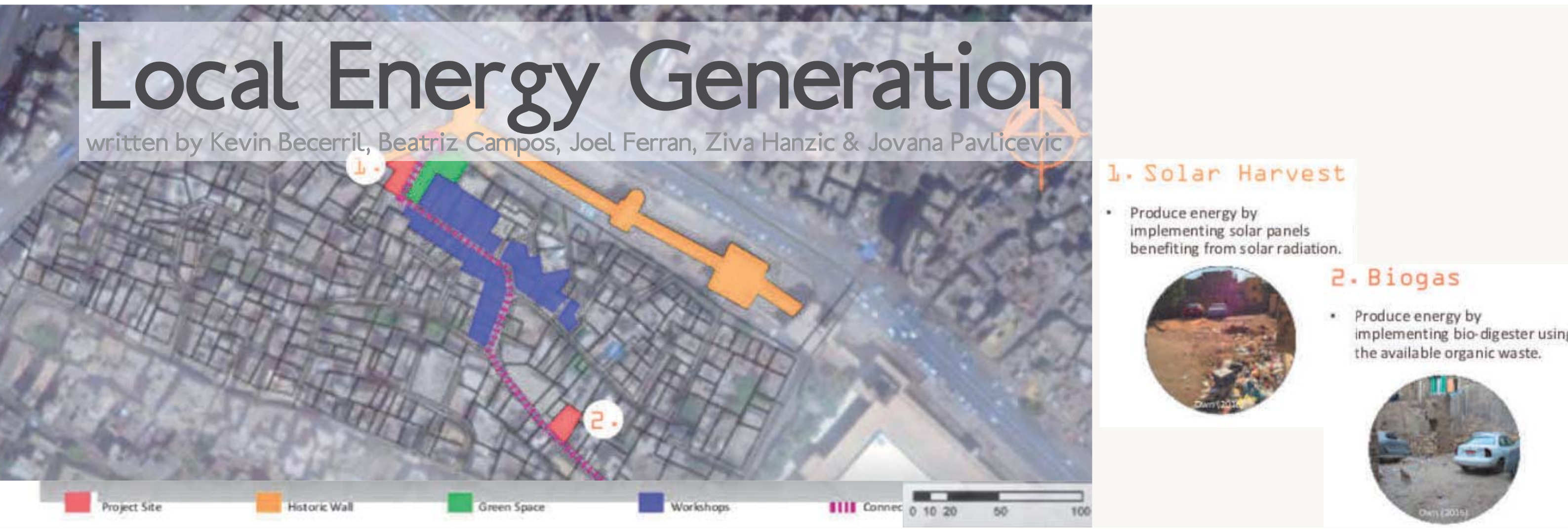


Fig. 1: Local energy generation concept design

ADDRESSING ENERGY SCARCITY

Egypt is currently in a state of energy insecurity due to the rise of power blackouts and decreasing gas reserves. Coupled with political instability and recent devaluations of the Egyptian pound, Egyptians are now in a volatile situation as energy access decreases and becomes more expensive. Already facing increasing cost of living standards, issues with energy access disproportionately affects the urban poor of Cairo. It could mean no longer being able to afford proper nutrition or schooling for their children. The inability to advance themselves or their children only propagates the cycle of poverty, creating further divisions in the socio-economic classes of Cairo.

This project seeks to help residents of the informal urban site of El Gamaleya become more energy independent through the formation of decentralized energy production sites. These local energy generation (EnGen) projects utilize the readily available resources found on site to produce sustainable energy in the most affordable way possible. In the case of El Gamaleya and in fact, almost every other part of Cairo, these resources come in the form of organic waste and sunlight. With about 60% of Cairo's waste being organic and the high amount of yearly sunlight hours, these resources are plentiful [1]. With the use of biogas digesters and solar PV modules, families will have the opportunity to confront these issues of energy scarcity [2, 3].

PROJECT IMPLEMENTATION

The local EnGen project will be implemented in two phases. During these different phases, the project interventions will take on different roles. The goal of the first phase is to create spaces that will offer opportunities for decentralized local energy generation, while providing multi-functional spaces that the community lacks. The second phase focuses on the expansion of the project throughout the community and Cairo as a whole.

Through this method, the scope of the project does not only stop at energy generation, but continues to address further issues the neighborhood faces. For this reason, the interventions will work together to improve the social sustainability of the area in hopes of improving the residents' standard of living.

PHASE 1: SOLAR EnGen

The Solar EnGen site will include the construction of a cafe that will house the solar PV Panels for the area. This site is in an ideal location [4] in the area for solar energy harvesting given that it is in a relatively open area in the neighborhood away from taller buildings and trees. At the increased height of the cafe of 4 meters, the solar panels should not have any issues of shading obstruction from the nearby buildings. When installation would begin, an additional structure could be further implemented in order to achieve an increased height, but this should not be the case.

The energy that is gathered on this site will be used by some of the nearby workshops. In this way, the users of these workshops will be able to utilize a more sustainable source of energy that is provided by the constant sun of Cairo. The batteries and other mechanisms will be located in the PV facilities room of the site. Maintenance will be done as needed under the coordination of the cafe owner and a PV module technician. The same will be done with the maintenance of the panels themselves.

The biggest issue that PV panels face in this area is dust from the surroundings. This issue can be addressed by the simple cleaning method of wiping down the panels with a cloth. This can be done on a weekly basis by the cafe owner himself. The cleanings could also be done more often should the need arise in times of increasing winds and dust storms [5].

The cafe itself serves to fill a gap in the community by providing a place where locals can come together to eat. Currently, there are not many nearby restaurants or cafes around the site location, and in order to go to one, residents have to leave the area. This cafe could serve to fill this void that currently exists. Given that it is located near one of the few green spaces of the area, it could add to the attractiveness of the space and encourage foot traffic.

The close proximity to the city wall would also help make this space attractive in the same way the green space adds to it. Currently, the site is littered with trash despite the nearby ancient wall and entrance to the space. By putting a cafe in this currently dirty space, the area will improve visually and give residents a space they can be proud about. Not only will residents be able to come to this area to enjoy the space but those living just outside and even tourists will be able to utilize the cafe.

In addition, the cafe is a covered area that can be

Fig. 2: Solar EnGen site location in El Gamaleya

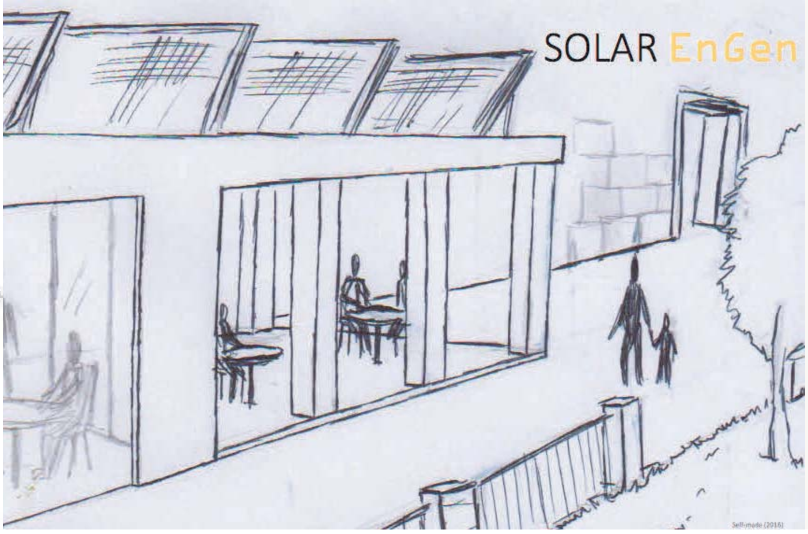


Fig. 3: Solar EnGen design

used for a variety of purposes. Most of the time, it can be used as an extension of the cafe where visitors can sit in a space that is better ventilated and shaded. At the same time, weekly markets can occur here, which would provide nearby workshop owners the opportunity to showcase some of the crafts they create (figure 4). One of the concerns we heard from a workshop owner during our interviews in the area was that, due to the lack of foot traffic, merchants don't often have the opportunity to directly sell to the consumer and instead have to sell through middlemen. This leads to a loss of income opportunities for them. By putting in these markets, a new income opportunity for these workshop owners is created. Given the cafe and the green space, the presence of visitors can be expected to follow and this can be capitalized on with the weekly markets. The markets will possibly later attract other consumers who, in turn, will use the cafe facilities as well. In this way, both interventions will work off of each other in order create a more overall attractive area.

This Solar EnGen will also serve as a landmark in the neighborhood. The cafe will attract both residents and tourists and expose them to the work of the local workshops. It will show how local energy generation is used to create their products, hopefully providing residents with income opportunities that are heavily needed. In this way, local decentralized energy production can fuel local industry.

SOLAR EnGen TECHNOLOGY

After an in-depth research into the different types of companies dedicated to the sale of solar panels in Egypt, it was concluded that two types are predominant in the market of solar panels. These technologies are solar panels with either monocrystalline or polycrystalline cells, which currently are the most used worldwide. By making a brief comparison, we can highlight three very important aspects relevant for our project: cost, efficiency, and energy production.

Starting with solar panels with monocrystalline cells, this type have the highest efficiency in the market. Solar panels with monocrystalline technology can reach efficiency rates of 17-20%, which this leads to greater energy production. Looking at companies in Egypt that use this technology such as Power & Save Cairo Solar or Photon Solar energy, it can be observed that prices range from upwards of 250 Euros [6]. It is important to mention that the suppliers of many of these stores are German and Chinese companies. The high prices of this type of technology means that the demand is not so high , which makes it difficult to find this type of panel in all stores dedicated to the sale of this type of products.

In contrast to this technology is the polycrystalline technology, where efficiency rates vary between 16% to 18%. The price for this technology is slightly lower as it can be found between 150 to 200 Euros in companies based in Cairo [6]. It is important to also note that there are considerable difficulties in discussing exact prices for these products, since cost often varies depending on the panel power, brand, suppliers and other external factors. Yet, we can still gain at least an idea of how much the average cost could be.

After making an appropriate comparison, we made the decision to opt for polycrystalline technology after having considered several reasons. Due to the technology's high demand, a great majority of solar companies have this type of technology available, making it easier to compare different types of panels that use polycrystalline technology. This would facilitate the development of this pilot project where our main objective is to demonstrate the advantages of using alternative and sustainable technologies

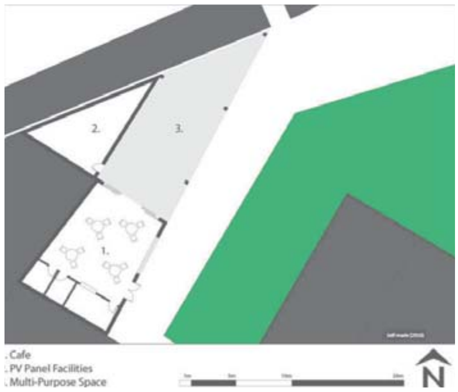


Fig. 4: Solar EnGen plan: (1).cafe; (2) PV panel facilities; (3) multi-purpose space

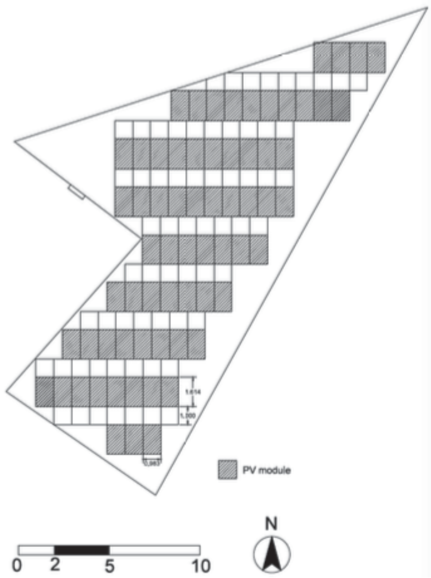


Fig. 5: Solar PV panel roof placement

Fig. 6: Bio EnGen site location

Fig. 7: Bio EnGen pilot location design

for energy production. Although the efficiency rate is slightly lower than that of the mono-crystalline type, the energy production is enough to obtain good results. Last but not least, taking into account the price of the product is always important since the budget is always amongst the most important considerations in any project proposal.

One solar panel can produce 422 kWh/m2 per year. When multiplying this with the 67 panels that would fit on the roof, the pilot project ends up harvesting 28,274 kWh/m2 in one year. The World Bank estimated that, in 2013, a single person in Cairo consumed 1,607.47 kWh/year, which means the proposal can provide energy for approximately 17-18 people for one year [7, 8, 9, 10].

PHASE 1: BIO EnGen

The Bio EnGen site will have the primary purpose of housing biogas digesters while also serving as a community space. It will serve as a space for education with a particular focus on women and children. In an effort to provide women with another space outside the home and mosque, this community space will have a primary focus on the women in the community. Here, workshops can be held to address issues such as illiteracy. Furthermore, it can also be used by locals for whatever purposes they may see as necessary.

In order to provide women the chance to improve their education and increasingly become involved in public affairs, there will be a playground intended for smaller children. With volunteers tending to the children and the necessary amount of helpers attending to the playground, the space ensures proper functioning and safety.

The construction of a playground for small children will provide a much needed play space that does not currently exist in the neighborhood. Kids are currently often seen playing in the streets or by the walls of the mosque. Furthermore, there is no real space for smaller children to play. This playground will help to make the site more inclusive of everyone, including children. This is something that is often forgotten in cities with more stringent problems such as Cairo but is important to consider for the well-being of a neighborhood.

BIO EnGen TECHNOLOGY

Deciding which biogas digester to choose for the area was based on an intensive research about the biogas digester types and technologies. When it comes to different technologies to produce biogas, the digesters can be divided into small scale digesters and industrial digesters. A majority of operable biogas plants around the world are designed to use animal manure as a main feedstock and cannot be used in urban areas. Our working area is located in the historical city center so we have space limitations and therefore big industrial biogas technologies are not eligible.

In 2003, ARTI developed a biogas digester that uses organic waste with higher energy density in comparison to animal manure and therefore the process of turning used feedstock into biogas happens a lot quicker (1–2 days compared to 30–40 days) while the amount of needed feedstock drastically decreases (1 kg of food waste can be turned into the same amount of biogas as 20 kg of animal manure). Further research was made among different small-scale digester technologies, to find the one most suitable for our working area [11].

Biogas digesters were compared through a multi-criteria analysis and, while all use organic waste for the biogas production, the difference is that HomeBiogas and Puxin are more advanced, efficient, and user-friendly when compared to ARTI design.

Based on the multi–criteria analysis, we decided that the most applicable biogas digester for our area in Cairo is the ARTI design. A crucial aspect when it comes to implementing the project in low-income informal settlement is the price of the project, and in this case the price of the ARTI design is approximately 10 times cheaper when compared to the designs by HomeBiogas and Puxin. At the same time, climate in Cairo makes ARTI's design more efficient as compared to its competitors.

The ARTI type offers various sizing and material possibilities for the fermenter and gas-holding tank. We decided to install biogas digesters with both tanks from plastic in black color and in sizing for one family (4–5 members), where fermenter tank has a volume of 1,000 liters and the gas-holding tank, 750 liters. The reasons for choosing plastic as a material and size of the digester for one family are material strength, durability, and lightness . Also, having one bigger digester with concentrated weight load on the multi-family building rooftop could cause trouble with regard to the building's structural sta-

Fig. 8: Bio EnGen pilot site rendering

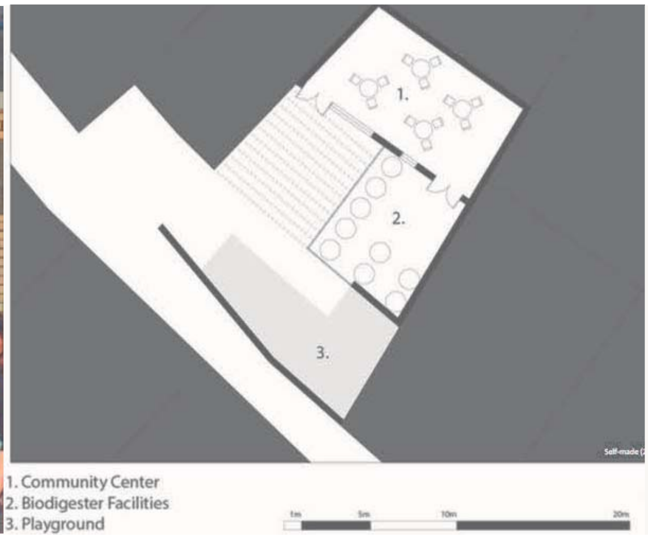


Fig. 9: Bio EnGen plan: (1) community center, (2) bio-digester facilities; (3) playground

bility. In contrast to that, with multiple digesters, there is a possibility of distributing the load uniformly on the rooftop, above load-bearing walls in order to not compromise the structural state of the building.

A biogas digester is first filled with 20 kg of cattle dung and water in which the bacteria for further anaerobic digestion are present. After 2 weeks, the production of biogas starts taking place and the upper tank begins to rise. When the gas is flammable, the digester is prepared to start using organic waste for daily production of biogas [12].

Every day, the tank should be filled with 1–1.5 kg of organic waste combined with 10 – 15 liters of water in the morning and the same amount in the evening. Within 24 hours, the biogas digester will produce biogas for 2–4 h of cooking [13].

PHASE 2: BIO EnGen - PROLIFERATION

The Bio EnGen pilot could not possibly provide enough biogas to all of the residents on the site and that is not its intended purpose. Its main purpose is to provide the necessary education and resources for the residents to help them to acquire their own personal biogas digesters. In this way, the benefits that could be achieved through the project can extend a lot further throughout the community. To achieve this, a program will be started in the community in order to introduce residents to the technology and provide them with a way to funding through a micro financing structure.

The education part of the program works by providing women in the area with 4 to 6 weekly workshops that introduce them to biogas digesters. During these workshops, they learn about the intricacies of the technology and how to tend to it. They see how they work and later how they can build one themselves. Some of the workshops will also show them how to clean and maintain the biogas digesters. Finally, they will be able to learn how the gas can be used directly in their homes as well.

The microfinance structure is based on some of the examples and principles examined by Ananya Roy's Poverty Capital [14]. Families will be given access to loans they otherwise would not be able to receive from the private sector banks. These are often low cost loans (in this case, in a total amount of 130 euros to cover the price of the biogas digesters) which normally, due to financing costs, are not suitable for the area. Members of the program will learn how they can pay back the loans in a timely manner and how to best save money for the future. This program will therefore not extend beyond their need for the biogas digesters. At the end of the educational program, families would decide whether or not they wish to apply for and receive the loan.

The most difficult barrier to success of social programs is getting people to register for accessing its services. A program might have the best intentions and clear benefits for a community, yet it will not be effective if people do not want to join it. In order to help ensure success in the program, an incentive system will built within it. During the course of the educational component of the program, participants will be asked to bring in organic waste they accumulated over the week. This waste will then be placed into the digesters in order to create bio-gas and give an example to the participants of how the system works. In return for the organic waste and participation in the meeting, participants will receive a gas container to take home at the end of the meeting. This bio-gas created by the biogas digesters with the organic waste provided in previous meetings would show the potential that such a system could have in the participants' homes. The gas would then be freely used by the women in their homes for cooking the family's meals. Getting free gas from the program would incentivize people to join and take advantage of the micro-financing opportunity. The workshops they would then have to attend would further do a lot to show the potential that biogas digesters could have in their own homes.

At the end of the program, participants would be given the choice of taking a microloan to fund a biogas digester in their home. They would no longer be able to receive free gas once they complete the program, so a successful execution of workshops and the possibility of continued gas production by using domestic organic waste would likely persuade them to take the loan.

Through the BIO EnGen program, the benefits that can be achieved with the use of biogas digesters would be spread throughout the community. The Bio EnGen site would become a hub for microfinance and biogas education while still providing a space where women could congregate for other purposes and activities. People from outside the community would also have the opportunity to join the program. In this way the Local EnGen Project could have far reaching benefits [15, 16, 17, 18].

WASTE 2 KNOWLEDGE

written by Buket Kara, Defne Yener, Fernando Miramontes, Mariana Cascardo Dias Vieira & Mehul Khoont

Fig. 1: Waste filled lot in El Gamaleya

INTRODUCTION

During the field trip to El Gamaleya, several problems - such as lack of open space and green areas, inefficient waste management, lack of community gathering hubs, intransitable narrow streets, low hygienic standards, ecological disturbance, lack of education and public awareness - were observed, among others. On the other hand, the area proved to harbour good neighbourhood relations and, although they had no complaints about their living conditions, inhabitants who had taken part in our field surveys were open to new ideas like household waste collection and community buildings. Most of all, they were pleased with the idea of new activities that were proposed in these projects.

According to the data and drawings provided by the Cairo University, the study area consists of approximately 670 lots. The assumption about population size was made accordingly by using the number of inhabitants of El Gamaleya. Every lot should have approximately 5 inhabitants per family, leading to a total calculated population of 13,260 inhabitants. With a total area of 126,493 m^2, it has been estimated that the area hosts approximately 5,120m^2 of vacant lots.

The goal of Waste2Knowledge is to develop a concept for a sustainable climate responsive neighborhood in the historic urban settlement of Cairo in order to improve the quality of living conditions and attract visitors. These goals can be partially achieved by removing solid waste in open spaces with the cooperation of inhabitants, as well as providing an alternative to the existing educational bodies.

IMPRESSIONS

The first and most prominent impression of the study area was that the environment was suffering from poor waste management, while some vacant lots were being used by the community for dumping waste. Therefore, the first step of the proposed project is to clean the waste and spread the awareness against waste and pollution in open spaces. Within this step, the condition of the vacant lots had to be improved. Thus, an appropriate solution was to use the vacant land to provide a waste collection facility for the local population by eliminating waste from the vacant areas. The focus area also needed a community space/open space to create a lively neighbourhood since it lacks appropriate open spaces for social gatherings.

The study indicates that some of the vacant lots have the potential to serve the community with a mixed function of waste management facility integrated with a community gathering space.

The current collection system in this area is controlled mainly by the AMA Arab Environment Company (AAEC). They are a local subsidiary of AMA International and are currently one of the largest companies in Egypt with a focus on solid waste management. The company focuses on street cleaning, container collection, waste treatment and disposal. Due to the large amount of garbage that is produced in the city, the company hires sub-categories of collectors (subcontractors), such as the Zabbaleen (garbage collectors), to assist in the garbage collection process [1]. The Zabbaleen are part of an informal sector that have been scouring the city of Cairo since the 1940s, offering to collect waste from the streets or even door-to-door, using donkey carts and pickup trucks [2]. After bringing the waste to their settlement in Muqattam Village, the material is sorted and transformed into useful products such as compost,

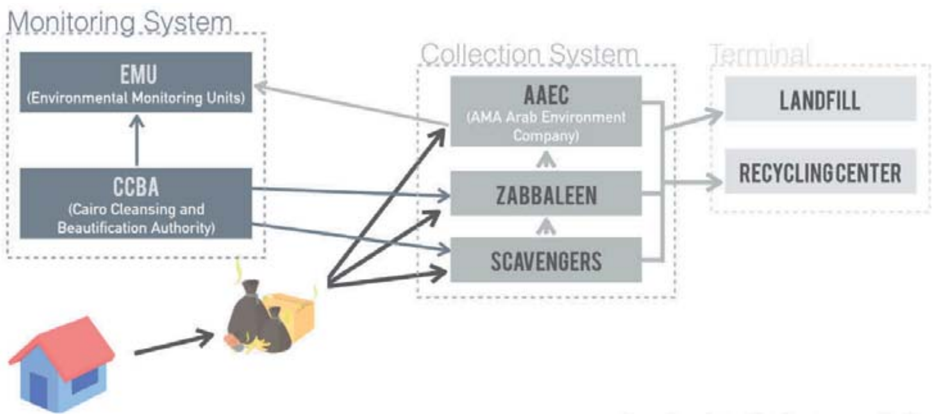


Fig. 2: Existing waste collection system

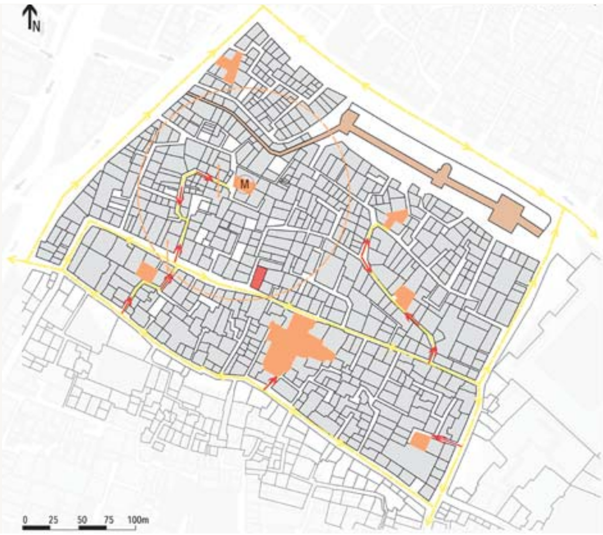


Fig. 3: Waste Voucher's cluster map

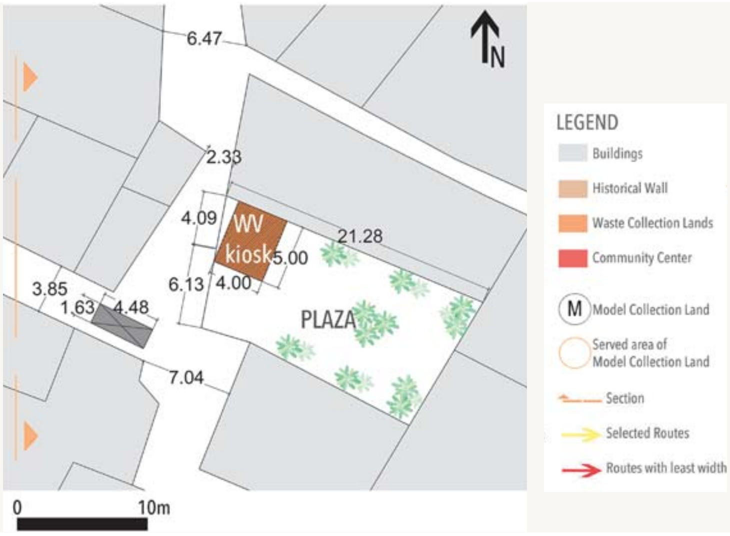


Fig. 4: Model waste collection on vacant lot

recycled plastic products, etc. After removing recyclable and organic materials, the sorted waste is passed onto various enterprises owned by Zabbaleen families for further processing [3].

In each district of Cairo, there is the Cairo Cleansing and Beautification Authority (CCBA) branch directed by a CCBA district manager. They work particularly in neighbourhoods with low-density population. The district manager is responsible for service operation, monitoring and reporting to the Environmental Monitoring Units (EMU). They also establish the necessary penalties, in case of inefficient functioning of the various bodies [4].

PROPOSAL

Solid waste management is a huge challenge for the Cairo municipality and other stakeholders. The city produces more than 15,000 tonnes of solid waste daily, which puts a tremendous strain on the city's infrastructure. The many unofficial garbage dumps across the city pose a major threat. They create a parallel system to and rival against the official waste collection inducing risks caused by decomposition of organic material such as proliferation of bacteria, flies, worms, rats, and other vermin.

The total waste collection data is calculated based on the waste generation in the area [3, 5, 6] and it does not include organic waste. For calculating the total waste generation, various aspects taken into consideration include the total number of inhabitants and the per capita waste generation in the study area. After carefully considering both, available data and estimates based on them, the total waste generation in the study area was estimated at 1.5 tonnes per day.

The vacant lots in the study area have a potential to become waste collection facilities, since the chosen lots are within walkable distance for the inhabitants. In order to specify these as waste collection lots, first, the project started analysing the areas that could be used to create liveable spaces within a 100 m radius. Open spaces were chosen based on high accessibility and waste collection possibility. Considering the volume of waste, an optimised minimum space requirement was determined to be 20 m^2.

The waste would then be collected from the collection facility everyday, due to the feasibility of daily transportation capacity and hygienic reasons. The location of the waste facility is by the wide road (min. 3.85 m street width), considering the requirement for vehicular movement for the waste collection on a daily basis. The routes were defined based on accessibility and ease of logistical service to the waste collection facility. In the case of El Gamaleya, the street network in the core area is too narrow for vehicular movement, which leads to considering the minimum required street width of 3.85 m for allowing easy access both in neighbourhood and connection with main roads.

To create a waste management network in the neighbourhood, the connection of facility land with main roads were calculated to fall within a 100 m radius circle. At the same time, the facility must have enough space for the waste collection. In the example illustrated later, the minimum requirements for waste collection and storage were shown by considering the possible collection route which matched with minimum street width. Logistically, it is necessary to ensure that the amount of waste introduced to the collection points is properly treated and stored. The calculati-

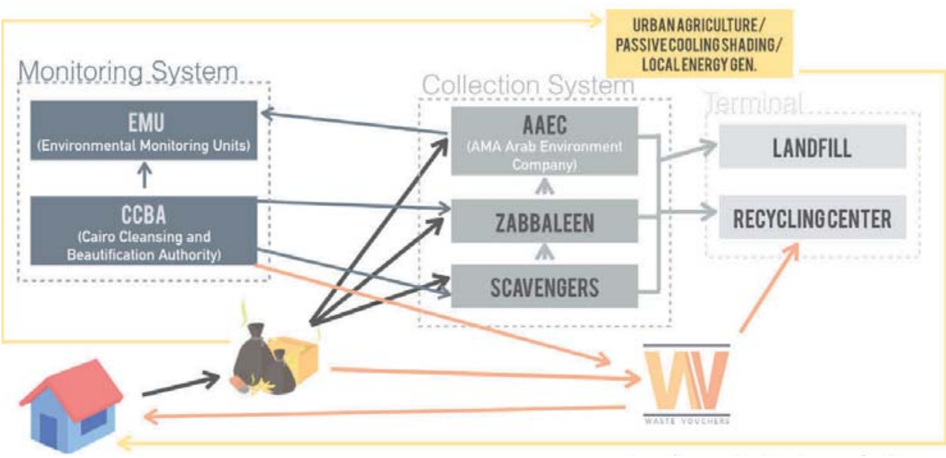


Fig. 5: Proposal for waste collection system

Fig. 6: Visualisation of a Waste Voucher kiosk

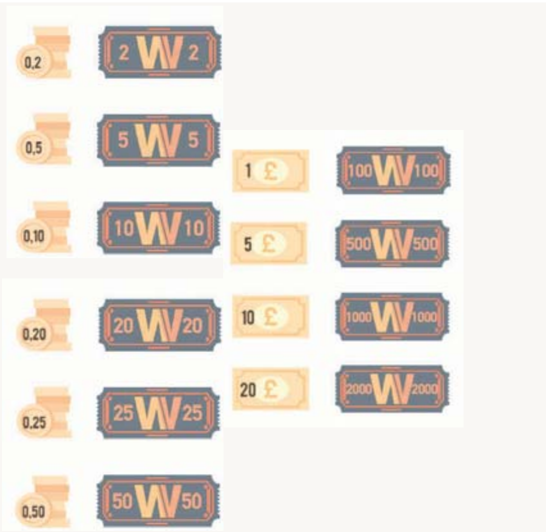


Fig. 7: Waste Voucher coupons

on of the possible waste generation volume in the study area indicates that the waste can be transported using a light-duty commercial truck, capable of driving through the narrow streets of the quarter. Due to hygienic reasons, the waste needs to be transferred to the recycling facility within 2-3 days of collection. In the case of a waste overload in the facility, the manual waste compression machine can be introduced to the required facility for increasing the volume of storage on daily basis. The compression machine is low cost and hand-operated, which benefits the system in terms of investment and ease of operation [7].

VOUCHER SYSTEM

In order to define the value of the vouchers, it was important to understand how much money could possibly be earned by recycling paper, plastic, metal, and glass in Cairo completely. The expected raw value per month is 11.53 EGP per household. Considering that this area has a total of approximately 13,260 inhabitants, the calculated outcome was to collect approximately 30,578 EGP in total per month. The collection points, transportation to recycling centres, and workers, amongst others elements, were considered. With each of these elements requiring specific investments, the proposal is to pay each inhabitant 50% of the raw amount received for the waste that is donated. As an example, instead of paying the donor for a kilo of paper value of 0.22 EGP, the amount of 0.11 EGP will be paid and the rest will be used for maintenance of the proposed system, the community centres, and their workers.

To understand the system better, an example of how the it would be applied in practice was created. A user of the system enters a collection point with the following waste (figure 8):

1.52 kg of paper + 2.56 kg of Plastic + 0.66 kg of metal type A + 1.23 kg of metal type B + 4.00 kg of glass.

1.52 x 0.11 (paper) = 0.17 EGP
2.56 x 0.6 (plastic) = 1.54 EGP
0.66 x 1.15 (metal A) = 0.76 EGP
1.23 x 0.1 (metal B) = 0.12 EGP
4.00 x 0.10 (glass) = 0.4 EGP

The user earns a total of 2.99 EGP which is equivalent to 300 Credit Points (CP).

According to a series of studies published in the Journal of Experimental Psychology, it was observed that "less transparent payment forms tend to be treated like monopoly money and are hence more easily spent (or parted with)" [8]. As such, it is expected that the use of CP would incentivize a rapidly growing parallel market for exchange of goods and services between locals.

COMMUNITY CENTER

The voucher reward system will work simultaneously with the institutionalisation of a social help system within El Gamaleya. This social system's ultimate objective will be to provide tools for the inhabitants through opportunities for social services, microfinancing, and entrepreneurship. Its initial step will be the creation of a community centre with services like workshops and counselling in exchange for the vouchers.

One of the target groups for the project is constituted of the residents and shopkeepers in El Gamaleya. Since they are the people responsible for the production, reduction, and separation of the waste, the system is designed keeping in mind the vital role they play in the community. The youth and children are also crucial stakeholders for the development of the project. The idea is to introduce this concept from an

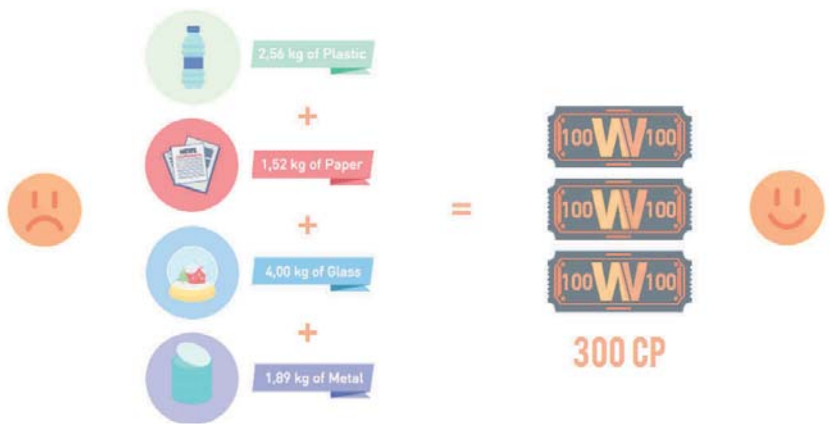


Fig. 8: Waste Voucher credit points scheme

Fig. 9: View and plans for proposed community center

early stage. There are many advantages to educating them and transferring this idea of waste separation as a practice that is not only necessary, but a way of life.

Independent professionals and experts are also crucial to establishing support groups who can aid the community centre by providing technical services. These professionals can include: cultural and technical experts (planners, scientists, engineers, architects, writers, historians, painters, artists, etc.), socio-economic experts, and legal experts, among others.

Strong educational tools are vital to enable new generations to be aware of the threats that an inefficient waste management system can cause. The community-oriented tools could include craft development centers with qualified instructors that could additionally host conferences, forums, workshops, summer schools for children, lectures and presentations (also through museums and cultural centres), applied arts education, technical education, and vocational training. In time, this would lead to the creation of a new generation of qualified young professionals to support the regeneration of the site.

Interactive events and activities that will support the local community by educating them of their own heritage and involve stakeholders for the protection of the site will be supported. These could include community events that raise public awareness and create social, economic, and cultural value in the community (such as festivals, exhibition, performances, and workshops for children and young people - including painting, poetry, photography, theatre, and storytelling). Competitions between inhabitants such as cleaning contests, football matches, or craft competitions can benefit the existing social ties. Many of the impacts represent some of the major social obstacles that need to be addressed in El Gamaleya and therefore serve as a basis for the creation of an architectural program. For example, working towards reducing child labour in the area can be balanced by providing a space where children can attend educational courses. Similarly, providing legal counsel for women creates tools to promote gender equality and open door policies can demonstrate this idea.

Fig. 10: Proposed site for pilot development

MARKETING

The proposal of the project is to include public participation from the community. Logistically, it is necessary to ensure that the amount of waste introduced to the collection points is properly treated and stored.

Fig. 11: Proposed logo

The calculation of the possible waste generation volume in the study area indicates the key to the project success. The public participation is also necessary when the entire system is based on their inputs in the project and the community or individual is gaining a profit to enhance the quality of livelihood. To achieve social awareness and participation response from the community, the campaigning and the marketing of the project is a necessary part of the project proposal. The campaign will start from the early stage of the project with the cleaning of the vacant land in the study area. The campaigning will include the identification of the project with the name and logo by the approval of the authority (figure 11). The logo is a critical aspect of business in marketing. As the company's major graphical representation, a logo anchors a company's brand and becomes the symbol and the most visible manifestation of the company within the target market. In that way, it became crucial for the development of this project to come up with a logo that could help the goal to achieve the total awareness and participation response from the community.

Sustainable Community Niches

written by Kathia Román Reina, Kunal Gaidhankar, Rabya Yawar & Thomas Adrian Fraser

Fig. 1: A rendering of the successfully established community niche

PROBLEM ANALYSIS

The narrow and winding streets of El Gamaleya, a low- to mid-rise residential and commercial district nestled in the northern corner of historic Cairo, are an easy place to lose your sense of direction. There is no grid, no orientation points, no real street signs. Yet while this presents a mild challenge to a visitor, the overwhelming majority of people on its inner streets are those to whom it is most familiar: the residents, workers, and neighbors who spend their days and nights within its boundaries.

PROBLEMS:	OBJECTIVES:
Not enough public social space	Generating public social space
Vacant land available & unregulated	Use and regulation of vacant land
Local workshops sell out of their production space	Local workshops sell out of a shared storefront
Circular economic opportunities inside the area are limited	Circular economic opportunities inside the area are created
Low energy efficient constructions	Climate responsive architecture

Fig. 2: Problems and objectives

This project is the result of a multi-faceted analysis of the needs, demands, opportunities, and realities of the place and the people who use it, work in it, and live in it. Our research question is a deceptively simple one: Which participatory and community-driven interventions on vacant land can be realized to address most, if not all aspects of sustainability in El Gamaleya?

The work began with a series of analysis methodologies to identify specific problems and ways to approach them. This was done by completing a thorough SWOT analysis, site visits and observations, interviews with people from the area (both residents and workers), and a logical framework set of problem trees to organize the various issues. From here, we identified 5 specific problems and converted these into 5 objectives to address our end goal: creating sustainable interventions that enhance and rehabilitate urban open spaces while improving occupant quality of life.

After the problem analysis came the site identification, with a priority on reaching as great a number of residents and occupants of the neighborhood as possible within the shortest walking distance. After the site was identified and guided by the definition of *niche* ("a place, employment, status, or activity for which a [...] thing is best fitted" [1]) , we proceeded with a process of specific design solutions and evaluations to clarify what would be the most useful and apt interventions to pursue. The designs were concentrated into two different approaches: one for a building that would provide commercial options, retail space, and housing; and the other for open space designs including both the green space as well as the zone of street between the park and the building.

Site	Easy Vehicle Access [1]	Buildings within 3 min. walkable distance (% of total) [2]	Plot Size (m^2) [3]	Potential Surroundings for further development [4]	Informal occupation - housing [5]
Site #1	No	45	193	Yes	No
Site #2	No	61	262	No	No
Site #3	No	65	194	No	Yes
Site #4	Yes	85	306	Yes	No

Positive / Negative

Fig. 4: Site selection analysis

DESIGN CONCEPT

The building design needed to respond to several concerns. First, it needed to respect traditional cultural norms in it's layout and use of residential space. Second, it needed to be climate responsive, flexible to the demands of the residents and help achieve their economic

Fig. 3: Definitions and concept

Fig. 5: Existing condition of the vacant niche

Fig. 6: Fulfilment of objectives of the niches

goals, and it needed (in our view) to be a good learning and teaching example for how more sustainable constructi-on and design could look in Cairo and Egypt. However, it also needed to be within the bounds of traditional con-struction techniques and capabilities, and priced in such a way to allow for replication, not simply remain proof of concept. To these ends, we selected a reinforced concrete frame for the main structural loads and infill compressed earth blocks (CEB) for infill walls. CEB have been proven by numerous Egypti-an researchers and producers to have solid thermal capabilities and low cost of construction. They can be produced on site with a simple device and have much less embodied energy than tradi-tional clay fired bricks [2, 3]. Combined with a number of passive strategies (cooling towers, cross ventilation, thick walls), using CEB as the main construc-tion material leads to a much more en-vironmentally friendly building.

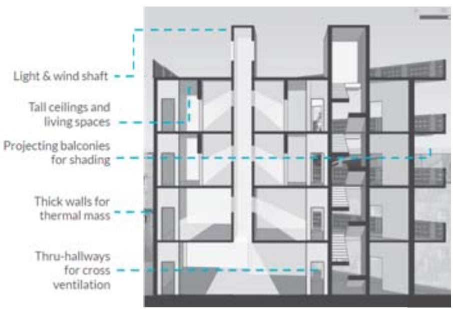


Fig. 7: Building section

Preserving the single existing green space was the beginning point of our open space considerations. Based on the "The modified 12 Quality Criteria for Good Design of Public Spaces at a glance" [4], the plot was evaluated and interventions were suggested to im-prove the currently unfulfilled criterias. These interventions were evaluated with the aid of a multi-criteria analysis (MCA) within the topics of: maintenan-ce, attractiveness, cost, cultural accep-tance, and local resources.

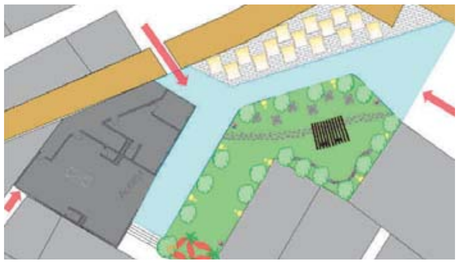


Fig. 9: Top view of the interventions in the park

Proposed interventions ranking high according to the MCA total score were selected and distributed along the green open space in order to pro-vide spaces for community interaction by the use of board games, shadowed benches, resting facilities and green ga-thering areas.

In addition, following local practices of outdoor and streets activities, the street between the open space and the building was incorporated to the inter-vention by delimiting it with concrete

Criteria [1]	Status[2]	Criteria [1]	Status [2]
Protection against traffic & accidents		Possibilities for walking	
Protection against crime & violence (feeling of safety)		Possibilities for standing / staying	
Protection against unpleasant sense experiences		Possibilities for sitting	
Scale		Possibilities to see	
Possibilities for enjoying positive aspects of climate		Possibilities for hearing & talking	
Aesthetic quality / positive sense experiences		Possibilities for play, unfolding and activities	

Source: 1 "The modified 12 Quality Criteria for Good Design of Public Spaces at a glance", Dietrich, 2016
2 - Own based on site visits (November 2016)

Fulfilled · Partially Fulfilled · Not Fulfilled

Fig. 8: Open spaces intervention analysis

Fig. 10: A rendering of the successfully established community niche

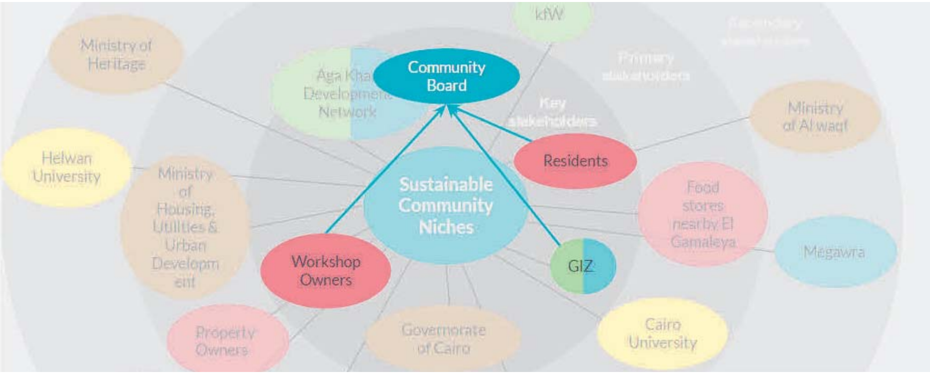


Fig. 11: Stakeholder analysis

bollards and street painting. To highlight the section of the wall in the intervention area, shadings and seats were placed next to it adjacent space.

IMPLEMENTATION

To empower the El Gamaleya community throughout the process, a participatory monitoring and evaluation model was proposed. Highlighted as an asset in community-based interventions, this cost effective model integrates local skills, resources, demands, culture, ideologies, as well as historical, political and social context within a transparent and open process. Within this participatory approach, stakeholders can develop a stronger sense of project ownership and the final results can be used to inform planning and implementation of future projects in the same area.

Focusing on stakeholders, these were identified and organized in five main catogories: society, governmental, education and know-how support, and financial support. As shown in figure 11, a color coding scheme was used to identify important members in each category and their relationship. The key stakeholders are part of the local society in El Gamaleya, encompassing everyone who is living or working in the area. The involvement of these stakeholders is crucial for the project implementation.

Governmental approval will be necessary, particularly from the Ministry of Housing, Utilities & Urban Development and potentially the Ministry of Heritage, for the building permit.

Property ownerships need to be identified in accordance with the Ministry of Al Waqf and Governorate of Cairo. The Ministry of Economic Development

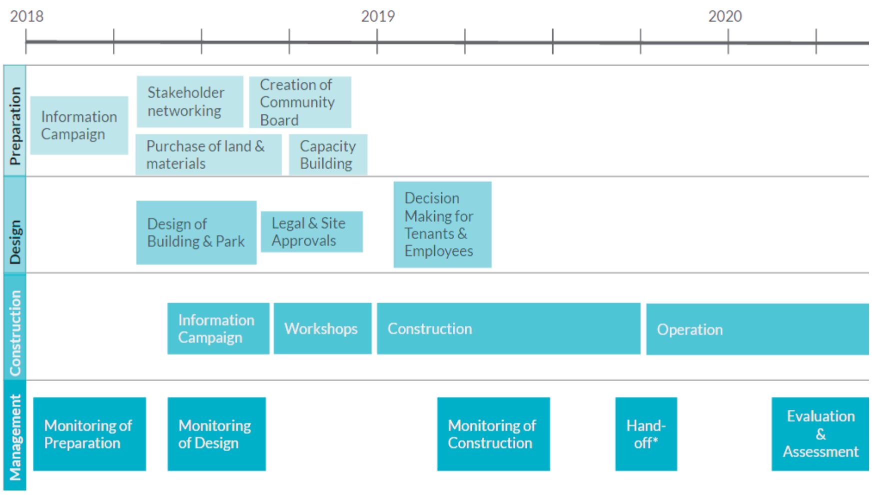


Fig. 12: Proposed site for model development

SHORT TERM

- Neighborhood capacity building
- Use of both open spaces and new residential housing
- Establishment of commercial opportunities for residents and business owners

MEDIUM TERM

- Identification and evaluation of more potential development sites
- Consistent employment and operation of commercial storefront and cafe
- Hand-off of ownership to community board

LONG TERM

- Bottom-up funding and design of future developments
- Integration of adaptive sustainable design and construction techniques

Fig. 13: Project goals

Fig. 14: A rendering of the successfully established community niche

and the Governorate of Cairo, assisted by GIZ and KfW, are experienced in developing and implementing participatory upgrading mechanisms in informal areas [5]. The KfW Entwicklungsbank (German Development Bank) is financing pilot interventions based on this approach, with projects often resulting in fast and visible change.

The project activities were grouped in four main parts (preparation, design, construction, and management) and distributed within a timeframe of two and a half (2.5) years. Looking towards to the future of the project, short, medium and long term objectives were proposed (figure 13).

Short term objectives coincide with the project goals, including items such as capacity building and the establishment of commercial opportunities within the area. At a medium level, identification of more potential development sites is important (on which replicas of the pilot project could be applied).

On the long term perspective, considering the importance of citizen control & empowerment, the project aims for crowdsource funding and more collaborative design of future development. Integration and collaboration with the other REAP project groups is considered very plausible and provides a significant opportunity to empower the local community by creating a showroom of the various strategies proposed for the neighborhood. Examples of possible incorporated solutions are urban gardening, PV energy generation, supplying the cafe with biogas or energy provided by PV, covering the open spaces with the shade structures proposed, and plant watering with treated wastewater.

CONCLUSION

Based on the site visits, initial analysis, project development, and expert interviews, we came to a satisfactory answer to our research question. Although no single intervention addresses all aspects, the combined product introduced in this project would help increase the livability of El Gamaleya.

In conclusion, we believe adaptive building strategies and sustainable technology can be combined with participatory economic opportunities and decision processes in interventions that address multiple pillars of sustainability. In addition, when designing culturally-engaging open space interventions and social space improvements, vacant land can be repurposed and enhanced to improve the livability of El Gamaleya for both current and future residents.

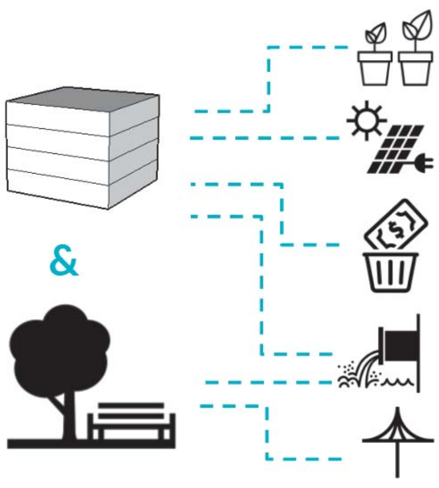
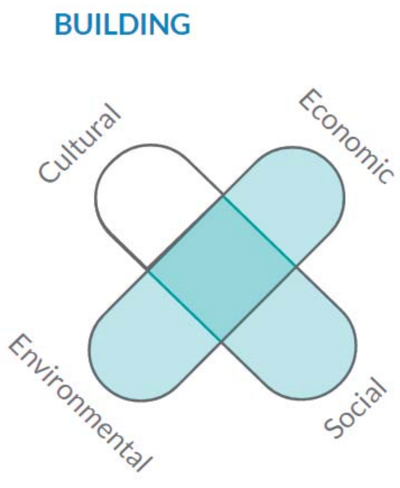


Fig. 15: Synergies with other REAP project groups



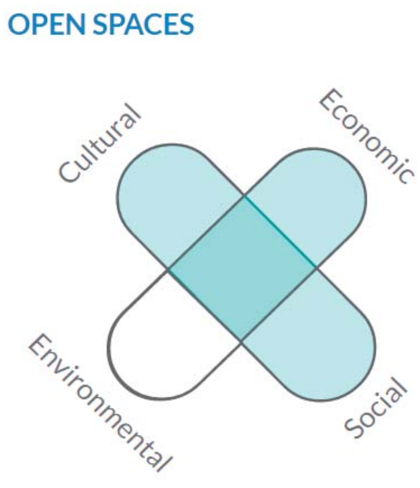


Fig. 16: Sustainability assessment

CONCLUDING REMARKS

Interdependencies

Conclusion

INTERDEPENDENCIES

written by Thomas Adrian Fraser & Petrut Ababei

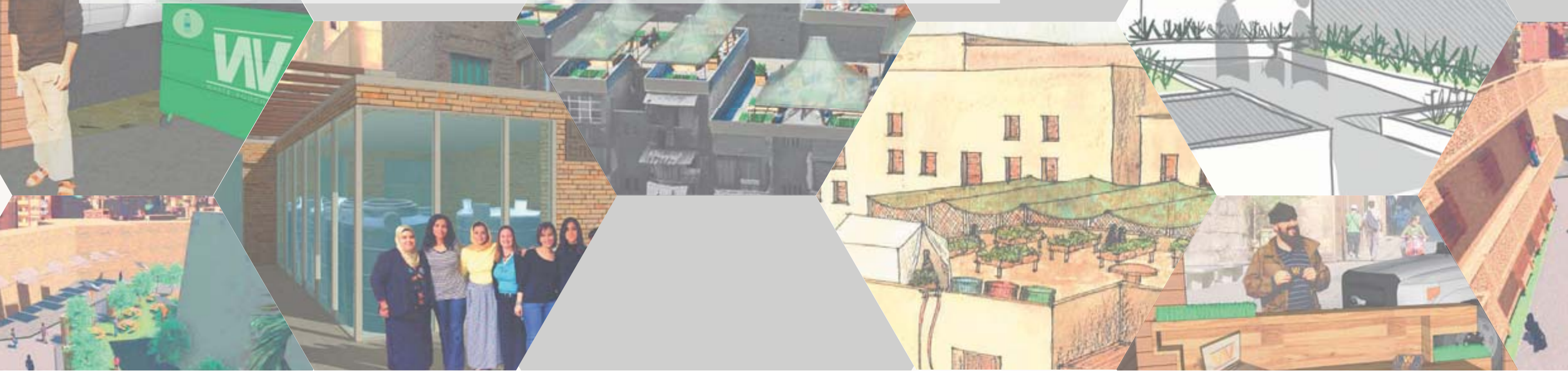


Fig. 1: Visual representation of interventions

Midway through the project development stage, a World Cafe session was held with all project participants to offer the opportunity for identifying and defining potential project synergies between REAP groups. On this occasion, a number of discussions arose, the conclusions of which indicated that some of the project concepts under development could work quite well together. In certain situations, it was deemed possible to incorporate a majority of the smaller projects under the umbrella of one of the others. With this reality in mind, it was decided that a portion of the project development time would be dedicated to considering and specifying which projects would work well together and which could be combined or condensed in various ways to work with others in a symbiotic or complementary fashion.

As shown in figure 2, possible project interdependencies are numerous and diverse. They offer tangible opportunities for exchange of relevant physical, monetary, and educational resources and outline the criticality of an integrated approach. Although theoretical in nature, the possiblity for co-dependance and collaboration speaks volumes about the variety of intervention concepts that are feasible for the area.

In addition, it is important to emphasize the requirement for careful and specific identification of potentials, risks, and needs that should be part of the selection process when considering implementation. Should any of the proposed interventions be pursued in reality, a recommended approach would involve the inclusion of whichever complementary project concepts or elements would strengthen the overall likelyhood of realization and contribute to the specific goals for the area. By doing so, a more robust, economical, and overall sustainable solution for can be designed for improving quality of life in El Gamaleya.

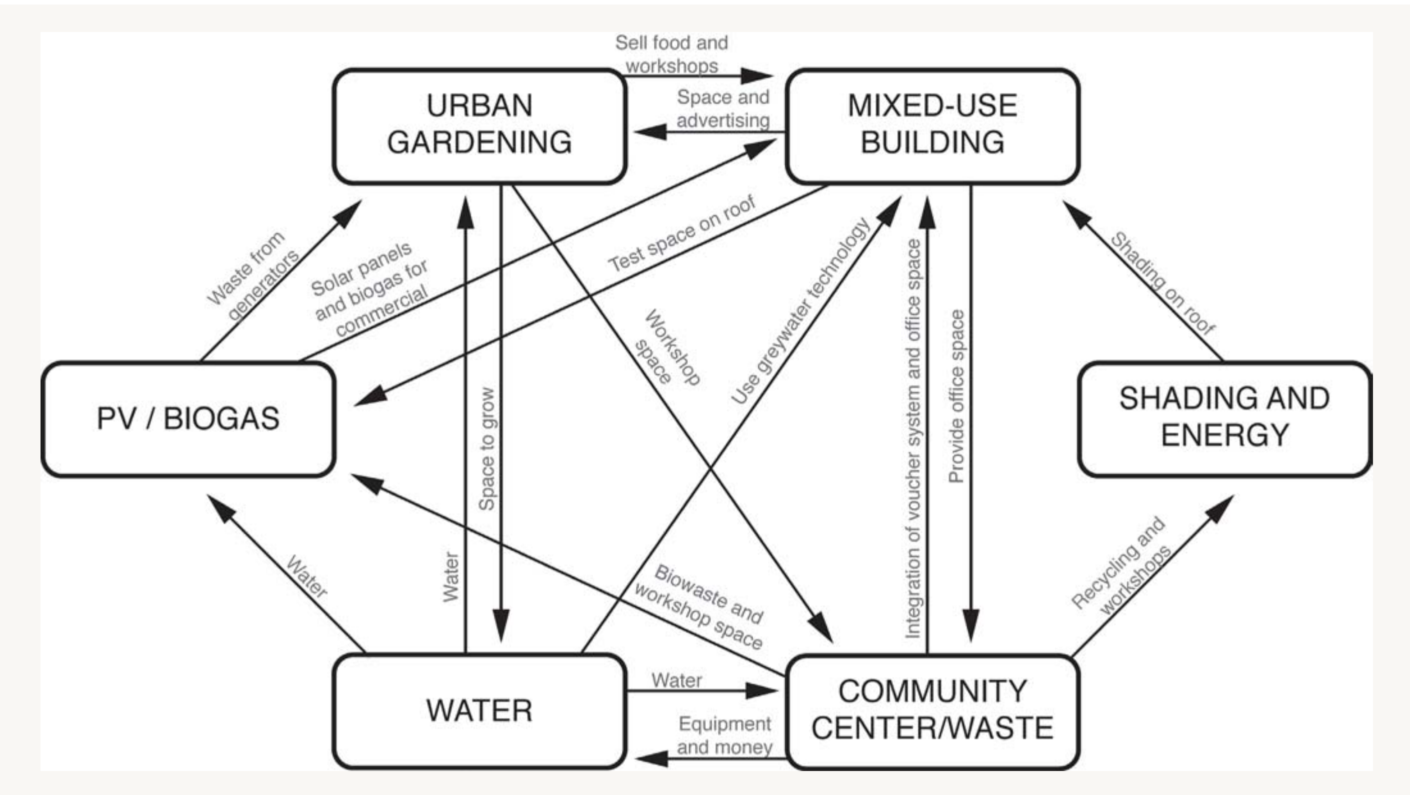


Fig. 2: Nexus of inter-relations between all proposed projects

CONCLUSION

written by Thomas Adrian Fraser

Fig. 1: Open urban spaces and structured infrastructure surrounding the iconic Tahrir Square, a symbol of hope for those who believe in the power of the people.

THE ILLUSION OF NEED

As we come to a close of our evaluation of various project proposals for increasing the sustainability, resiliency, and quality of life for the people of El Gamaleya, it is important to strike a significant note of restraint. Simply put, we are very aware of the limitations of these proposals and the necessity for further study to determine technical viability, overall efficacy, and, more importantly, a demonstrated need for such interventions. In a neighborhood where people are generally more concerned with having enough to eat and getting their children to attend school, a set of so called "first world solutions" can appear to an outsider as nothing more than the illusion of help. Yet, we do believe that the base arguments, evaluation strategies, and proposed solutions can be feasible starting points for real work in the area.

Deep-seated problems cannot be solved with bandages and good intentions and small scale interventions such as those on the preceding pages will never be the kindling for a revolution of either lifestyles or culture. The authors of these project proposals entertain no delusions in regards to the actual impact the realization of these projects would entail for the greater Cairo area. At the same time, we believe that in places where the government is dealing with greater problems and the population is generally left to fend for themselves, small changes can have large impacts for a few. And, from those few, change can slowly spread to the many.

The political stability in Egypt is currently fragile and the outlook is unclear. With the uncertainty of the national government comes a more general unrest in the region, especially in the context of looming, increasingly visible impacts of climate change. No scholar or scientist is willing to describe the exact changes that will come in the near and far future for the people of Cairo and we have no intention of adding our names to a list of fortune tellers.

What we are willing to do instead is to advocate for and develop on opportunities we believe exist for improving the sustainability and livability of El Gamaleya. Our projects are suggestions, concepts, ideas, and brainstorms - the product of the freedom of abstraction combined with the certainty of academia. Our hope is that the resulting proposals can contribute to a growing body of knowledge and work that will eventually see itself realized in the streets, buildings, and neighborhoods of cities just like Cairo all around the world.

Fig. 2: Other parts of the city grow and function more organically, catering to its peoples needs.

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Fig. 1: Al-Azhar Park at noon

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[Figure 1] Rooftop gardening proposed in El Gamaleya

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Fig. 2: Visual impression: Al-Azhar Park at dusk







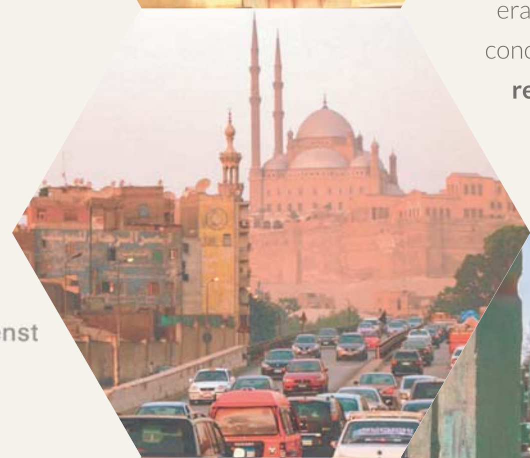


The third and last semester of the international Master course in Resource Efficiency in Architecture and Planning (M. Sc. REAP) culminates in the undertaking of an **international research project**.

This brochure provides an overview of the project's scope, methodological approach, theoretical analysis and results, as well as their translation into **urban interventions as proposed by the 7th generation of REAP** students.



The Architectural Department of Cairo University (CUFE) and HafenCity University cooperate with the goal to generate concepts for **sustainable climate responsive development in a historic urban area** in Cairo, Egypt.



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