Image source: Traveling Guide Info, 2012

# A Growing City



## Chapter: 5

# Concerning Concerns

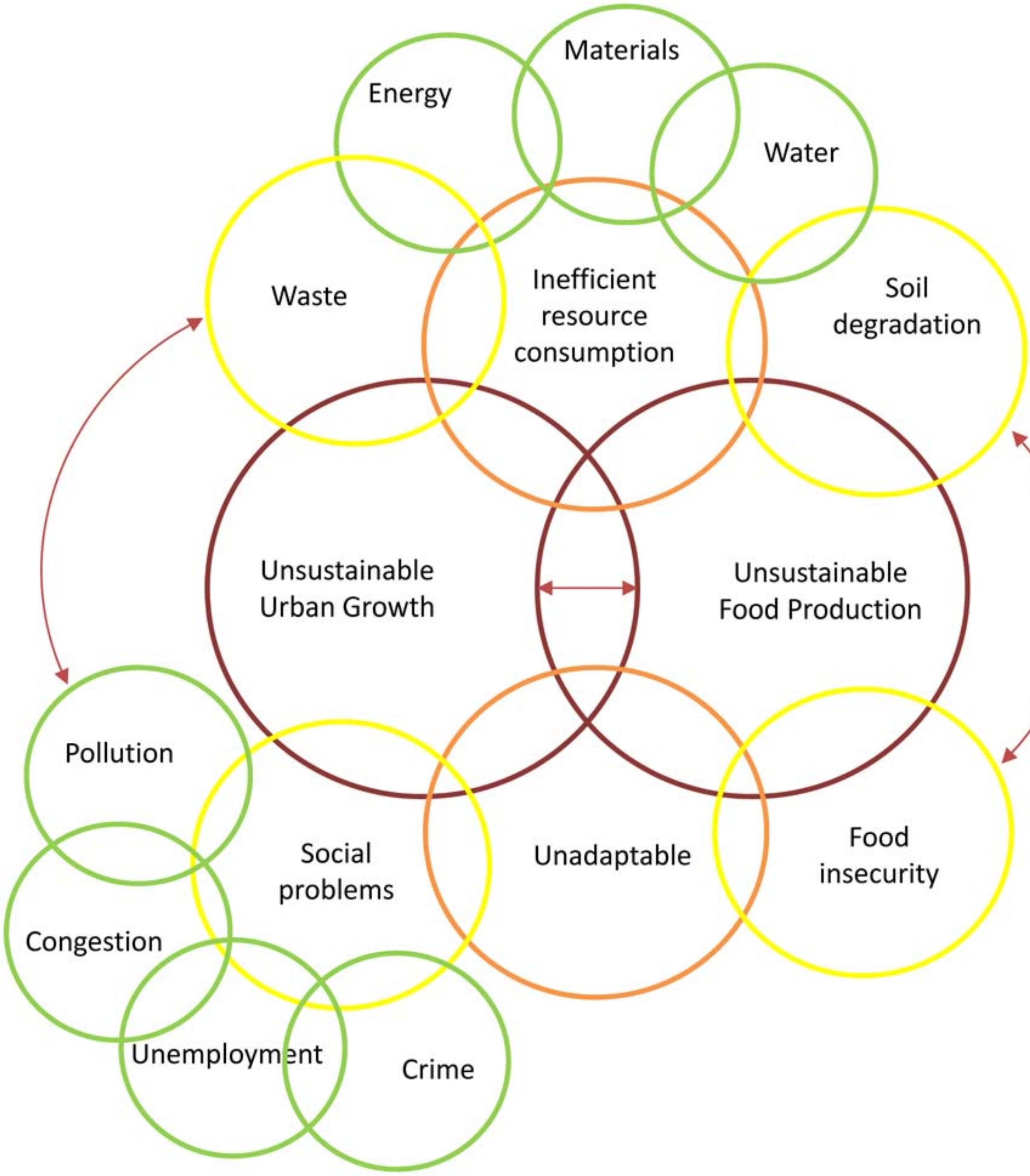



Fig. 5.1: This Venn diagram shows the various concerns around food security in the inner city of Johannesburg. The roots of the problem are highlighted in the red circles and the effects of them radiate out. Each time a circle overlaps another it is because there is a link between the two. Thus unsustainable urban growth and food production lead to inefficient resource consumption and unadaptable infrastructure, as shown in orange. These breed the concerns highlighted in yellow, manifesting in those seen in green. An intervention that hopes to be successful cannot merely address the issues in the green circles, but needs to get right into the middle where the problems begin. (Source: author, 2012)

The site has a rather peculiar context. While the context is light industrial, there are many pedestrians and much socializing that goes on there. These are factors that need to be considered in the approach to the design. Faraday Market, besides being a major destination, is also directly linked to food security through health and the need for medicinal herbs. This must be faced by any agricultural intervention in the inner city. The majority of the herbs, according to one muti seller at the market, come from KwaZulu Natal. The Sangomas (traditional healers) often have to plan months ahead to drive by taxi down to KwaZulu Natal in order to buy more herbs, or to get their herbs delivered.

Also important to consider is what would happen to the taxis who currently informally occupy the site. It could be considered that the Faraday Taxi Rank is underutilized and has enough space and facilities to accommodate a fair portion of the taxis that use my site rather than the taxi rank. However, also a possibility is another vacant plot of land immediately south of the M2 highway. This does not displace the taxis beyond their sphere of influence as this site is very much the same distance from Faraday Market as my site is, the difference simply being that it is south rather than north. This site has also been highlighted by the 2009 development framework (by Annemarie Loots et al.) as a potential public space. This site currently facilitates a pedestrian through-route that goes from Faraday to City Deep.

Another important factor is soil contamination. This needs to be addressed through my proposal in order to remedy the site and make it fit for growing food. However, this usually requires a process which takes time and time is not always a luxury. Therefore the design needs to consider ways of healing the soil while at the same time growing food. This can be achieved through the use of multiple types of farming. As mentioned earlier a combination of permaculture and aquaponics has multiple benefits. Further to those mentioned earlier, aquaponics can allow for food to be grown in a secure and contamination-free environment, while the permaculture gardens can include healing the soil on site as part of their production cycle. Permaculture teaches that plant types and stages of growth should be varied for the same piece of land, rotating at different times and even allowing for a rest period. This is the cycle that can incorporate a period of soil healing as well.

One of the most effective ways of dealing with nature (which is essentially what agriculture is), is to let it run its natural course. The methods used to grow the food should consider how it would naturally grow, which is exactly what permaculture does. With the same attitude, in order to heal the soil effectively in terms of money and resources one should look at natural ways of treating it.

Fig. 5.2: The informal herb stalls at Faraday Muti Market. (Source: author, 2012)

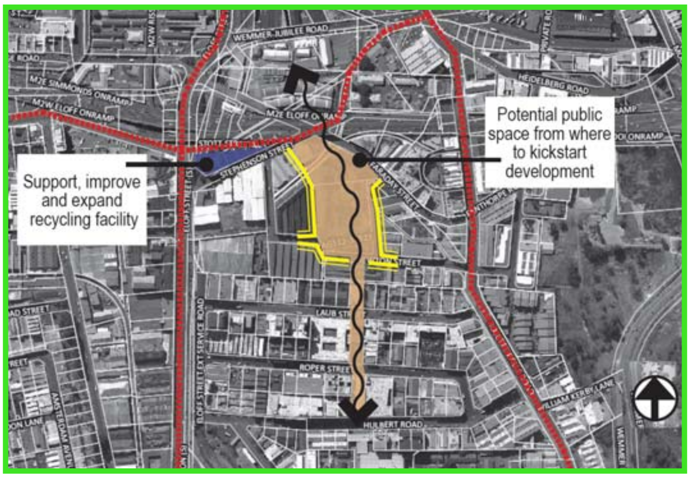



Fig. 5.3: The orange highlight shows the vacant site spoken of above which can be used for a public space or for the taxis. The two dotted red lines are Eloff Street on the west and Rosettenville Road on the right. The black arrow join Faraday Market in the north with City Deep in the south. The blue highlighted area is an existing recycling facility. (Source: Annemarie Loots et al., 2009: 25)

Certain chemical elements occur naturally in soils as components of minerals, yet may be toxic at some concentrations (Shayler et al., 2009: 1). Other potentially harmful substances may end up in soils through human activities. In addition to possible effects on human health, elevated levels of soil contaminants can negatively affect plant vigor, animal health, microbial processes, and overall soil health (Shayler et al., 2009: 5).

Soil pollution disrupts the essential cycles of decomposition and energy recycling (Rogers, 2010). Acidic soils can leach vital nutrients, such as calcium and magnesium from the topsoil, making them unavailable for plants (Rogers, 2010). It can also kill soil bacteria. These bacteria are necessary to fix nitrogen from the atmosphere and make it available to plants and micro-organisms (Rogers, 2010).

Several methods can be used to clean up soil pollution. The soils on site are contaminated by the mines, making them acidic. Additives such as lime or limestone can neutralize the effects of acidic soil conditions (Rogers, 2010). According some reports sewage and softening sludge from water treatment plants has successfully been used to reclaim abandoned mine sites polluted with acidic mine drainage (Rogers, 2010). This is similar to wetlands.

Wetlands are incredibly efficient ecosystems. There are two types of wetlands commonly used to treat damaged soil. One is aerobic which is good for net alkaline soils (Zipper et al., 2011: 3). The other is anaerobic which is better for acidic soils (Zipper et al., 2011: 5). These include the addition of a bed of limestone beneath or mixed with an organic substrate, which encourages generation of alkalinity (Zipper et al., 2011: 5). The substrate can be comprised of biodegradable organic materials that are placed over limestone, or as an organic-limestone mixture. The limestone is placed so that waters must move through organic substrate prior to contacting it, which allows bacteria in the organic material to remove O2 from the percolating waters (Zipper et al., 2011: 5). This process helps to prevent armouring of the limestone. The term "armouring" refers to coating of Fe on limestone surfaces, a process that renders those surfaces less reactive (Zipper et al., 2011: 5).

General guidelines for anaerobic wetland construction advocate use of a 300-600 mm layer of organic matter over 150-300 mm bed of limestone, or placing a mixture of organic matter and limestone to a depth of 500-1000 mm (Zipper et al., 2011: 5). Cattails (Typha sp.) or other aquatic vegetation may be planted throughout the wetland to supply additional organic matter for the O2-consuming bacteria and to promote metal oxidation with the release

Fig. 5.4: Mine tailings in Johannesburg with acid mine drainage. (Source: author, 2011)

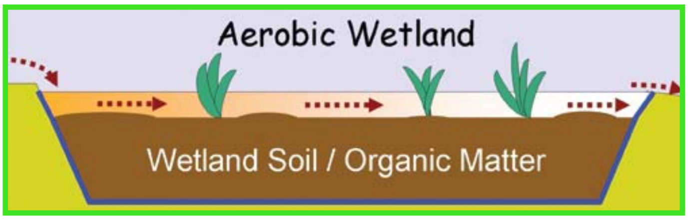



Fig. 5.5: Aerobic wetlands soil treatment. (Source: Zipper et al., 2011: 3)

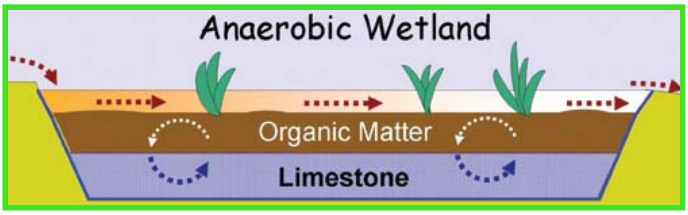



Fig. 5.6: Anaerobic wetlands soil treatment. (Source: Zipper et al., 2011: 5)

of oxygen from their root system (Zipper et al., 2011:5).

Another system which can later be used to improve soil quality and filter water at the same time is called Living Machines. Based on the principles of wetland ecology, it uses a tidal process to clean water, and is a very energy-efficient system (Living Machine, 2012). The Living Machine system incorporates a series of wetland cells, or basins, filled with special gravel that promotes the development of micro-ecosystems (Living Machine, 2012). As water moves through the system, the cells are alternately flooded and drained to create multiple tidal cycles each day, much like is found in nature. The specially-engineered gravel within the cells promotes the development of micro-ecosystems, which efficiently remove nutrients and solids from the wastewater, resulting in high quality effluent (Living Machines, 2012). "Although a typical Living Machine system recycles thousands of gallons of water a day, everything occurs below the wetland surface. All the casual observer sees are lush, vibrant plantings" (Living Machines, 2012).

The main components of a Living Machine System are:
•Primary Tank: here solids settle and begin to degrade
•Equalization Tank: the tank buffers periods of high and low flow.
•Stage 1 Tidal Flow Wetland Cells: these aggregate media-filled planters are alternately drained and filled up to 18 times per day.
•Stage 2 Tidal Flow Wetland Cells: a portion of water moves to Stage 2 and undergoes the same process, where smaller treatment media provides faster treatment.
•Polishing System: water undergoes final polishing and treatment.
•Reuse Tank: treated water enters the reuse tank before moving on to different reuse applications.
(Living machines, 2012)

Fig. 5.7: Cattail reeds. (Source: Your Dream Backyard, 2011)

Fig. 5.8: Living Machine installed in an atrium. It looks just like any green feature. (Source: Ecofriend, 2008)

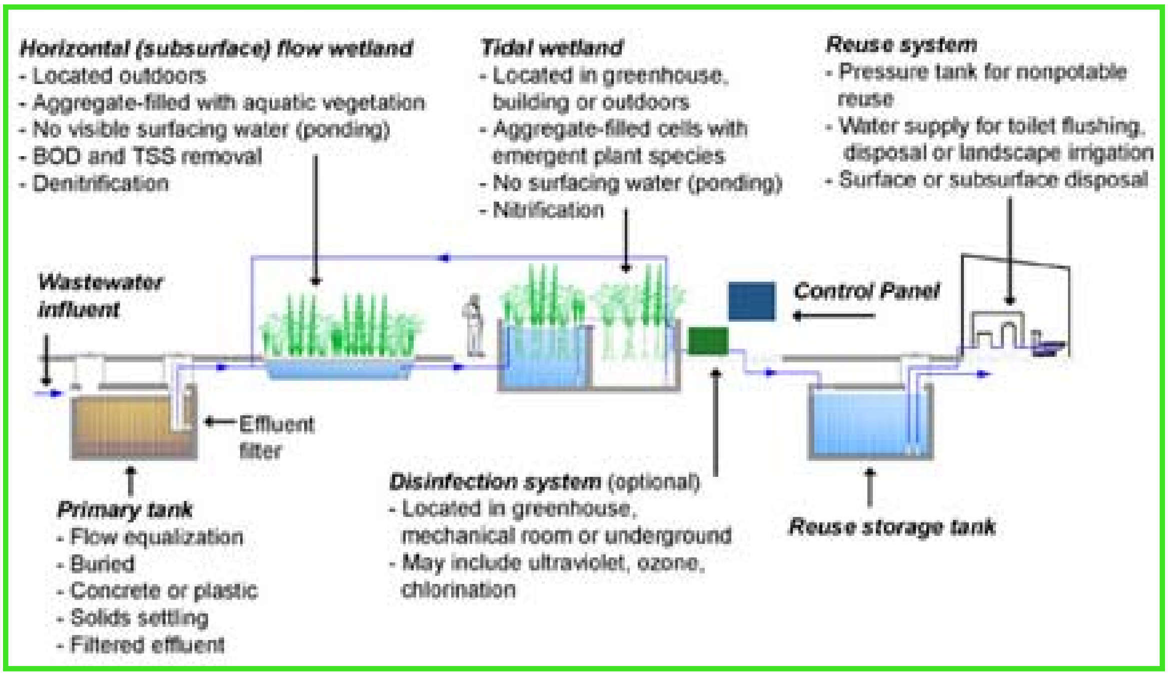



Fig. 5.9: A diagrammatic explanation of the Living Machine system. (Source: Apartment Therapy, 2012)

# Lessons from the Past

Joubert Park and Siyakhana are both successful urban food gardens. Therefore it would be unwise to try and compete with them. Joubert Park addresses T.B. patients and provides for their specific needs. Siyakhana is situated outside the inner city and influences the particular surrounding community there, while also reaching out further. As my research has shown AIDS is strongly linked to well-being and food security. South Africa also has some high statistics with regards to population affected by HIV and AIDS. So I propose that my design scheme should address people with AIDS. This can be done by providing employment for those strong enough, or providing employment to unemployed relatives of the infected persons. I also propose counseling and nutritional advice for these people, with certain of the foods grown on site being specific for helping with AIDS. On a side note, in a conversation with a Sangoma, I was informed that there is a concoction called the AIDS mixture which is believed to help people infected with AIDS. The herbs that make up this mixture can be grown on site.

Involving the surrounding community and AIDS affected community in the permaculture farms draws on the successes shown through Siyakhana and Mobile City Farm. These two are good examples of how communities benefit from skills development and food production. Learning further from Mobile City Farm, I propose that my scheme would have mobile components or components of easy assembly which can be placed in the left over spaces of the city. This allows food to be grown closer to where other people may need it, as well as increases the area available for food production. Given the density of the inner city and the small area of many of the vacant sites, these components should also be able to grow food vertically. In the same way that Mobile City Farm addressed the pollution on their sites, my design must address the contamination.

On the issue on inner city density, the Plantscraper in Sweden shows a tall building used to grow plants vertically. This is very context specific to Sweden as a first world country. Their unemployment and AIDS statistics are far lower than those of South Africa and therefore community involvement is less necessary. Growing vertically with hydroponics requires less labour than permaculture. Again, using aquaponics and permaculture together is more tailored for the South African context, and encourages participation through a lower density flexible design. This design can learn from Joubert Park through its use of reclaimed and salvaged materials. This reduces the cost while recycling the waste from other projects or places, closing loops that are currently open ended.

The mobile components spoken of above can take a modular approach, as seen in biomimicry. This makes movability easier, manufacture simpler, and can be designed for certain materials that are abundantly available. The modules would need to be flexible enough to stack upwards, as well as stretch in multiple directions on the horizontal plane.

# A Natural Response

The first thing to do when applying biomimicry to architecture is to consider the function of the design or component. One should ask what it is that the design needs to do, then ask why (Biomimicry SA, 2012). This allows an understanding of the end goal and this understanding leads directly what to look at in nature for a possible answer by asking "how does nature do it?"

Life's principles, as described in chapter 3, provide responses that are conducive to life – creating good quality of life. The issues related to agriculture, the site, resources and energy required for the building, and the social aspect of the project are the ones I considered. The questions I asked are listed below:

How does nature cultivate cooperative relationships?
How does nature maintain community?
How does nature restore barren landscapes?
How does nature move from pioneer to successive ecosystems?
How does nature cycle nutrients?
How does nature not waste?
How does nature adapt to changing conditions?

In researching these questions I found that many of them are addressed through a similar theme of feedback loops. From there I looked into how nature creates feedback loops. But as for other functions not achieved through feedback I found that nature always uses readily available materials which have life-friendly chemistry, that is to say that they assemble and biodegrade easily, benefitting the ecosystem in their use and degradation. (As a side note, a great information resource on nature, from where I got much of the answering information to these questions, is AskNature.org)

Cooperative relationships are achieved through each member of a community performing their task and often being cut off from the community upon failure to do so. One particular example I wish to highlight is the fig tree and fig wasps. In exchange for the pollination service provided by the wasp, the fig fruit provides room and board for the wasp's developing young. However, wasps do not always pollinate the fig. Fig trees "punish" these "cheaters" by dropping unpollinated fruit, killing the wasp's offspring inside (Science Daily, 2010).

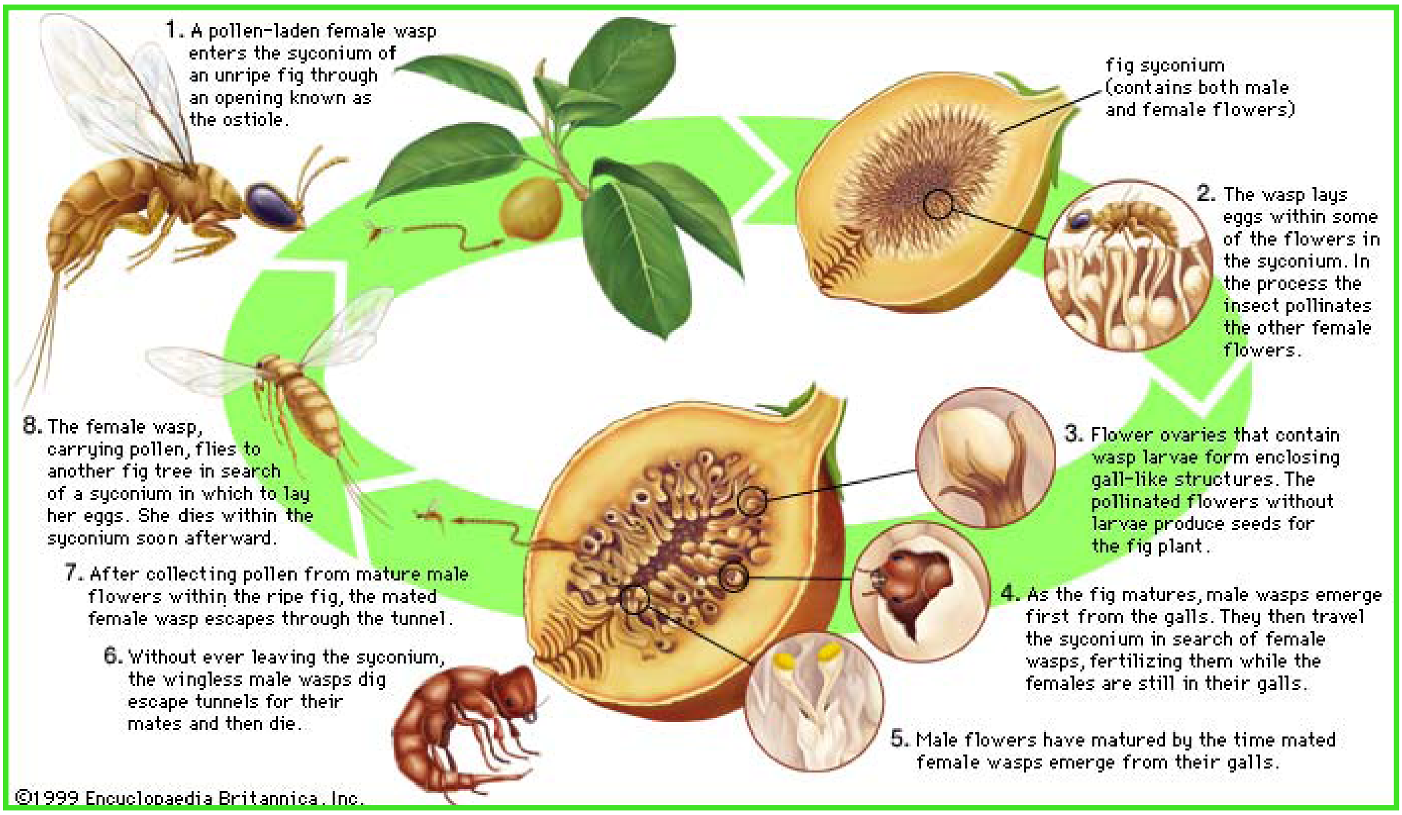


Fig. 5.10: The mutual relationship between a fig tree and fig wasp. (Source: Ecological Observations in Singapore, 2012)

Restoring barren landscapes is often done through processes such as wetlands, and certain pioneer plant species such as lichen (shown in chapter 4). The lichen goes into a desolate site and begins to break down the rocks and restore nutrients to the soil, as do other fungi.

As for not wasting, nature makes use of readily available materials, recycling everything, and using everything as resource efficiently as possible. In nature that which is most abundant is most valuable. Examples of resource efficiency in nature include hollow tubular structures which are strong and flexible such as bamboo, feather shafts of birds, and insect appendages (Biomimicry Institute, 2012). Plants and animals never use more resources than they need.

Comparing a tree and forest to a building and a city one can notice significant similarities. Both of them provide similar things to their contexts, whether it be shelter, food, nutrients, energy, heating and cooling, shaping the environment physically etc. Therefore I considered what things are needed for a tree to grow and how the tree uses them. What I found was that the things which shape trees are light, gravity and wind, and the things trees need are soil, water, light, energy, carbon and nutrients.

As trees need energy (light and wind), so do buildings. As trees need nutrients, so buildings need income and maintenance to keep running. As trees need water so too do buildings. As trees need carbon and release oxygen, humans need oxygen and release carbon dioxide. The problem here is that we release too much carbon dioxide (and other more harmful greenhouse gases) through our technologies and lifestyles. Therefore the appropriate response here is to reduce carbon emissions and pollution.

For a more comparative chart of things in nature which address the concerns my project is addressing please see appendix A.

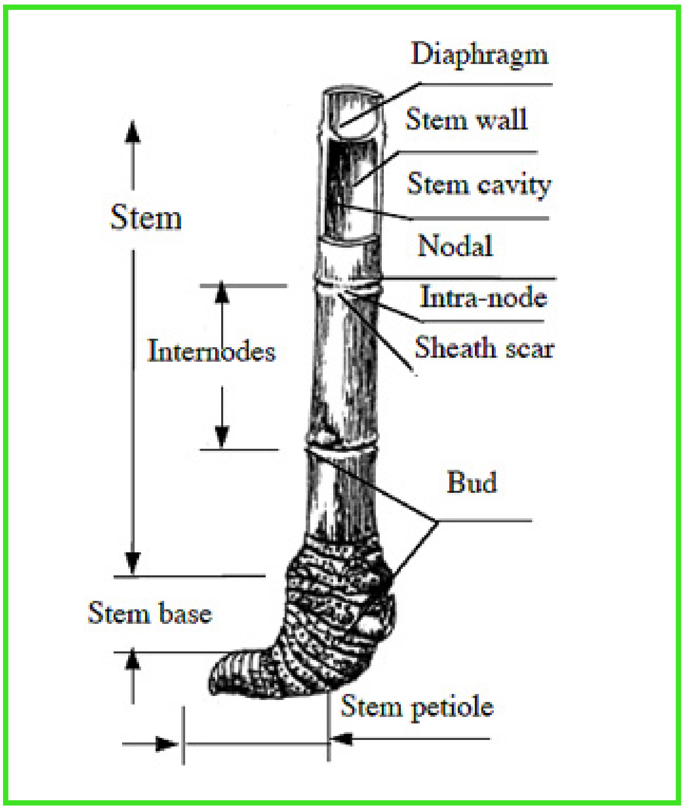



Fig. 5.11: A bamboo stem, showing the hollow inside and resource efficiency. (Source: Guadua Bamboo, 2012)

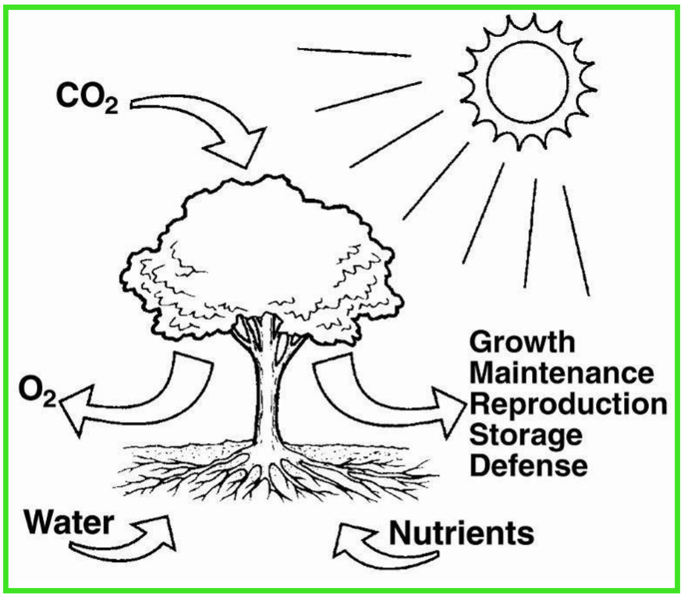



Fig. 5.12: Simplified functions of a tree. (Source: unknown)

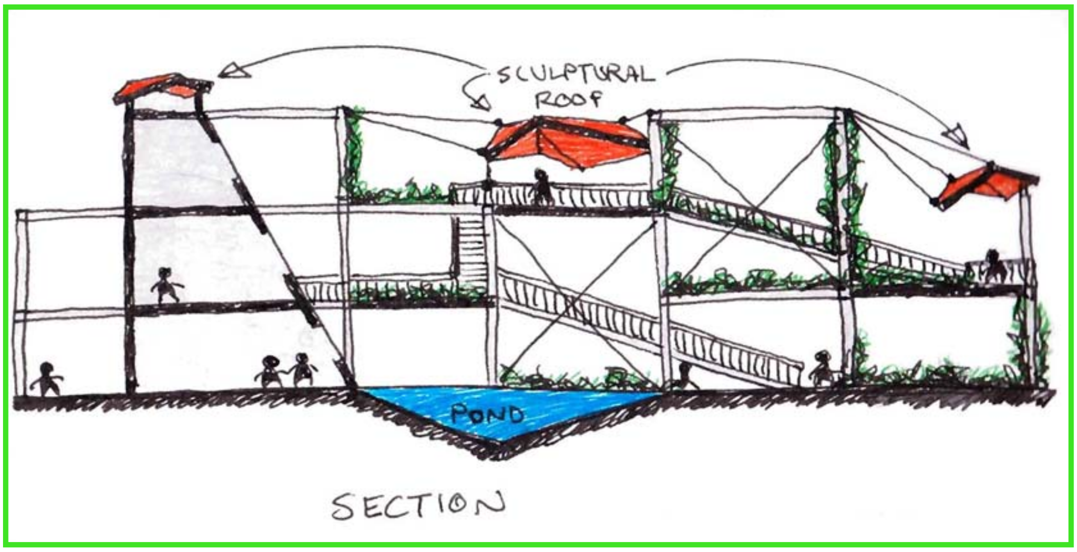



Fig. 5.13: An early conceptual sketch exploring a scaffolding-like structure offset against an enclosed building.

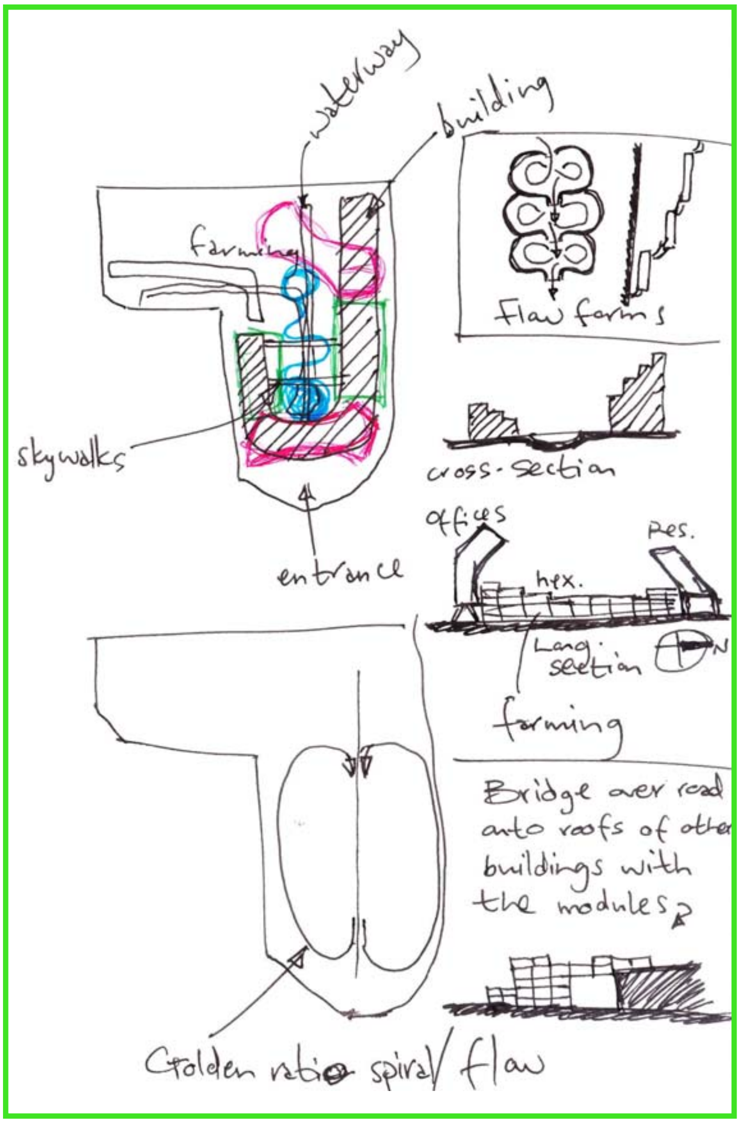



Fig. 5.14: This sketch shows an exploration in flow on site, whether it is the flow of water, energy, or people. The movements I desired were of a spiral ilk, mimicking a form of flow seen constantly in nature.

This sketch also shows how I intended to frame the site with buildings on all sides, containing the farming in a more secure interior "bowl" or "pot".

The vertical growing elements could then extend onto nearby buildings.

From this I divided the site with a north south axis around which the different forces would flow.


Fig. 5.15: Early sketch design trying to link parts of the accommodation together and considering a complex hexagonal modular building design. After this is was realised that the scale was too large and the hexagons became too complex for certain basic spaces.

Looking further into how nature captures water, energy and wind for use I began to develop a design. The main application of biomimicry in my design is in the realm of systems, more than in form (but it still fits form to function), and it also uses many natural processes to achieve its goals.

I began by considering the best placement for each part of the program. This came directly out of the context, following the biomimetic principle of being locally attuned and responsive. I noted the most public areas on site and the most private. From this I determined to put the market and informal theatre in the most public corners – the theatre in the Kruis Street corner, and the market at the bottleneck of foot traffic from Salisbury Street and Rosettenville Road.

Then the public interface components of the building followed. Reception and public information desks are placed on the ground floor providing easy access for the public. The classrooms, library, nutritional treatment facilities, and seed shop are also on the ground level addressing the public. This is accompanied by the gallery which can exhibit food awareness facts and projects, or related community art exhibitions etc. It can also be used to make available to the public any information regarding food security in the city, where food is sold, where food is grown, the risks and benefits in certain contexts, food kitchens etc. This could be a valuable resource for the public and for future researchers.

The private offices are on the first floor, and the caretakers' flats are on the second floor. The service yard is along Rosettenville Road where there is the best access for trucks and heavy vehicles. The service entrance is also on this eastern side of the site. The food court is immediately north of the main building, with the main building providing a thoroughfare through from the market and sheltering the food court.

The food and tools storage are on the west and east edges of the site respectively. This hems in the farms limiting access to them. The farms are capped at the north end of the site by the aquaponics halls, located in the most private part of the site where they can be best monitored and maintained. The aquaponics halls are designed to allow for easy use of space inside, as well as rooftop farming outside. The roof is terraced with the highest side being the south. This encourages wind flow over the roof as the prevailing winds come from the north. The wind flow draws out stale and old air from inside the halls. Skylight bubbles protrude from the roof allowing direct light to terraced racks of aquponically grown vegetables, which are connected to fish tanks in the halls. Other round standing tanks grow food horizontally in the halls.

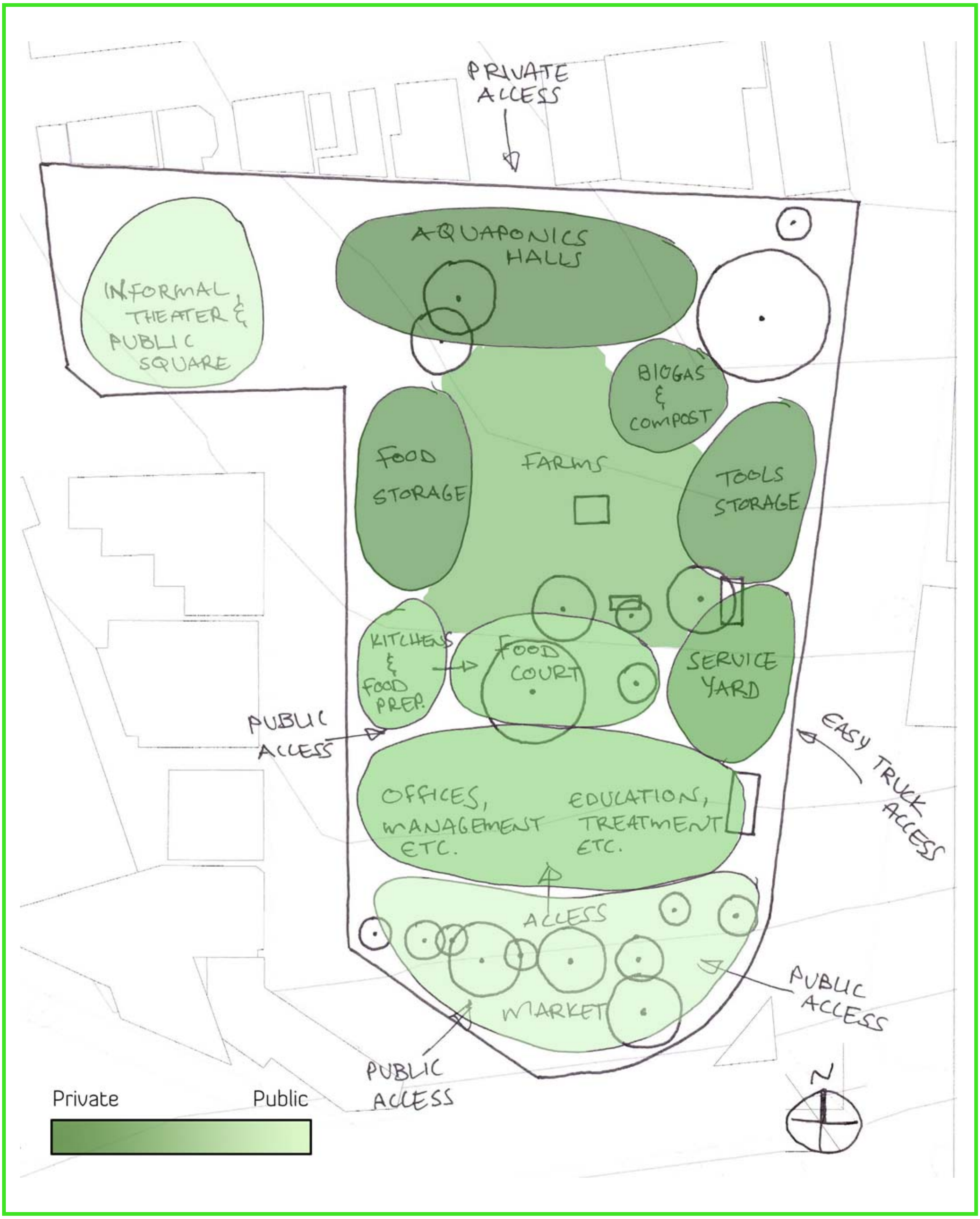



Fig. 5.16: Placements on site based on public and private and major pedestrian areas on site.

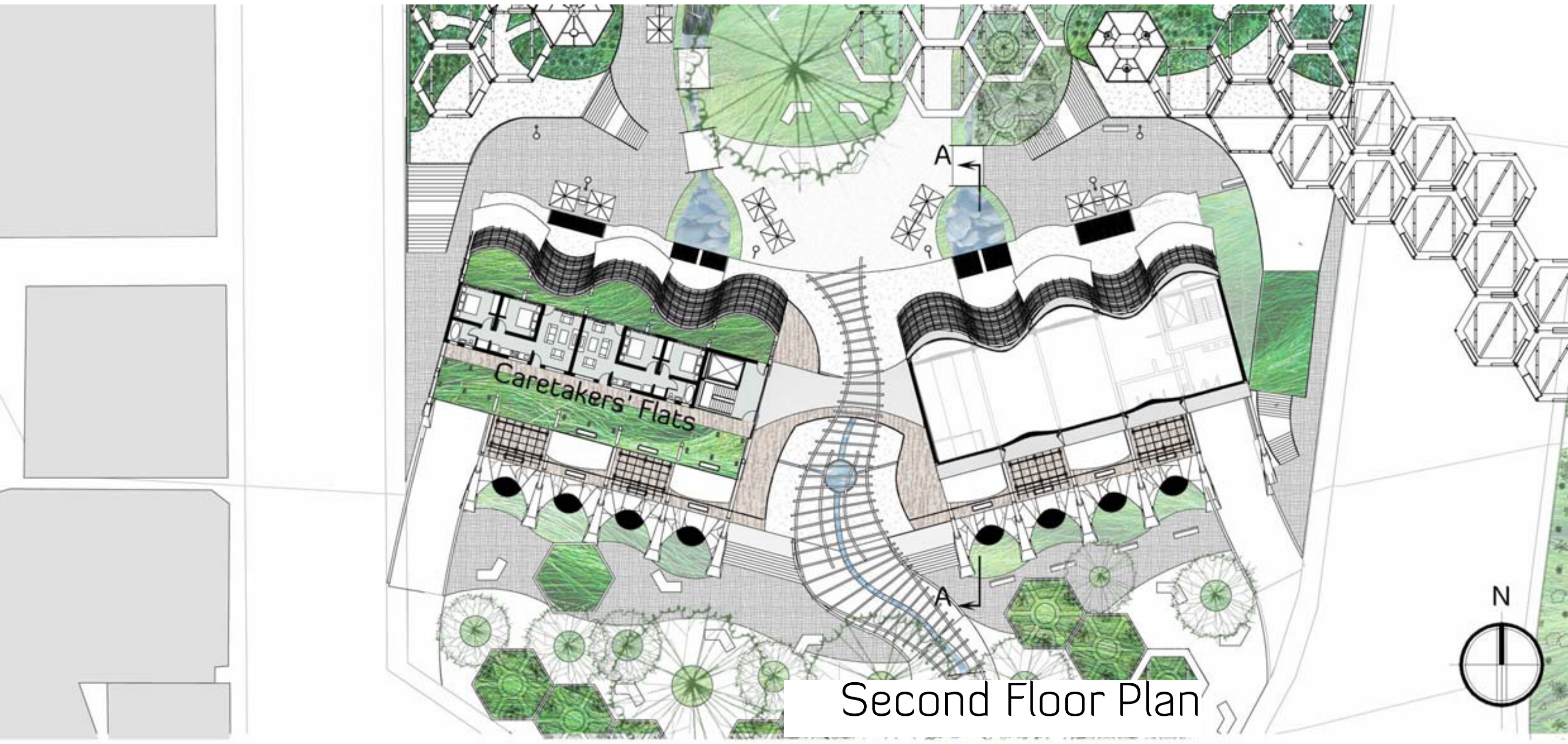

Kruis St
Aquaponics
Halls
Informal Theatre
and Public Square
Salisbury St
Food Storage
and
Fast Food Stalls
Salisbury St
Wemmer Jubilee Rd


A
Aquaponics
Halls
Farms
Tools Storage
and
Service Yard
Rosettenville Rd
Main Building
Market
Farms
A
N
Site Plan

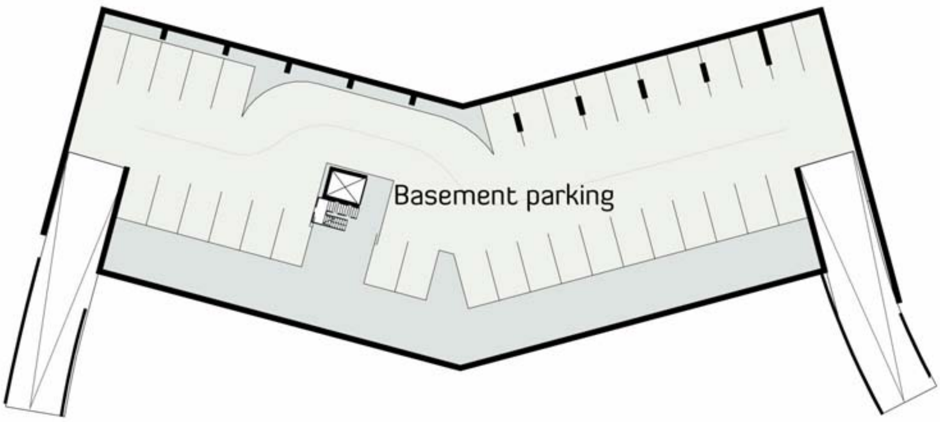



Ground Floor Plan


First Floor Plan

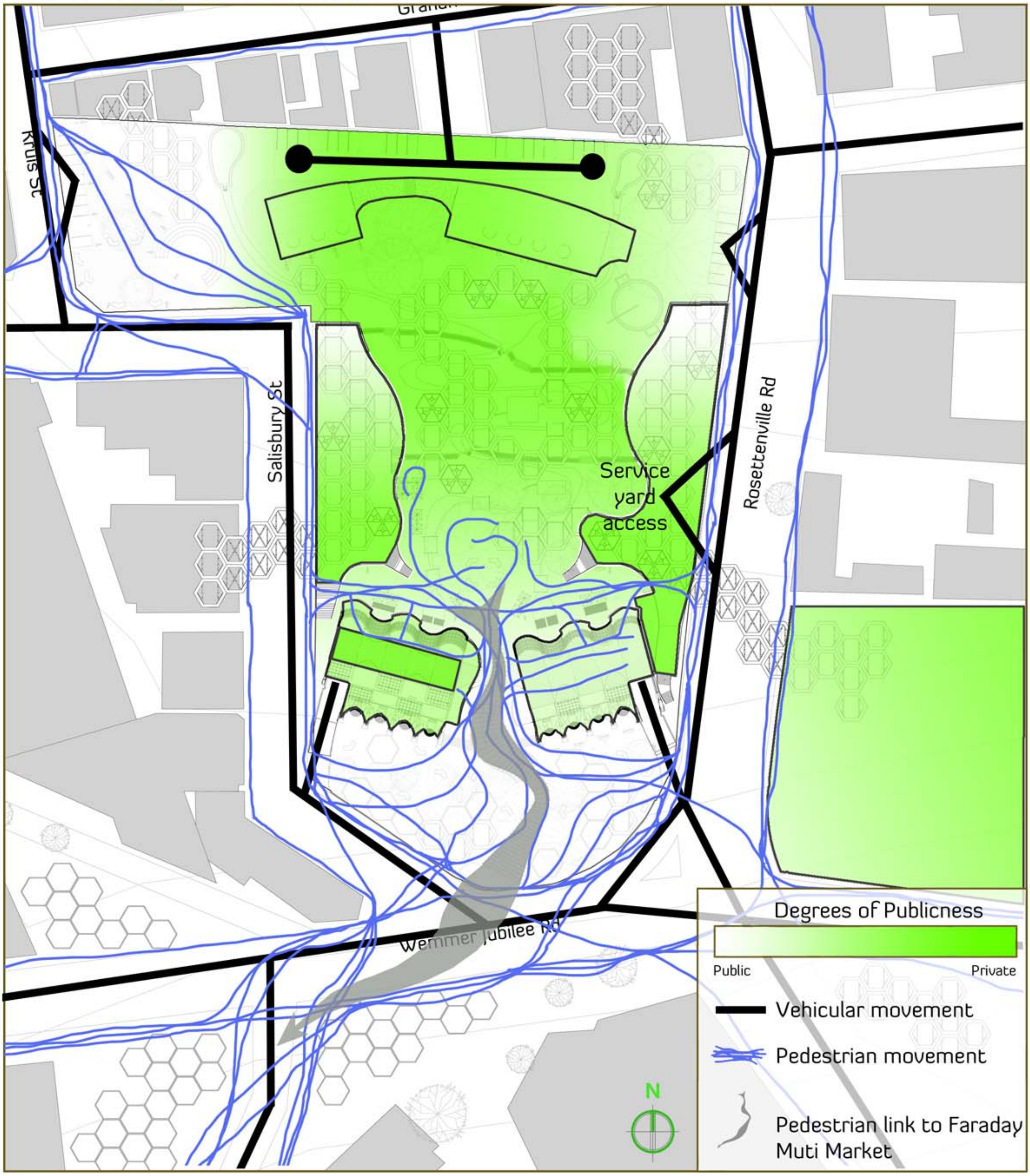



Second Floor Plan

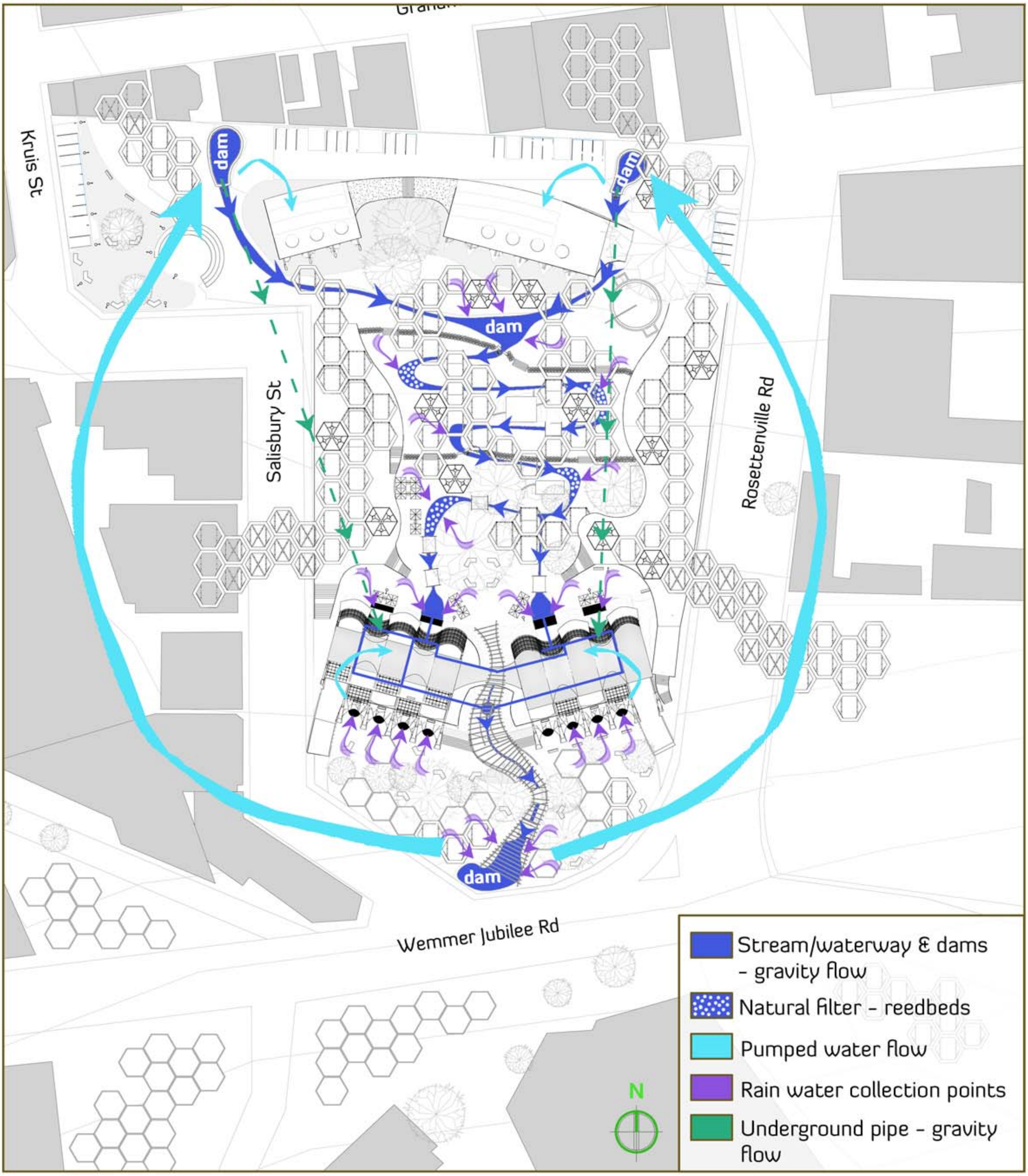



Basement Plan

# Flow of People and Vehicles



## Flow of Water on Site




A waterway runs through the site flowing freely as a stream from north to south with the flow of gravity (the north is the highest side of the site). The waterway is also multifunctional (another biomimetic principle) and not only holds water for irrigation but also treats it with reed-beds, and isolates the aquaponics halls in a near island-like manner. This creates a metaphor of the cleanliness of the environment inside the aquaponics halls (necessary for the health of the food grown inside). The landscape has been terraced on the contour lines, creating different levels. These levels act subconsciously as degrees of privacy, and consciously in aiding downhill water flow. At each level change a waterwheel is placed to harness hydro energy which can be used for pumping the water back from the southern corner to the dams in the north. This creates a water cycle on site. The water is filtered before and after being used along the way for irrigation, consumption and cooling.

The farms are located in the land in the middle, and accommodated within hexagonal modules. These modules fit within each other progressively in a nested manner on the horizontal and vertical axes. The design differentiates between the building and the farms by considering the building to be the development – that is, the infrastructure which facilitates the growth of the farms. The farms are housed in modules which grow according to need and available resources. Thus the biomimetic principle of integrating development with growth is applied. When it comes time to expand to future sites a smaller amount of development infrastructure will be needed, allowing for more growth in the subsequent sites.

Through feedback loops it can be determined whether a certain location on site (or in another vacant lot in the city) is good for growing food or not. If it is realised that it is not good then the module can be easily disassembled and moved to another location deemed more desirable. This allows the growth of this development to spread through the city.

Feedback from the public at the informal theatre or the market will inform what foods are desired by the people and what foods are selling well or badly. This design shows a model of farming which can adapt to changing physical and social conditions.

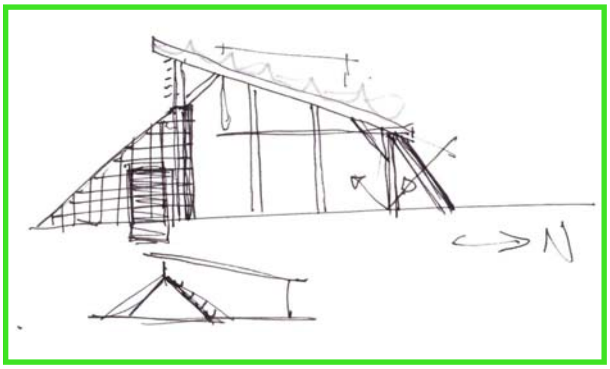



Fig. 5.19: The concept of the aquaponics halls, showing the roof angled towards the north in order to catch sunlight for rooftop farming.

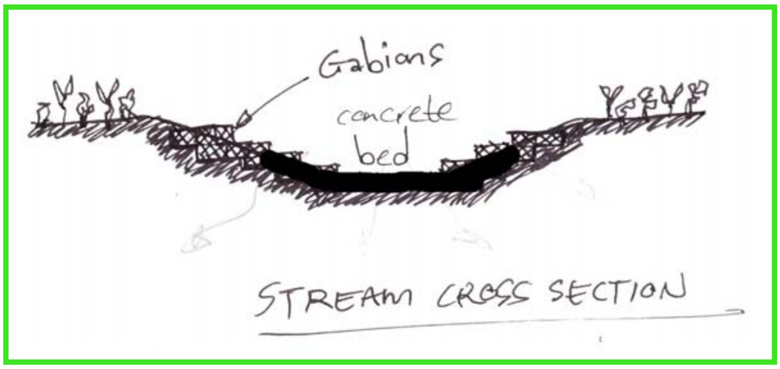



Fig. 5.20: The streams allow for a constant amount of water flow without being absorbed into the soil. Excess water from storms overflows the stream bed and filters through gabions. The gabions prevent erosion but the excess water can still irrigate the soil and replenish the water table.

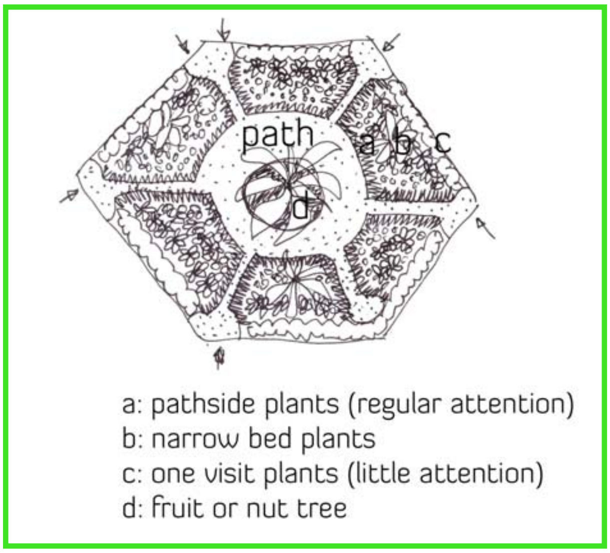



Fig. 5.21: The concept of permaculture-style gardens fitted within each hexagon module. This allows for a variety of mutually beneficial food types to be grown at any time in the modules. Through these relationships between the plants pests are kept at bay and soil conditions remain good for growing. (Source: taken from Mollison, 1988: 274)

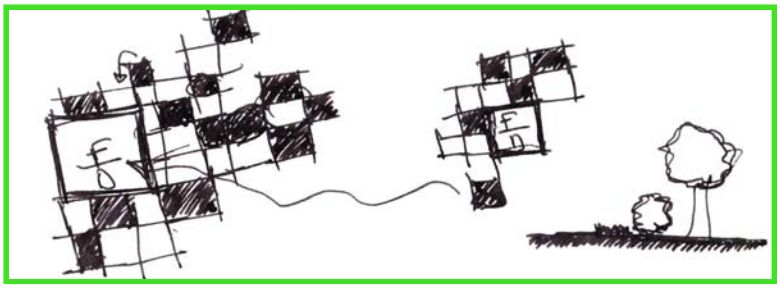
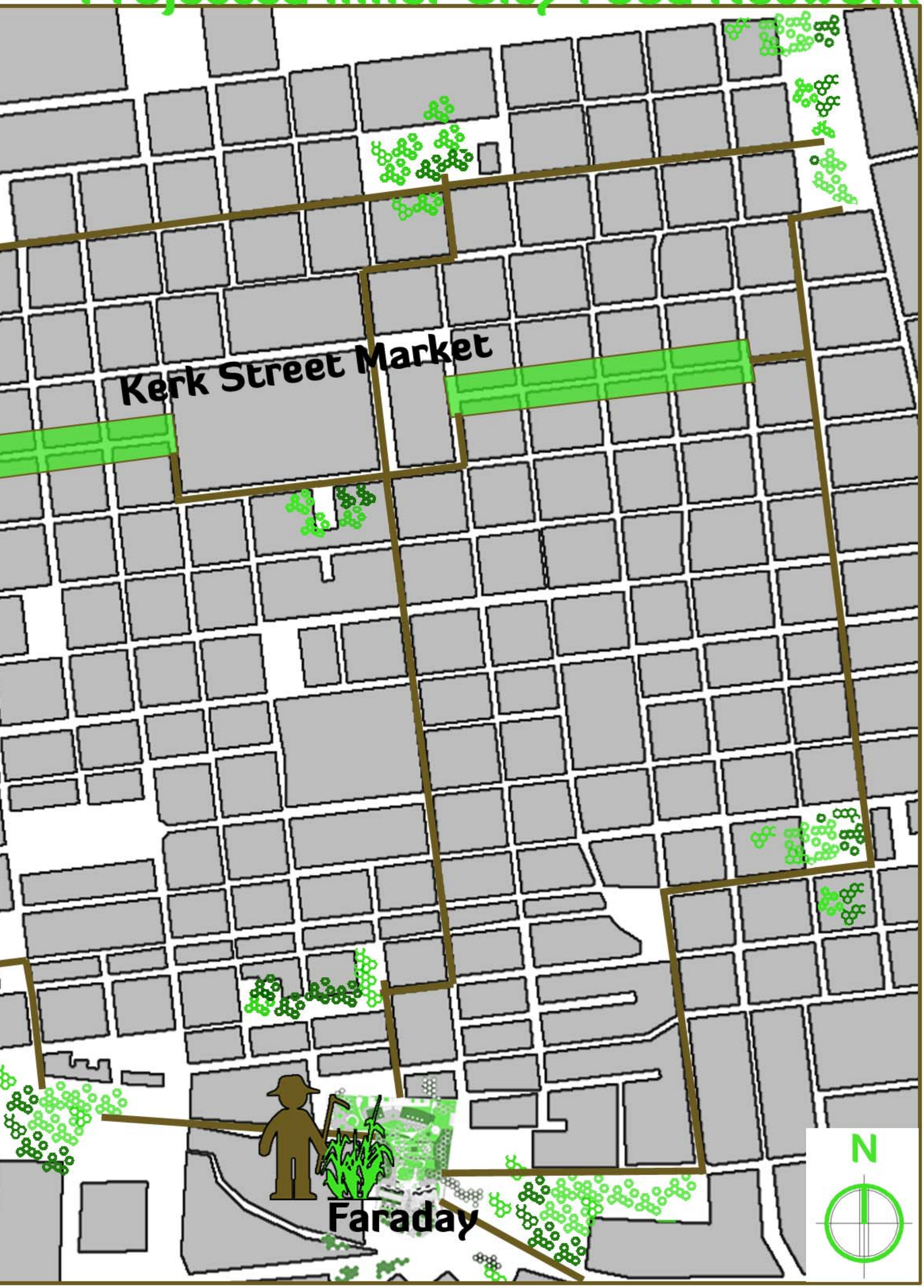


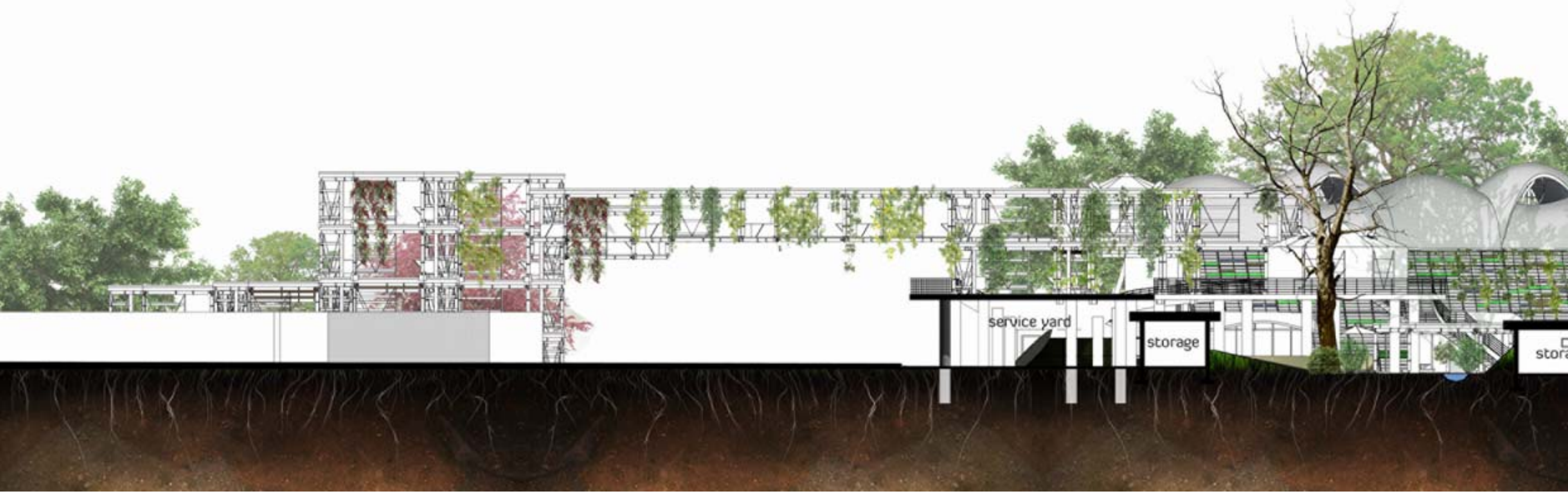

Fig. 5.22: This sketch shows how the design begins with functional development (F-D), and facilitates growth of modular farms (seen in the checkered pattern). Future functional development would not need to be as big as this initial "mother ship" design proposal.

# Projected Inner City Food Network



market
02 Second Floor
01 First Floor
00 Ground Floor
-01 Basement
offices
classroom
seed shop
solar
food court
basement parking


market

service yard
storage


Section AA


South Elevation


North Sectional Elevation

The main building is proposed as a headquarters building which would facilitate and manage the development of urban agriculture through the inner city. My approach to the form of the main building began with sunlight, since this is the most abundant resource and very problematic if not addressed properly. Therefore I orientated the building to the north, capturing the most natural light. This aids in controlling the fluctuations in Johannesburg's climate of warm summers and cold winters. The depth of the building is less than fourteen meters at any point in order to allow as much natural light and ventilation as possible.

The building was then split into two wings, with a thoroughfare dividing the wings. This breaks the scale of them, making them more human in scale, while opening up to draw people in from the market to the food court. A pergola which would be planted with vines acts to lead people from the Faraday Muti Market through the food market on my site and into the food court, with a vista of the farms. This creates a visual and physical link to the Faraday Muti Market. Other hexagon modules could be used at the Muti Market to provide shelter for some of the more informal stalls while growing medicinal herbs for the healers.

I then considered what sources of energy are available on site and how to use and capture them. They are sun and wind. The site gets plenty of sunlight, and being at the southern end of the inner city the buildings in its immediate proximity are not stiflingly tall. Therefore they do not block the sunlight or the wind. Sunlight is captured in as many passive ways as possible by orientating the building northwards and maintaining a narrow building design. The development would also incorporate solar water heating.

The design of the main building grew out of the concept of the solar atrium, which will be discussed in greater detail in the next section. This atrium runs the length of each wing of the building, regulating internal temperatures and adding a sensitive and life-filled biophilic space. It acts much like a conservatory and should be a very pleasant and calming space to be in. this brings nature directly into the building and brings people into direct contact with nature.

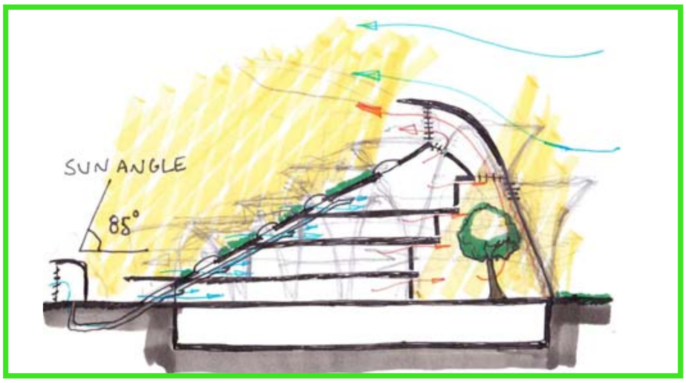


Fig. 5.23: Conceptual section of the main building and solar atrium in summer

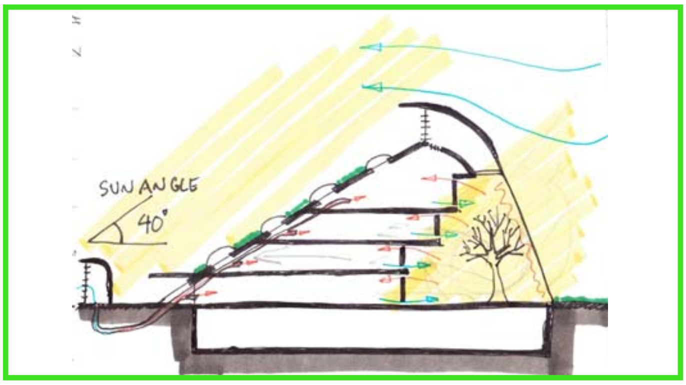


Fig. 5.24: Conceptual section of the main building and solar atrium in winter

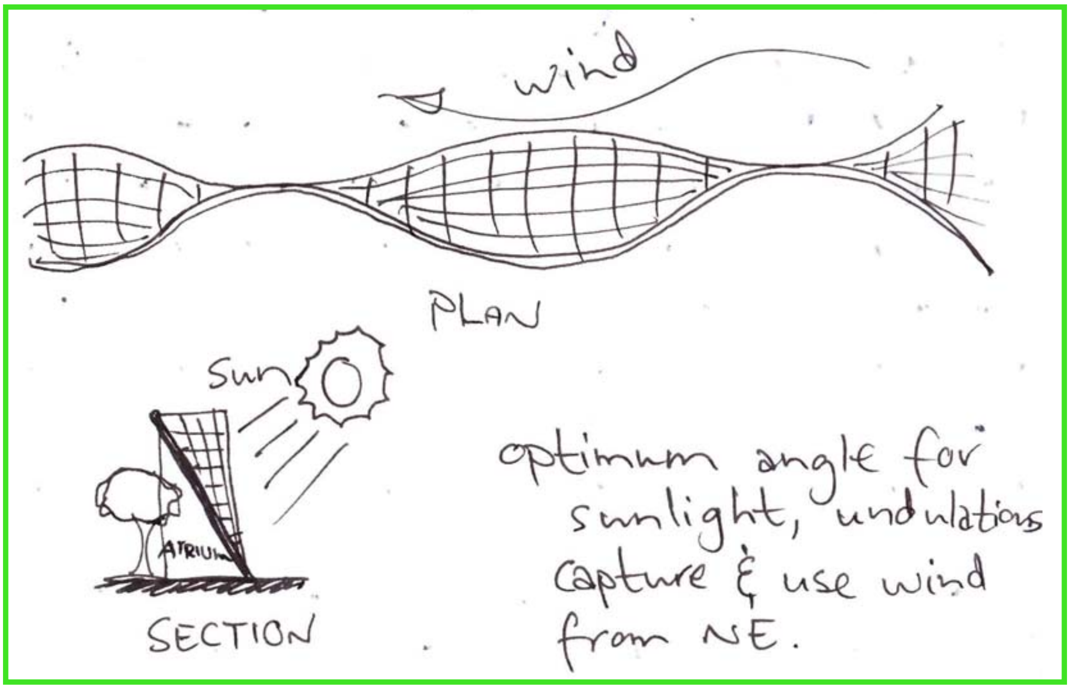
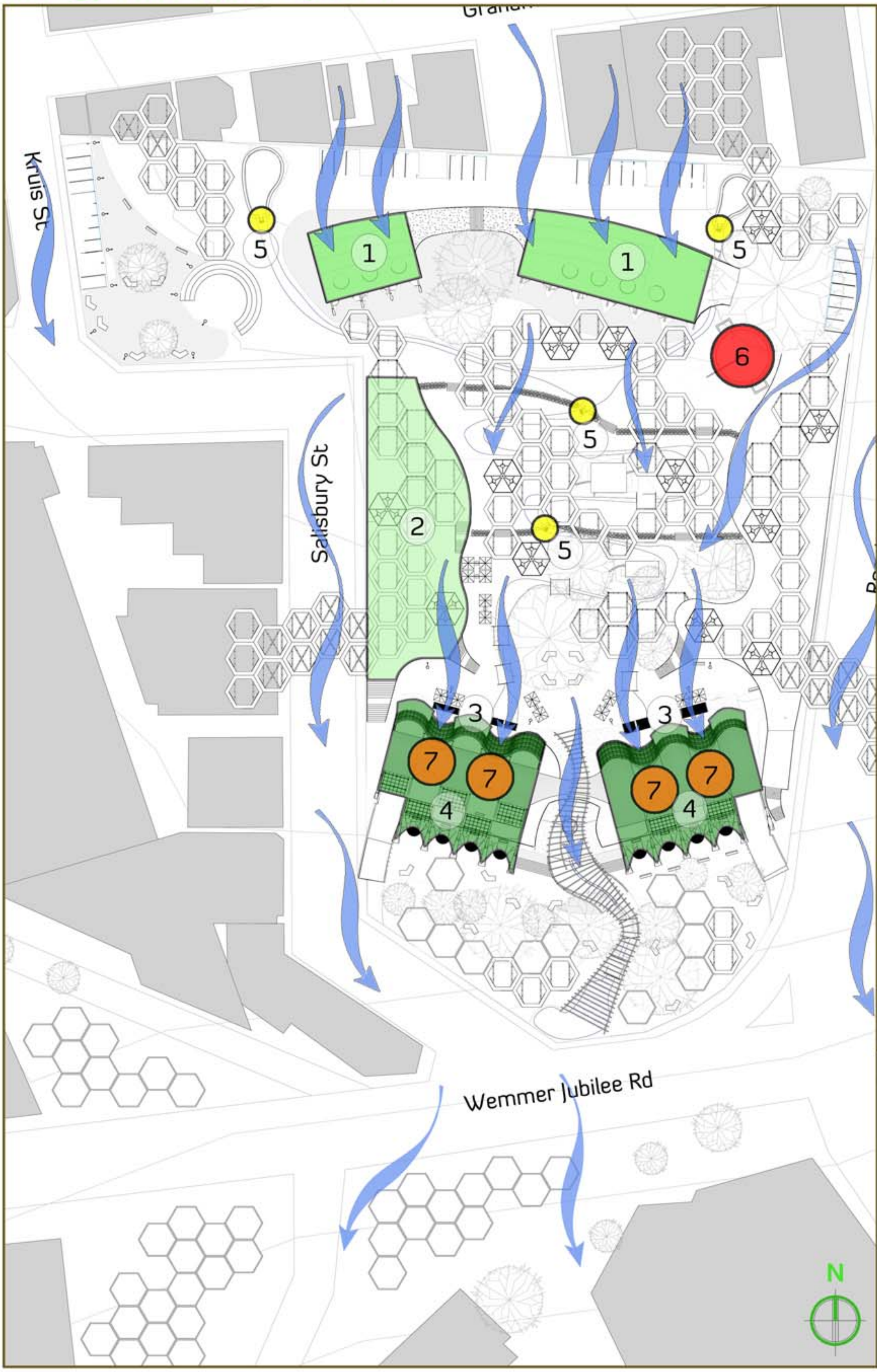


Fig. 5.25: Conceptual plan of the solar atrium, considering sun angles and wind direction.

## Energy Flow and Capture




### Passive Technologies

1. Thermal mass, solar collection, natural ventilation, natural light.

2. Thermal mass, natural ventilation.

3. Solar Atrium: evaporative cooling, natural ventilation, solar heat buffer, shading from vines and plants. Plants lose leaves in winter allowing direct sunlight to heat the atrium.

4. Thermal mass, phase change materials, natural light.

### Active Energy Caputure

5. Hydro power from waterwheels.

6. Biogas digester.

7. Wind turbines on roof and Solar Ivy on atrium facade.

Prevailing wind direction for Johannesburg

Passive Technologies

High Effectiveness Low Effectiveness

Active Energy Capture

High Production Low Production

Solar Ivy is a photovoltaic product designed to capture sunlight while being more aesthetically pleasing than common PV panels. It draws inspiration from ivy plants that grow on buildings (Solar Ivy, 2012). It also utilizes recycled and reclaimed materials and life-cycle analysis to ensure that the system and its component parts can be recycled and reclaimed (Solar Ivy, 2012). The leaves can be made in different colours, spaced at different distances apart, and can be moulded to fit the form of nearly any façade (Solar Ivy, 2012). This product can be used on the façade of the solar atrium in my design.

Given that this project is an urban farm there will be lots of organic waste from the plants. This waste will be taken to the biogas digester which will then power the development and more. According to Mollison (1988: 174), a 270m3 digester can power a town of one thousand people. The digester in my design can easily produce more than that from the waste generated on site.

Further thermal control is achieved through evaporative cooling, thermal mass and phase change materials. The phase change materials help to keep the building cool in summer by absorbing heat and then discarding it outside, and keep the building warm in winter by releasing heat into the building.

All toilets in the design would be composting toilets as this creates fertiliser which can be used for the fruit and nut trees, and all the existing toilets can be changed to composting toilets. This reduces the amount of water required to operate the development. (Water usage is further reduced through aquaponics which is a water efficient way of producing food.)

Water is collected in the ponds and dams on site as well as through channels designed as part of the main building. These channels send it to storage tanks in the basement. The waterway which runs through the site meets the building and proceeds to flow into it in small channels. The inlets to these channels are pressure controlled, and any storm water overflow is directed into storm water channels which run under the building and back out into the dam at the southern corner. This is all gravity fed and the building sits on a contour higher than the dam.

The channels that run through the building are on the ground floor. They run through a series of reedbeds in the solar atrium which also have falling water fed directly from the dams at the north end by underground pipes. The channels in the building bring the presence of water to every part of the building. This is calming and has mental benefits. It also serves as a metaphor of cleansing for those who come for treatment, as if they are going through cleansing waters. The channels flow out of the building again reconnecting in a fountain in the thoroughfare and flowing down steps in the middle of the ramp, to end in the collection dam at the southern corner.

Fig. 5.26: Solar Ivy (Source: SMIT, 2010)

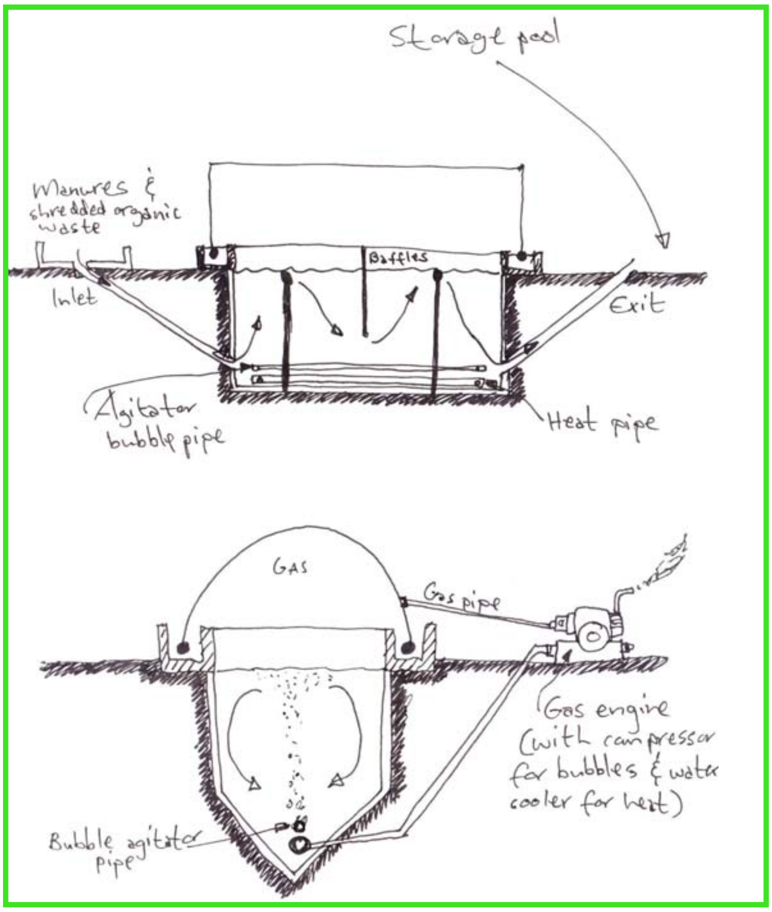
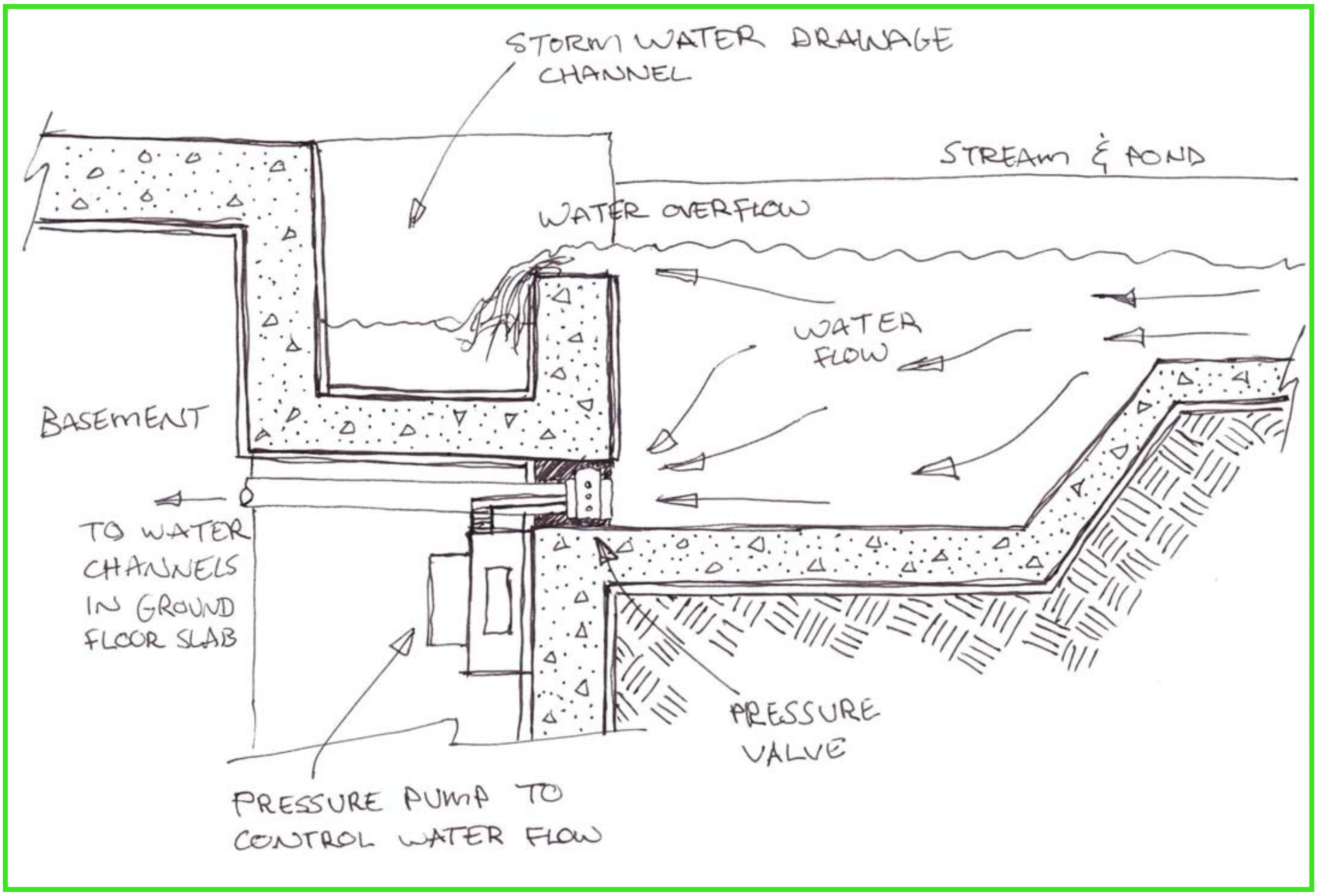



Fig. 5.27: (left) Diagrammatic sketch showing how a biogas digester works. (Source: Mollison, 1988: 174)

Fig. 5.28: (below) This sketch shows how the water entering the building from the stream and ponds does so under a controlled pressure. Any excess water from storms flows over a lip into a storm water drainage channel so as not to flood inside the building. (Source: author, 2012)



# A Technicality

This project has focussed on systems to a large degree. It is the systems that influence the design, and how the design uses the systems forms a technical study in the design process. The cycles of interest, as mentioned earlier in this chapter, are those of the farming modules and their needs, as well as the design of the main building.

I begin this technical study with the farms in the form of the hexagonal modules. They are designed to be multifunctional with food growth in the horizontal plane and trays stacked vertically. These would be made with salvaged and recycled materials. The hexagons can easily be fitted with a drip irrigation system that waters the plants efficiently. They form a matrix system which cycles through different stages of land use, including soil healing, fertilisation, food growth, and resting. The land cycle joins to the cycle of water use on site at the point of soil healing and irrigation.

The hexagons are made from bamboo and recycled materials. The shape allows for each length of bamboo to be the same and it can expand in multiple directions. It is more flexible than rectilinear modules, creating a more organic growth. They are designed to be easily disassembled with lightweight construction. This allows them to be mobile in being moved if necessary, while being resource efficient and using hollow tubular structures. The bamboo joints are basic and modular as well, allowing for easy manufacture and disassembly, as seen below.

Through the cycle of healing damaged land and making use of leftover land in the city, the hexagons imitate pioneer plant species such as lichen and fungi. They go to the barren sites and prepare them for growth, providing nutrients to the soil. They do so little by little and through natural processes such as the Living Machines.

The water is used on site in a cyclical manner, incorporating the farms, building use, cooling, soil treatment, and filtration.

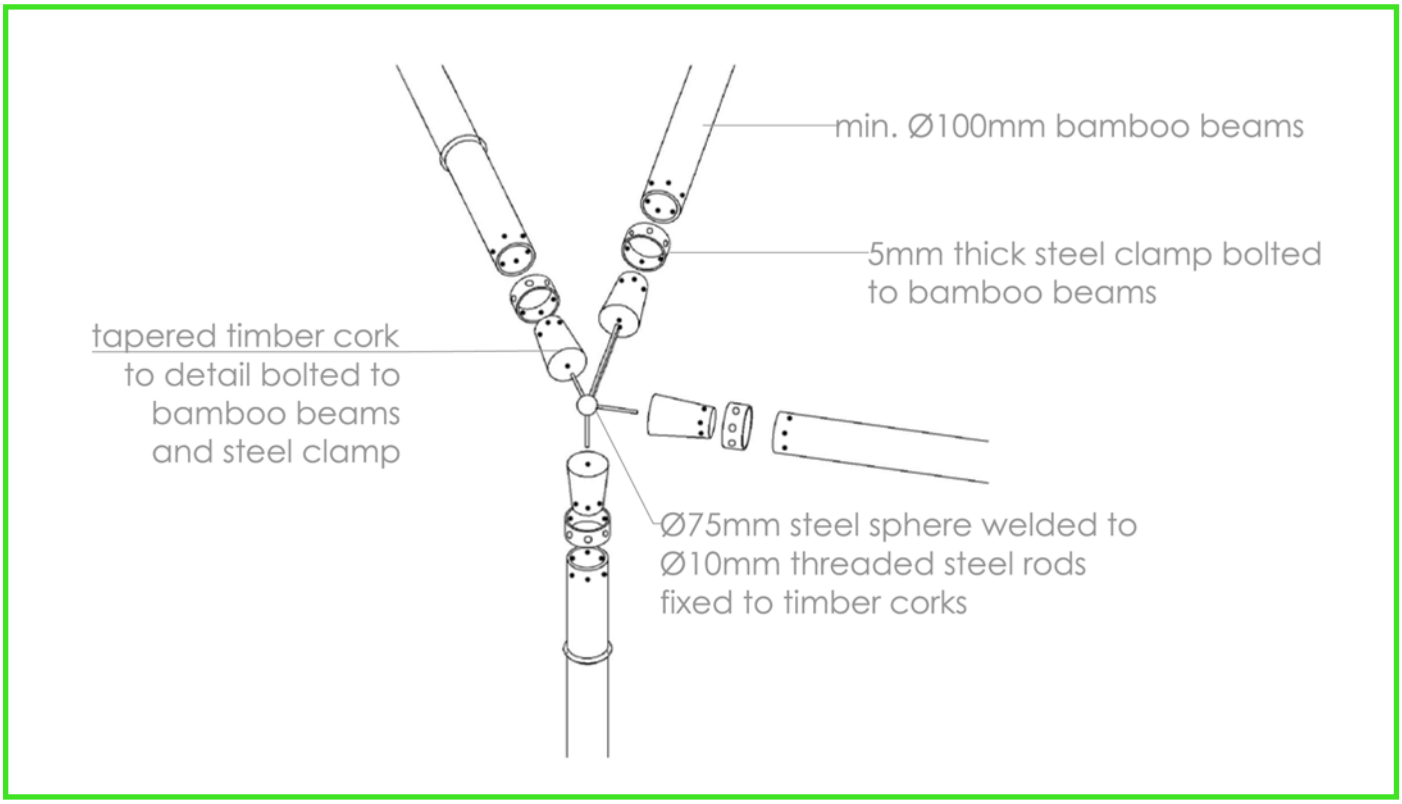
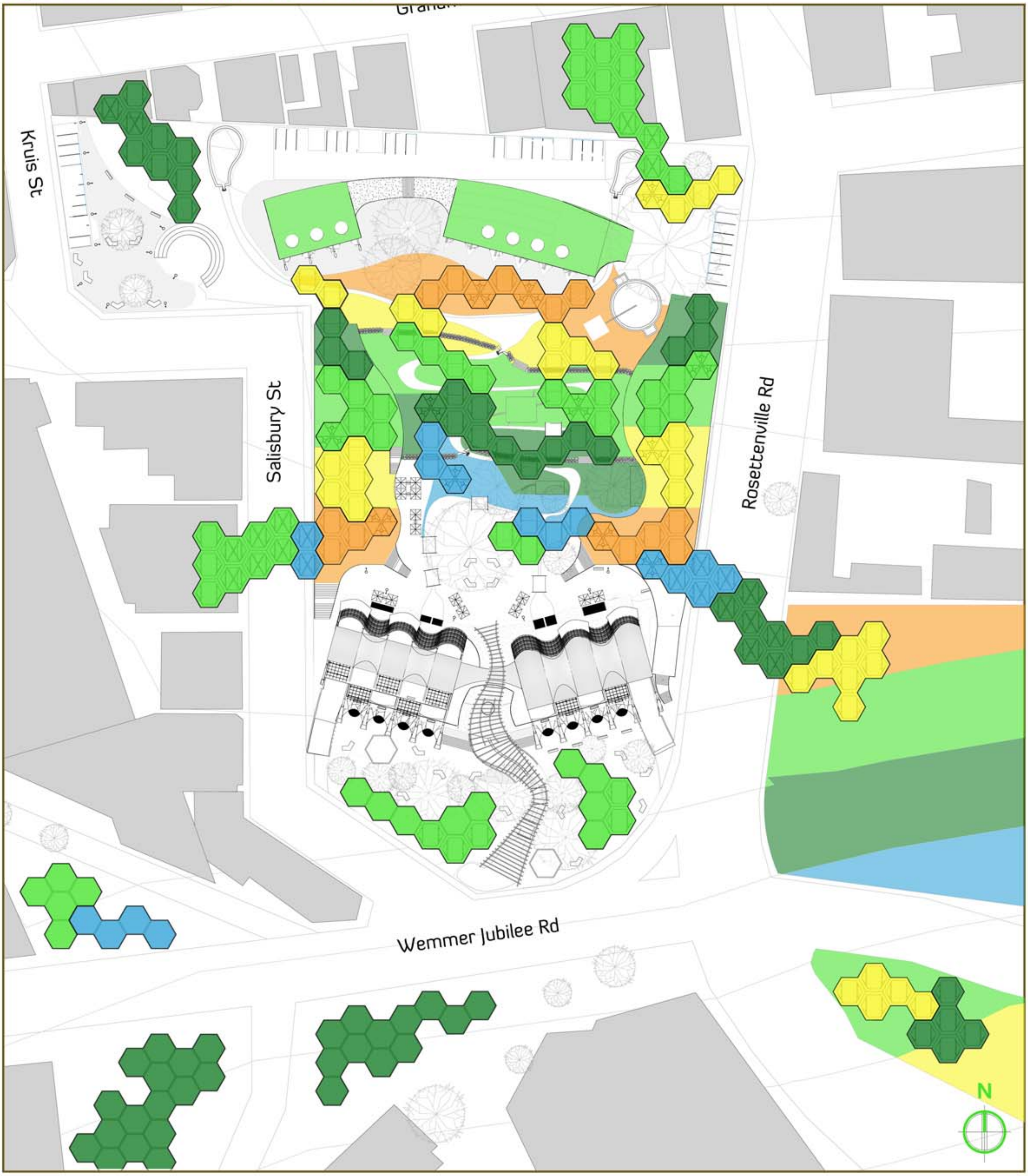
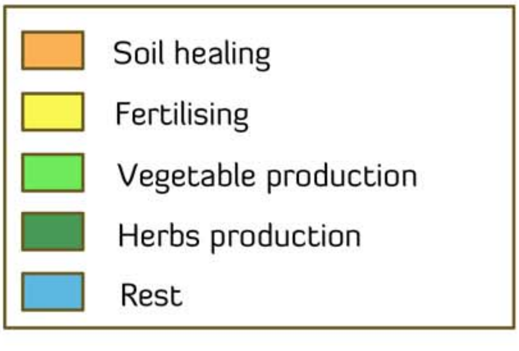


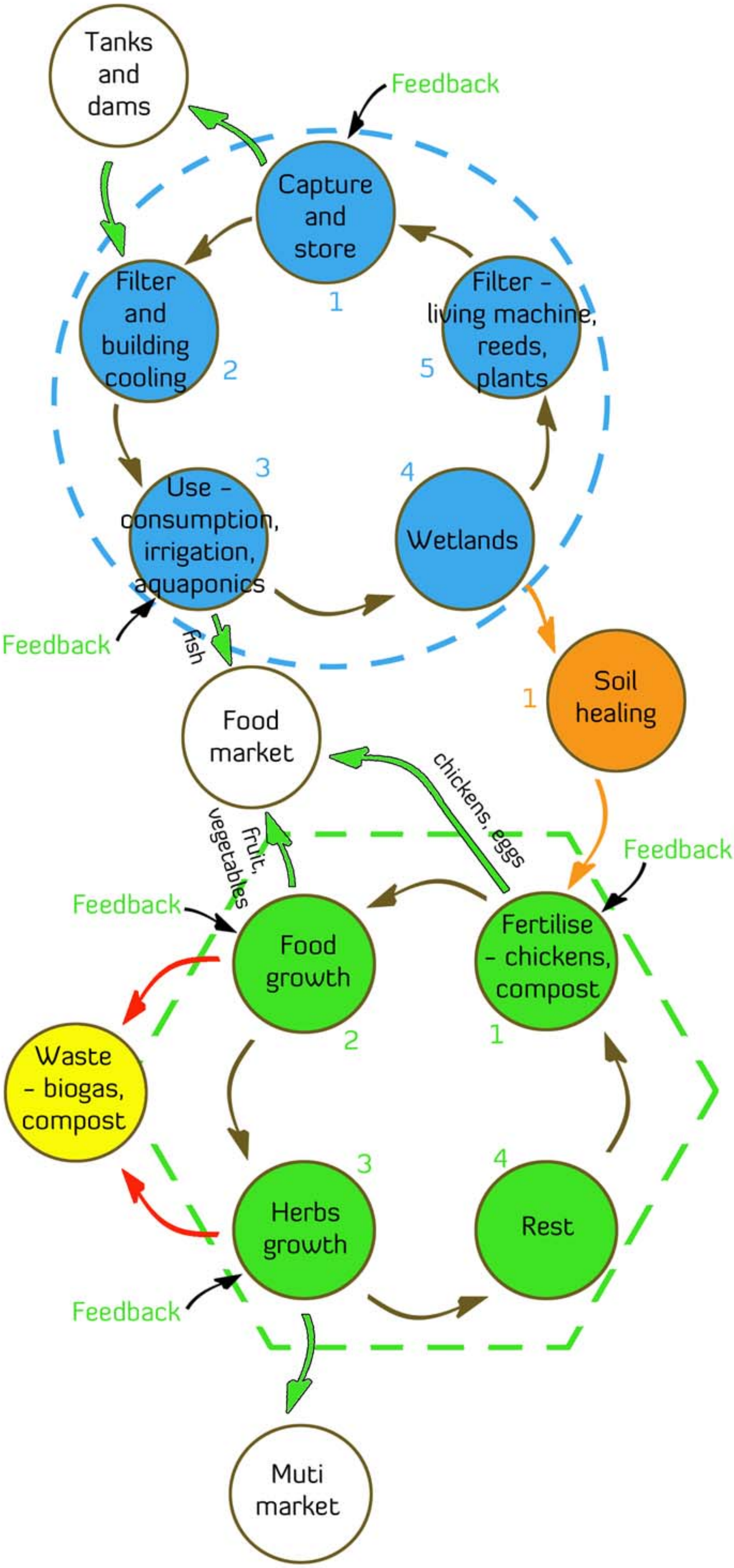

Fig. 5.29: A diagrammatic detail of the joints between each stem of bamboo. (Source: author, 2012)

# Cycles of Production and Soil Use




This image serves as a representation of how each part of the site can cycle through different stages of use at any time. These stages can be facilitated through the hexagon modules but are not limited to them. There are also cycles within each stage where different fertilising methods are used, different vegetables and herbs are grown at different times, and different soil treatment techniques are used.




1. On-site dams and basement storage tanks, with directed storm water channels.

2. Mechanical filter, use for evaporative cooling and biophilic presence in main building.

3. Aquaponics - growing fish & using fish waste to nourish vegetable and herb growth. Plants clean the water.

4. Wetlands - heals contaminated soil, natural water filtration.

5. Living machines - heals soil & treats water with aquatic plants, mimicking tidal wetlands in a tank.

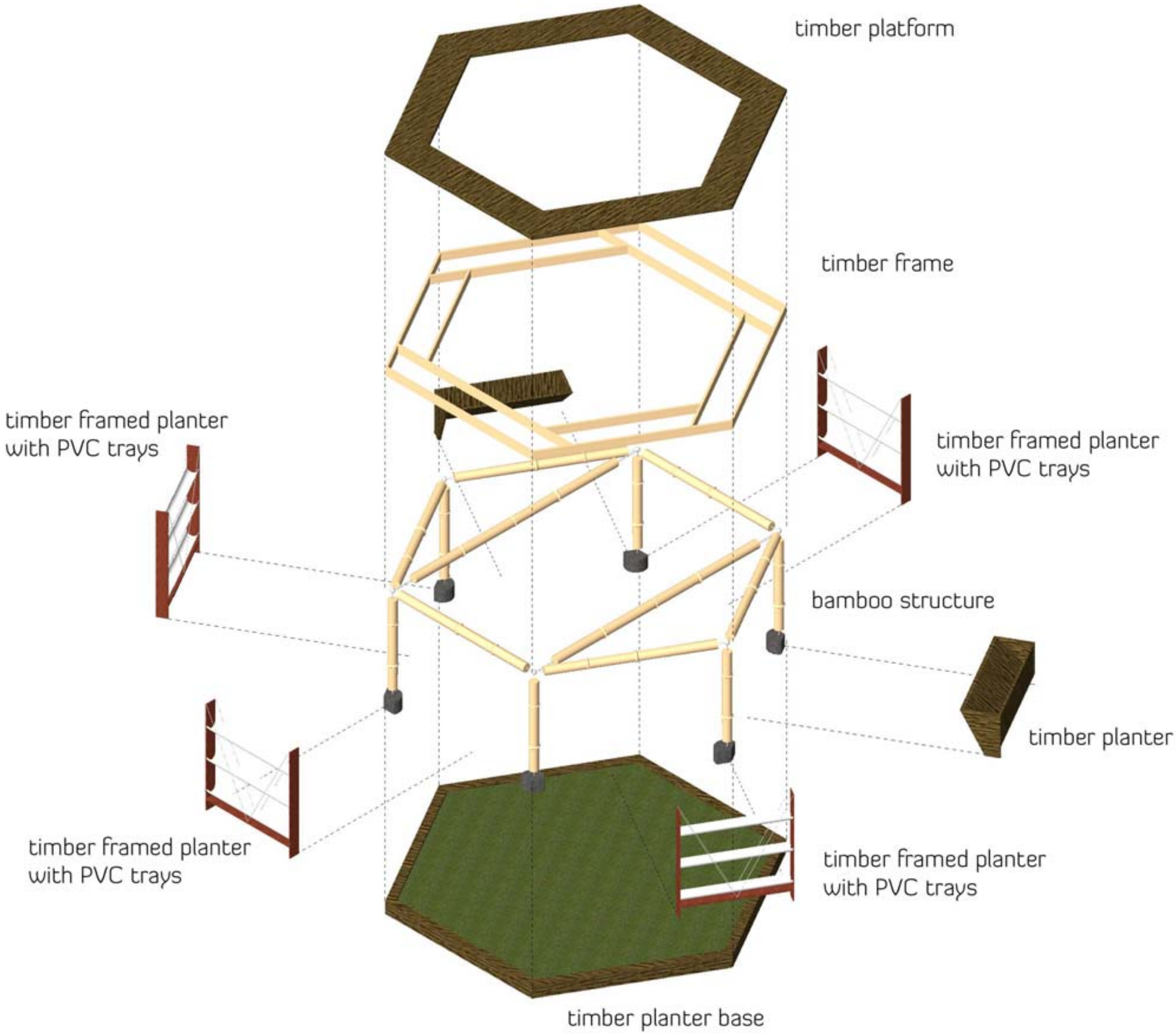
1. Living machine wetlands can heal soil. Wetlands with added lime can heal soil. A combination of straw and oyster mushrooms can heal soil. It is recommended that these are used cyclically.

1. Chickens scratch soil, manure nourishes it. Compost and nitrogen fixer plants nourish soil. Nitrogen fixers are usually legumes (such as clovers).

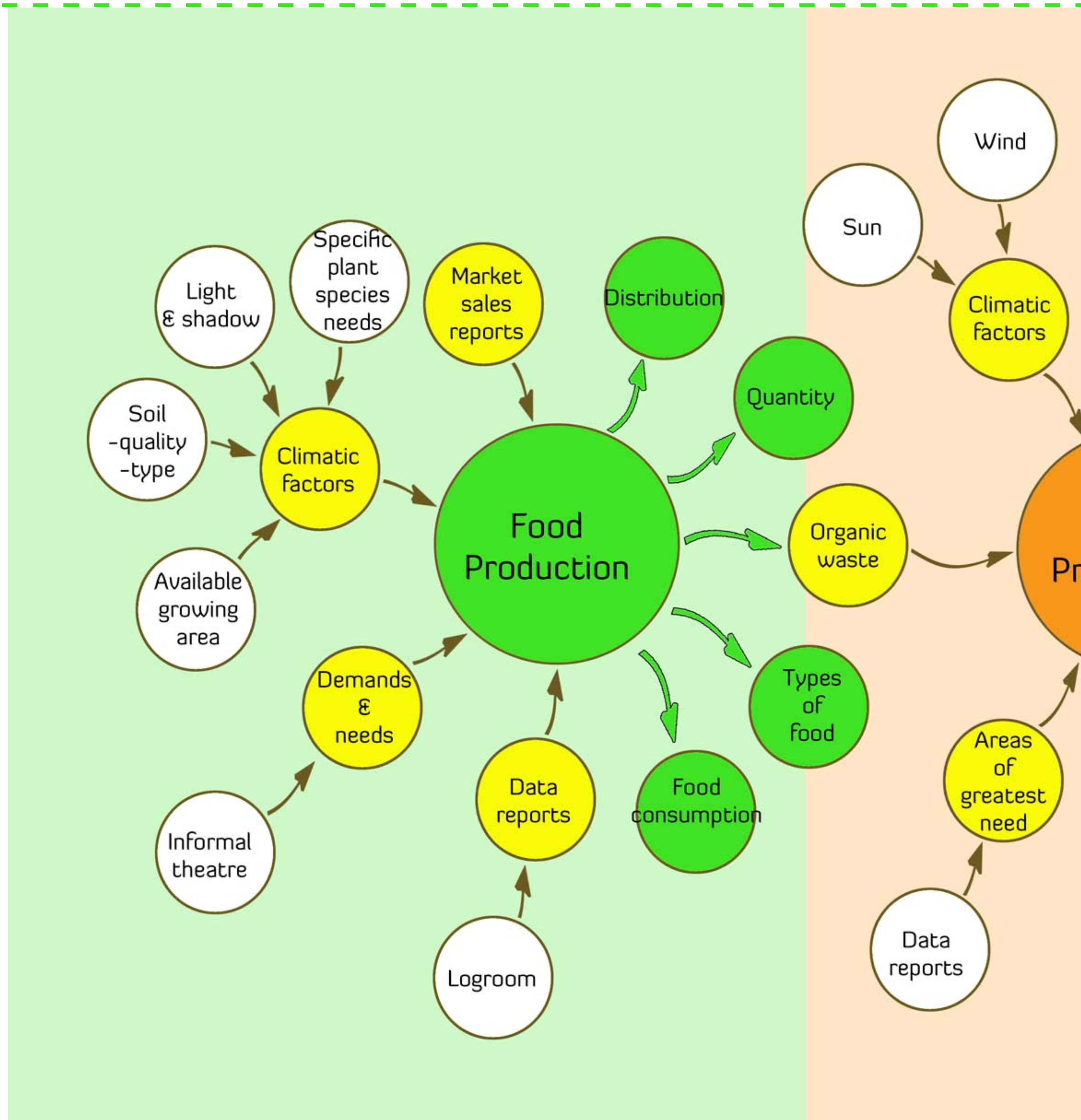
2. Growth of fruit and vegetables can alternate between species each time the cycle changes.

3. Growth of herbs species can alternate each time the cycle changes.

4. Soil is allowed to rest and regain nitrogen and other nutrients for next planting.

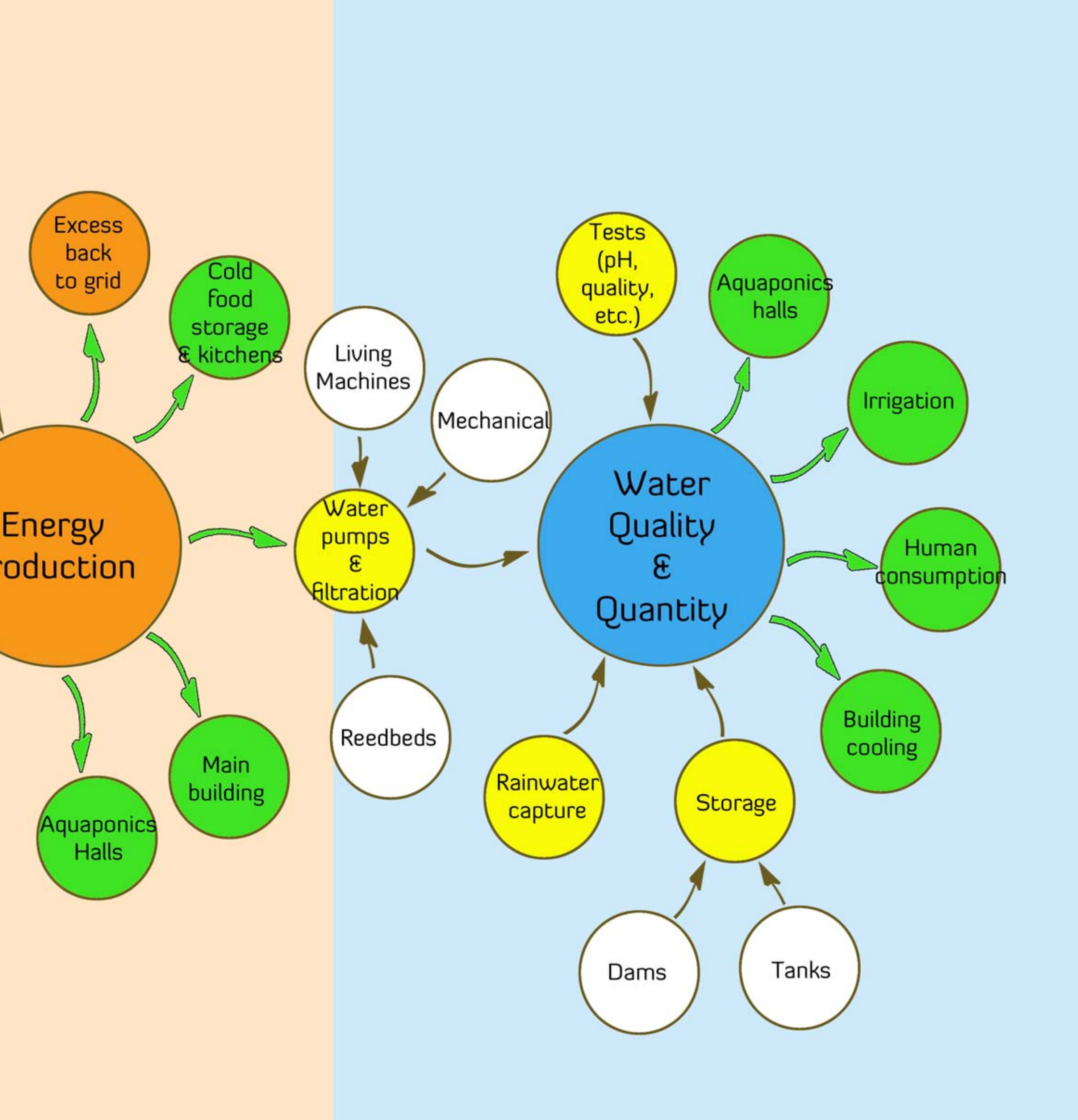



The above exploded diagram shows each part of a typical hexagon module. Each of these parts can be easily attached or removed. The frame is bamboo joined as shown above, with a platform on the top for reaching high fruits on the trees or for standing on when the hexagons stack vertically. Wherever possible the materials are all recycled.




This image shows the different feedback loops incorporated in the design of my project. Types of feedback include:

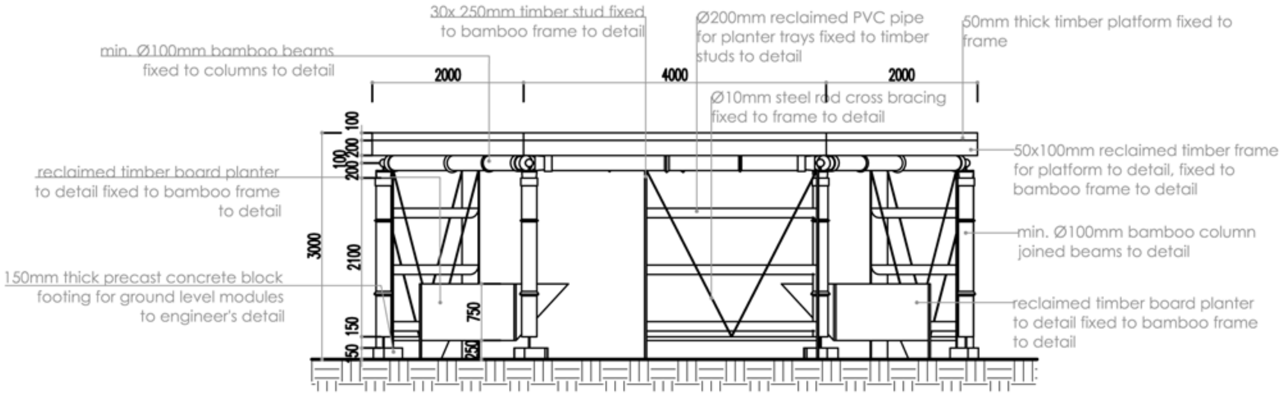
Informal theatre - where people can voice their needs and demands for food types to be grown.
*Market sales - where it can be seen what types of food are selling best and worst.
*Food growth and production - to monitor quality, quantity and climatic conditions (such as light and shadow, or soil condition). These can be noted with the correct equipment and logged in the log room.
*Water quality and quantity - as relating to needs for consumption, irrigation and aquaponics tests can be done for water quality and pH, and water storage levels can be monitored appropriately.
*Energy production and consumption can be logged, leading to changes in usage patterns and energy distribution.
*The main building will be fitted with motion sensor lights, thermostats to monitor indoor temperature and humidity,



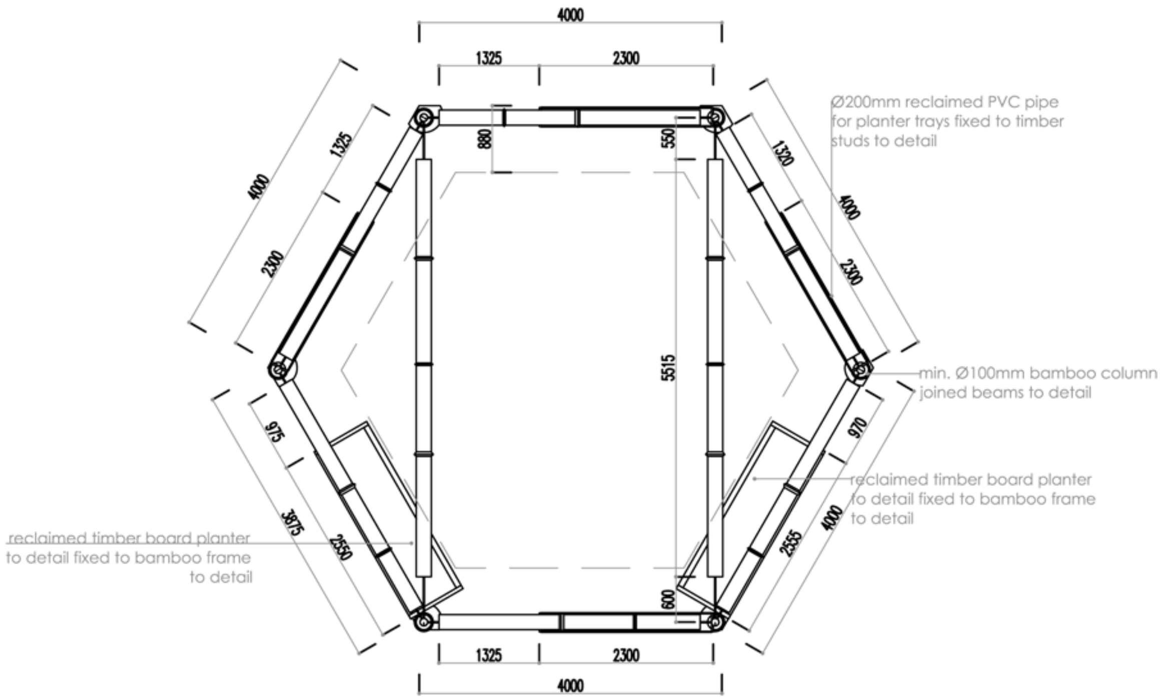

as well as the ability for people to manually control their working environment.

This incorporates the biomimetic principle of evolving to survive, through the ability for the design to change and be informed by feedback loops. This will ensure enduring performance in the use of resources and production of food, and it allows for things which are not functioning well to be learnt from and changed.

The feedback loops and log room also create a data base of climate, soil conditions, and food within the city of Johannesburg. This can be a valuable resource for future reference.




Typical Hexagon Module Elevation
Scale 1:100
(scaled down from 1:50)




Typical Hexagon Module Plan
Scale 1:100
(scaled down from 1:50)

Fitting Form to Function

The main building incorporates numerous systems of interest to this study. Firstly the shape was derived from solar studies. My desire was to have the market in the south afforded access to direct sunlight in summer and winter. This meant addressing the winter sun which sits lower in the sky and would more likely be blocked by the main building. The sun angle at the winter solstice is 40 degrees so I made the angle of the southern façade 40 degrees avoiding blocking the sunlight. Pergolas planted with vines on the southern decks limit the heat gain in summer. On the northern side the building floors overhang each other by 62.5 degrees. This is the angle of the sun at the equinox. The equinox is, for Johannesburg's climate, a good time to start allowing heat in as seasons change to winter, or to keeping heat out as they change to summer. The atrium façade mirrors the angle of this overhang in order to capture as much sunlight as possible.

The form of the atrium façade undulates in plan. This is inspired by the fins of a humpback whale. The shape of these fins undulates at the front where water pushes against them. This shape has been proven to be more aerodynamic than a smooth surface (Dunn, 2008), reducing drag and increasing fluid flow over the surface. They have been mimicked in things such as fans and even some airplane wings. The fins produce 32% less drag and 8% more lift than a smooth fin (Dunn, 2008).

This is used for the façade in order to channel wind flow across the façade (which aids with cooling in summer) and also to wind turbines on the roof where the air flows faster. In summer the wind is stronger than in winter, and it comes from a more easterly direction. It would then be

Fig. 5.30: The fin of a humpback whale and a fan arm modeled on it. (Source: Dunn, 2008)

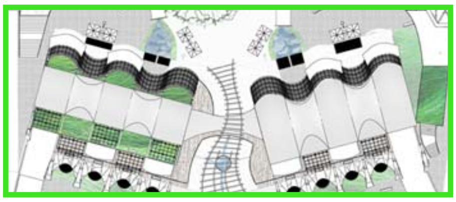
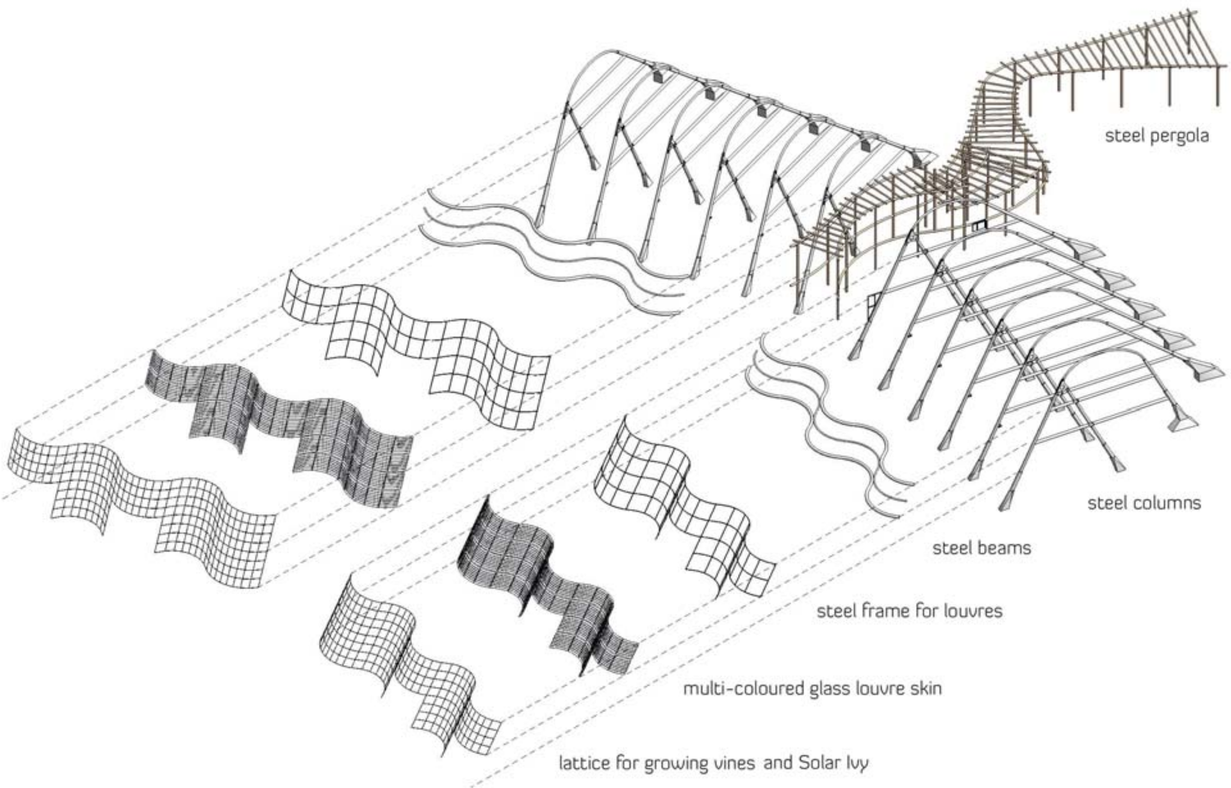


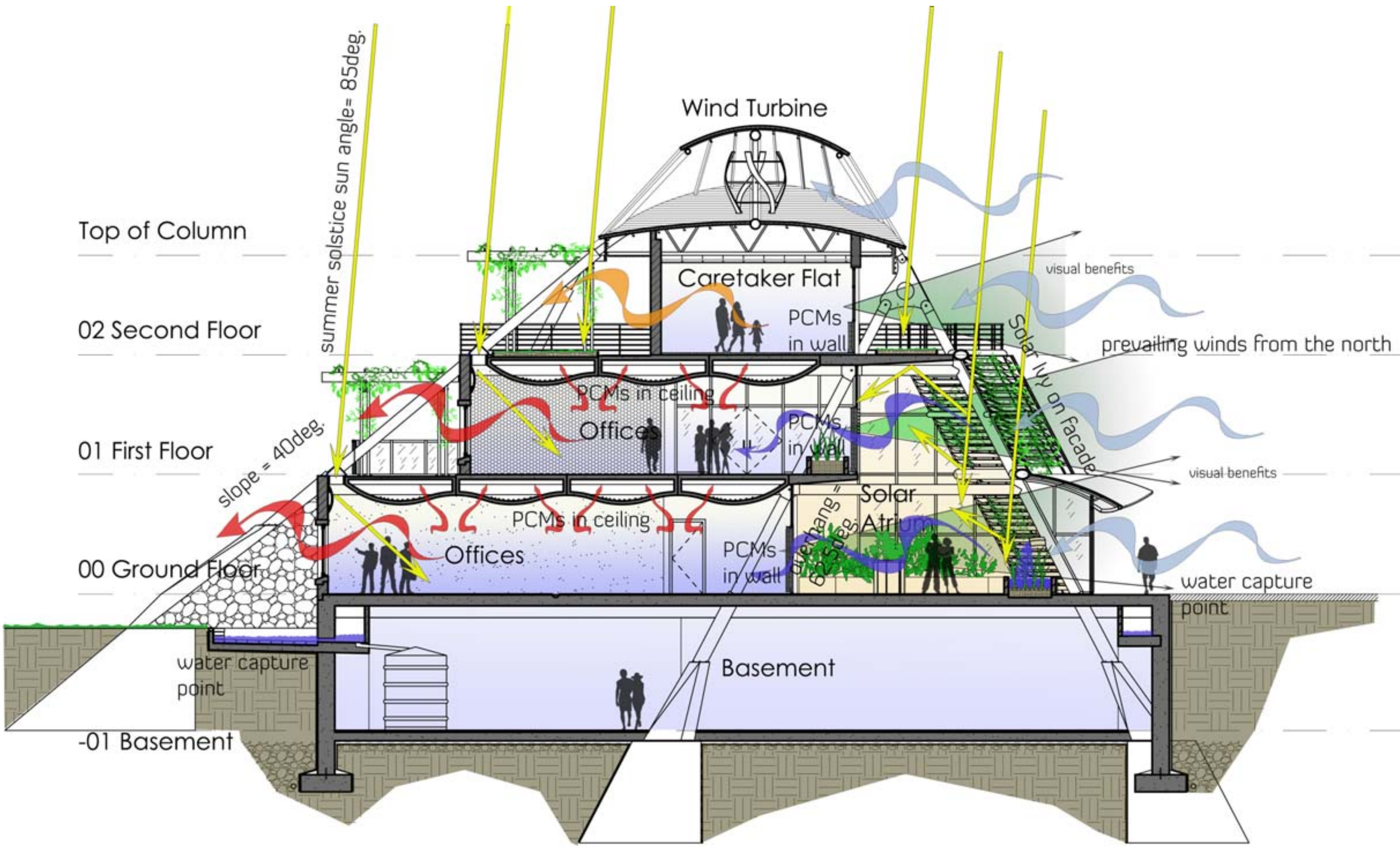
Fig. 5.31: The roof plan of the main building of my design is similar in shape to the fin of the humpback whale. This aids in directing wind over the building. (Source: author, 2012)




Exploded Perspective of Atrium Facade and Building Structure directed across the façade causing flowing air to enter the building and aid in cooling. The wind channelled to the turbines is then stronger than the direct wind strength. The turbines produce energy for the building. The shape of the roof allows for good wind flow over the top, and creates a vacuum on the southern side drawing out the warm and stale air from inside.

The solar atrium is the internal climate regulator. The façade, in addition to the above description, will have movable glass louvers. These will be open in summer to allow cool air to flow through into the building, and closed in winter to prevent cool air from getting in. It gives the feeling of being an outdoor space in summer, but an indoor space in winter. The louvers will be made of different coloured glass to create an interesting light effect inside the atrium.

In summer, as seen in the section below, the atrium cools the building. The water fountains coming out through the columns of the building aid in evaporative cooling by creating a splash in the ponds that catch the water. The splash simply separates smaller particles of water from the main body and these evaporate more easily. As they evaporate they cool the air that passes over them driven by the wind into the occupied spaces in the building. The fountains also provide the sound of water which has calming effects on the mind. This biophilic gesture affects the atmosphere inside the building, encouraging mental health and well-being. This is strengthened by the presence of plants in



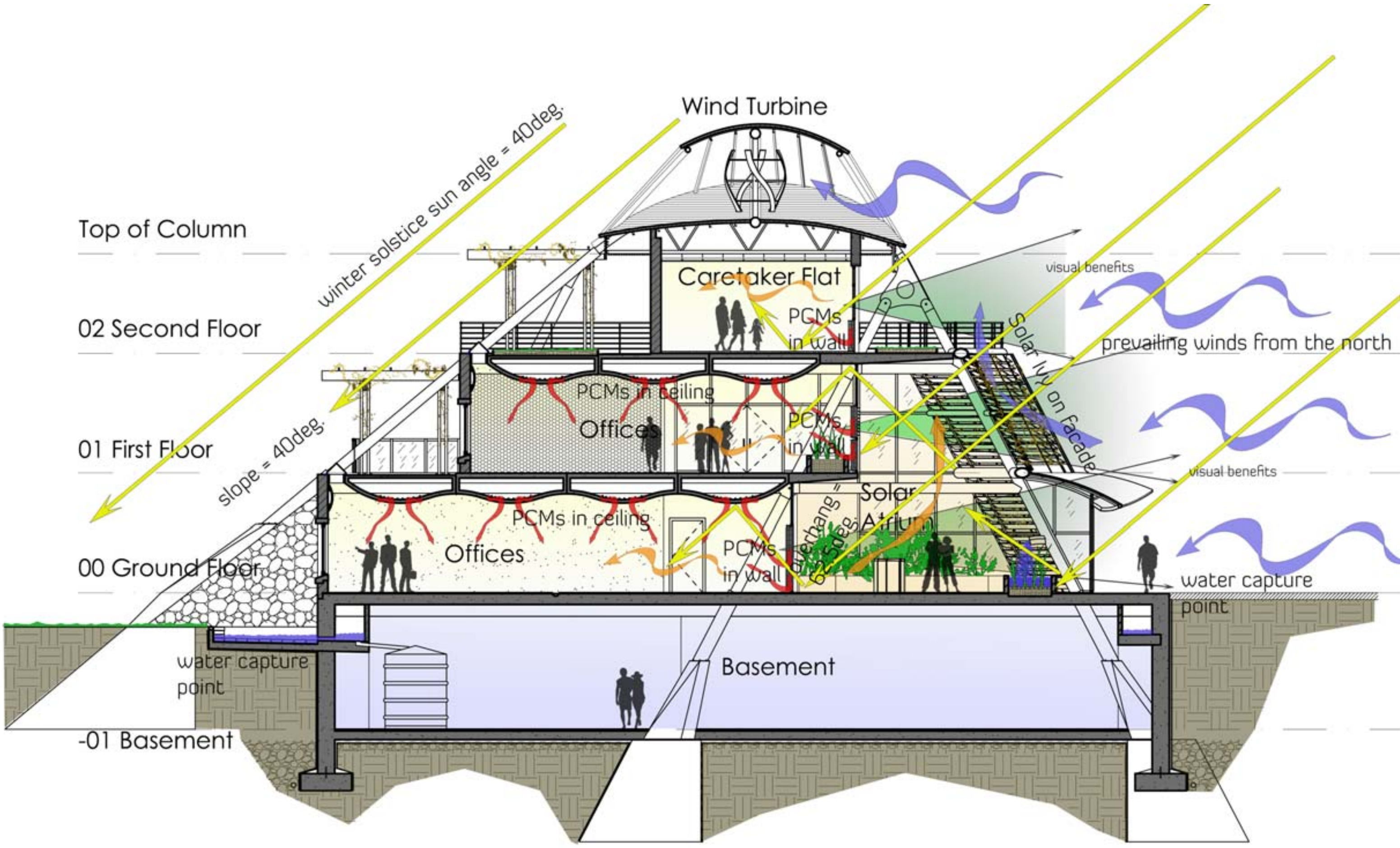

Summer Solar Section
Scale 1:200
(scaled down from 1:100)

the offices and atrium. The plants in the atrium also assist in controlling the interior climate, while the vines and the solar ivy provide shade to the atrium to reduce solar heat gain. Thus the atrium has multiple functions.

No direct light will enter the occupied spaces in summer do to the overhang of the floors. Phase change materials in the ceilings and walls slow down the movement of heat from outside, and remove heat from the inside. The shape of the ceilings encourages air flow inside which aids in heat transfer and removal, and fresh air entering the building.

The atrium works in reverse in winter, acting as a solar collector room. With the louvers closed the cold winter air does not enter the building. The vines will lose their leaves in winter allowing for more direct sunlight to enter and heat the internal space. The sun angle will be lower than the overhang of the floors at this time of year and direct light will enter the occupied spaces. This heat then radiates through the building. The phase change materials ensure that the inside temperature remains constant and thermal mass stores up the heat energy from the day to keep the building warm at night. This reduces the required heating load for the next day.

The building also affords easy visual access to the farms which would be a dominant green aspect in the urban landscape. This is beneficial to the workers inside the building as my research in chapter 3 shows.




Winter Solar Section
Scale 1:200
(scaled down from 1:100)

This design considers the full cycle of resource usage. The common way of using resources today is a linear way, as seen earlier in this thesis. This is inefficient and creates unwanted waste. But in nature there is no such thing as waste. One thing's "waste" is another thing's food.

Thus this design considers how waste generated here and elsewhere can be incorporated. As many construction materials as possible are recycled or reclaimed from waste, and the waste generated here, which is primarily organic waste, is used in a biogas digester to power the building with more than enough power to spare and supply the surrounding buildings and industries.

Multi-functional Design

Every part of this design has multiple functions. This biomimetic principle aims at resource efficiency through one simple and elegant solution.

The hexagonal modular design not only accommodates food growth but also heals contaminated soil and maintains soil quality. The cycles would be closely monitored and informed through feedback loops in order to ensure quality of soil and food.

The cycle of water storage, use and treatment on site, is done through as many natural processes as possible accommodated in the design of the buildings and systems. Water, as the source of life, becomes a major feature in the design of the main building with channels carrying water through the building, as well as water fountains in the solar atrium aiding in thermal control and creating a calming natural sound inside which assists in maintaining mental wellbeing.

Integrating Development with Growth

The development of this site acts as a pioneer development, or a "mother ship" development. That is to say that it serves as the headquarters from where future urban agriculture installations could be managed. Therefore the main building has facilities to operate and manage the systems of growing food. Each time there is need for more food growing space less infrastructure will be needed in order to install it.

Through this approach food can be produced in a decentralised manner. This increases resilience in our food production systems in case of disaster. Decentralisation is

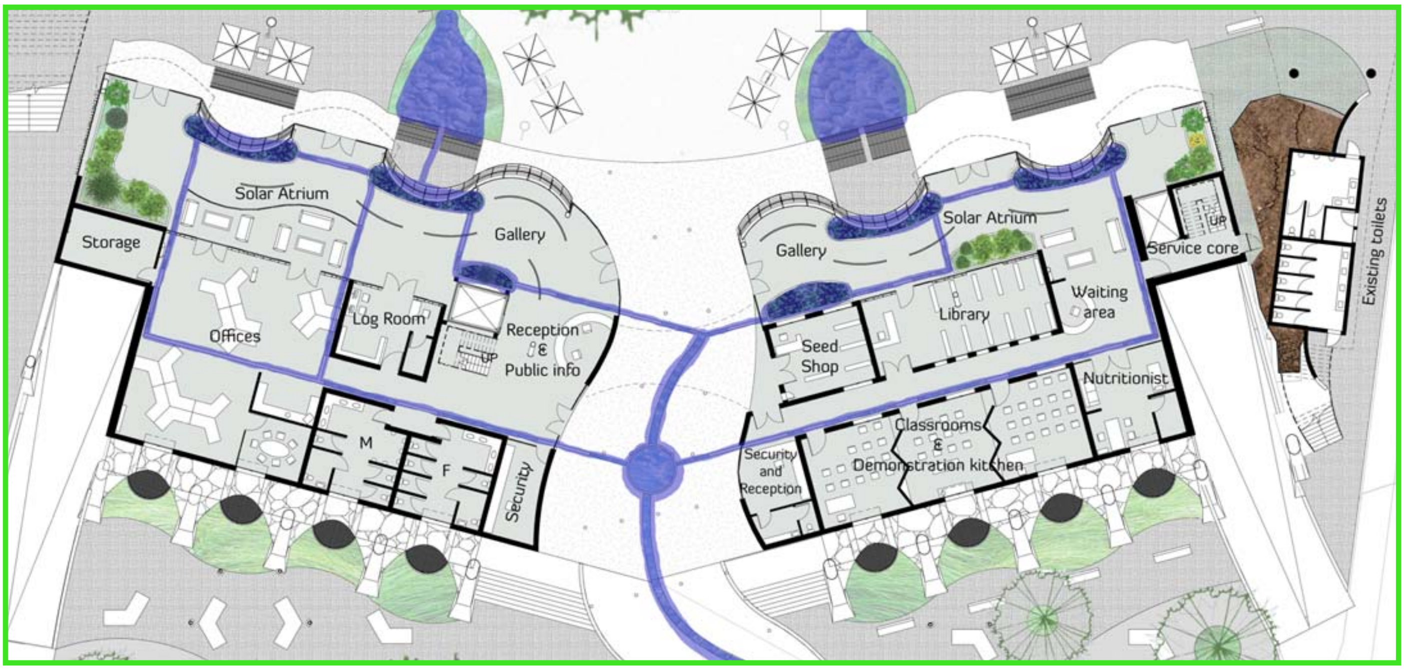



Fig. 5.32: The water channel in the ground floor of the design.

one way nature manages to perpetuate certain species and diversity.

The growth is achieved through the hexagonal modules. These modules fit into each other like a matrix, allowing for efficient use of resources and space. The components are nested into each other. They can also be assembled one component at a time as money allows.

Locally Attuned and Responsive

The design is born directly out of its context. It considers Johannesburg's sun in all seasons, prevailing wind directions, and rainfall. This is seen in the solar sections above.

Given that Johannesburg has wet summers and dry winters the need is to collect and store enough water in summer to serve the building and farms throughout winter as well.

The design is further locally attuned through the materials used in the buildings. These are recycled and reclaimed, sourced locally and making use of what can be found ready in Johannesburg.

Using Life-friendly Chemistry

As far as possible the materials in this design will be made from recycled or reclaimed materials. As the technical section on this page shows, even the structural elements can be made from salvaged materials. Using salvaged materials or recycling materials closes loops from other parts of the city. This helps to reduce the waste of the city as a whole. Many things each year are wasted which are still in good enough condition to be used in some way or other.

Concrete can be recycled by being broken up into smaller rocks and used as ground fill. The concrete slabs themselves are harder to make from recycled materials, but they can be made from Hempcrete, which is a concrete made using water, hemp aggregate, and a lime-based binder. The process of growing the hemp sequesters more carbon than is produced by making the concrete. Also, Hempcrete has very good thermal and acoustic properties. At the end of the life of Hempcrete it can be broken down into smaller blocks and will then decompose without causing harm to the environment.

Other materials include bamboo and approved or recycled timber. These have low embodied energy and are renew-

Fig. 5.33: Hemp plant and Hempcrete blocks. This is an environmentally friendly building material and is also incredibly strong. (Source: De Smit, 2010, and Geiger, 2011)

able resources.

One of the disadvantages of modern lightweight construction is its lack of thermal mass, which means this type of building can overheat in the summer and can't retain heat in the winter. However, it is also possible to replicate the effect of thermal mass of the building using phase change materials (PCM). PCMs limit excessive temperatures by storing the excess heat during the day, and releasing it during the night. This mimics the effect of thermal mass, which also stores heat during the day and releases it during the night.

The principal application today is the production of ice, or chilled water at night, which is then used to cool environments during the day. Reservoirs are often filled with water or molten salt. Wax, such as from a bee hive, is also a phase change material.

The system depends on the shift in phase of the material for holding and releasing the energy. For instance, processes such as melting, solidifying or evaporation require energy. Heat is absorbed or released when the material changes from solid to liquid and vice versa.

PCMs can be located in building components such as walls or ceilings, or can be arranged in separate heat or cold stores. The heat or cold is stored automatically and released when indoor or outdoor temperatures rise or fall beyond the phase change point of the material.

Adapt to Changing Conditions

Cities are dynamic entities. While the buildings remain stationary, the spaces between are often changing all the time. They often fluctuate in their levels of activity, shadow, available area etc.

The world is constantly in motion, therefore a biomimetic design needs to respond to that motion. This design adapts in multiple ways to increase the performance of the design components and food production. The hexagon modules, as seen above, are very flexible. There are numerous types

This image and the one on the opposite page depict different scenarios for the hexagon modules. They show the flexibility of the modules. Linear urban spaces can be connected by bridging across roads while still allowing space underneath for cars and trucks to pass. Other benefits of the hexagon modules is that they help to green the urban environment. This gentrifies the city as well as reduces the urban heat island effect.

of hexagons that have been developed in this design. From vertical growing racks to fully enclosed greenhouses, these hexagons adapt to fit the needs of the context and food production.

This project would be able to adapt in more ways than merely the hexagons. Socially it would function in such a way that the community members involved in the farms have certain responsibilities. In exchange for their services they are given income, food, education, and in some cases even a temporary place to live. This creates a model that addresses the major influx of unskilled and uneducated people from the rural regions to the city. Should they fail to play their part they would have to leave so that other people in need can have an opportunity. Once the people have reached a certain level of self-sustainability they can go off and make a living from their new skills.

Thus there is a social cycle involving the community around the farming sites as well as those affected by HIV.

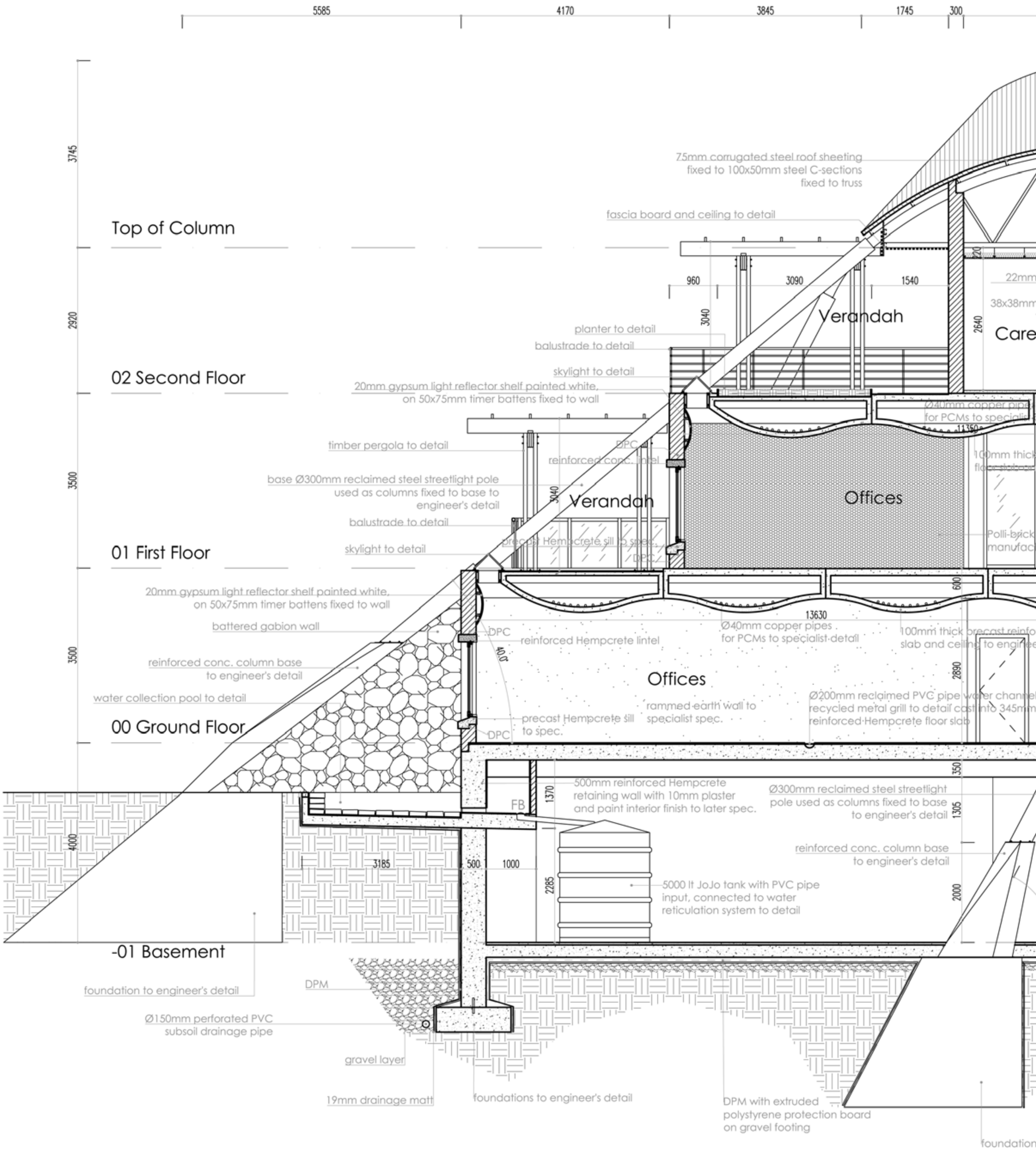
Commercially this design allows for adaptation in terms of what foods are grown and sold. If certain foods are selling better or in higher demand then the farms can grow more of those foods.

This also shows how the design adapts agriculturally and architecturally.

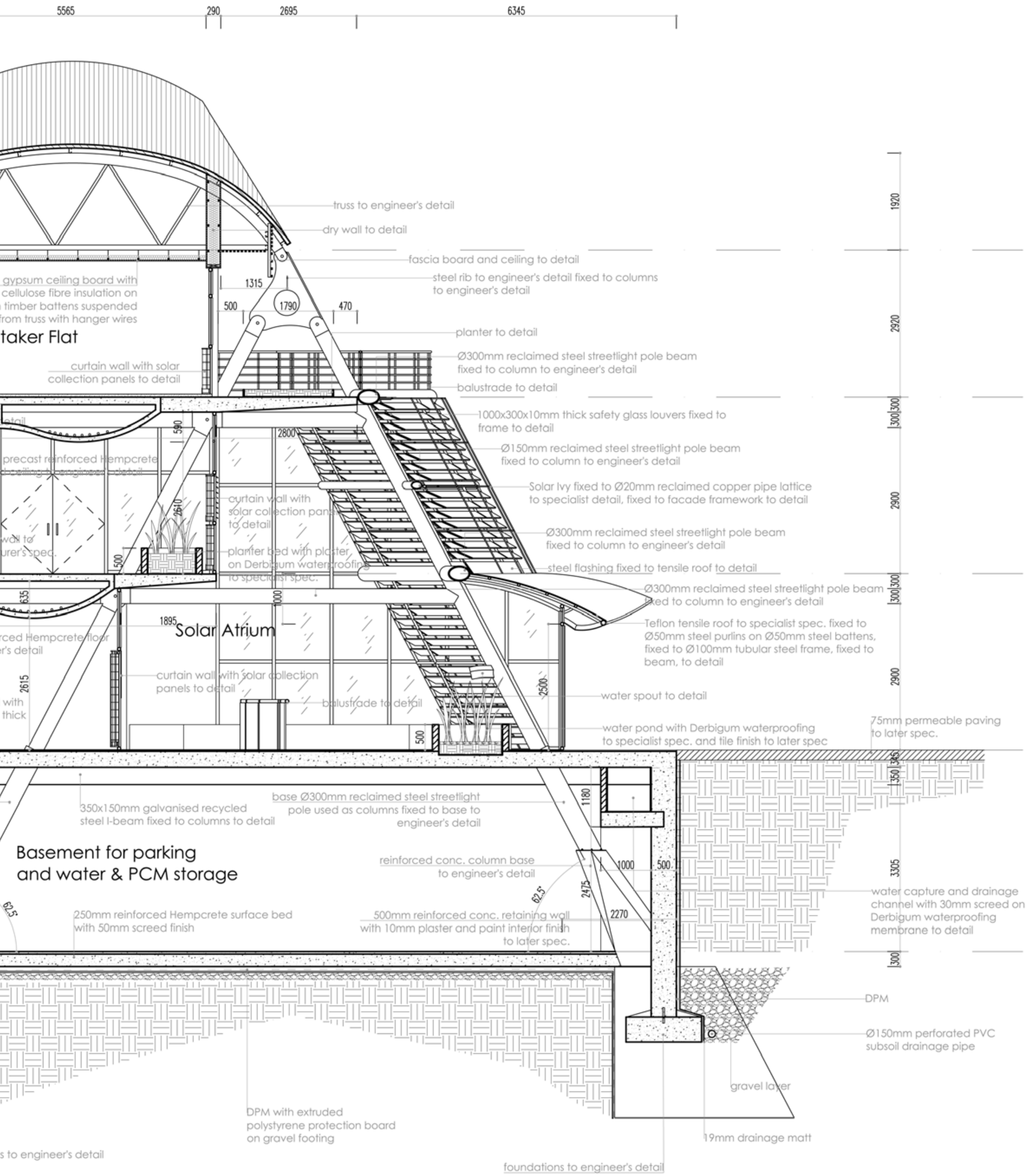
<u>Evolve to Survive</u>
This biomimetic principle is incorporated through the ability for the design to change and be informed by feedback loops. This will ensure enduring performance in the use of resources and production of food, and it allows for things which are not functioning well to be learnt from and changed.

The feedback loops and log room also create a data base of climate, soil conditions, and food within the city of Johannesburg. This can be a valuable resource for future reference.

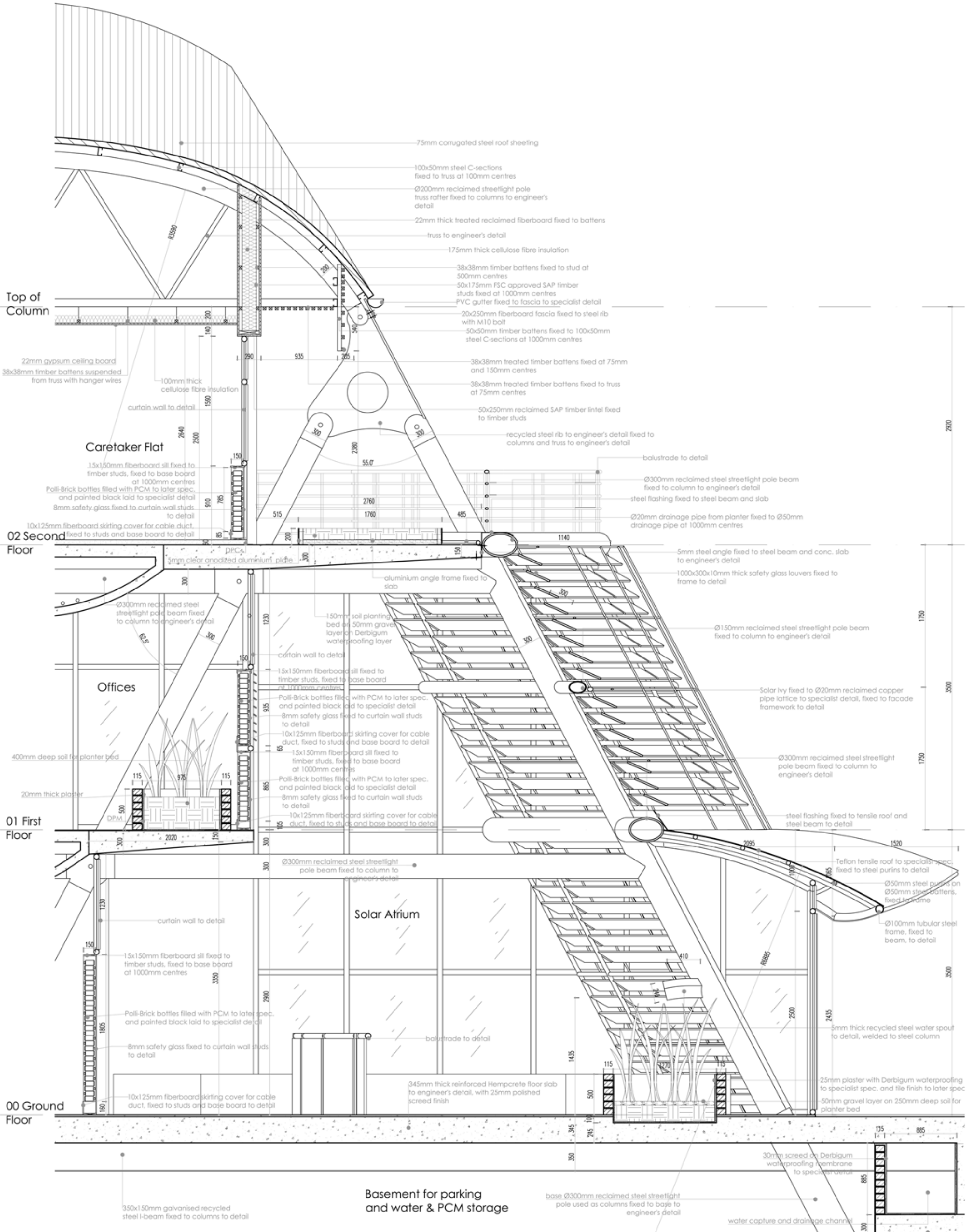
The hexagon modules can be adapted for different types of surfaces, or move in multiple directions as they grow. The primary limitation is where shadows from adjacent buildings are too overbearing for the intended food growth area. Plants require sunlight, most of them direct sunlight, in order to grow. Even in vacant urban spaces, if the shadows cover too much of the site then food will not grow well there. Thus, north-facing sites are ideal for growing food in Johannesburg.




Section Through Building
Scale 1:100
(scaled down from 1:50)



5565
290
2695
6345
truss to engineer's detail
dry wall to detail
fascia board and ceiling to detail
steel rib to engineer's detail fixed to columns to engineer's detail
gypsum ceiling board with cellulose fibre insulation on timber battens suspended from truss with hanger wires
taker Flat
planter to detail
Ø300mm reclaimed steel streetlight pole beam fixed to column to engineer's detail
curtain wall with solar collection panels to detail
balustrade to detail
1000x300x10mm thick safety glass louvers fixed to frame to detail
precast reinforced Hempcrete
Ø150mm reclaimed steel streetlight pole beam fixed to column to engineer's detail
Solar Ivy fixed to Ø20mm reclaimed copper pipe lattice to specialist detail, fixed to facade framework to detail
curtain wall with solar collection panels to detail
Ø300mm reclaimed steel streetlight pole beam fixed to column to engineer's detail
planter bed with plaster on Derbigum waterproofing to specialist spec.
steel flashing fixed to tensile roof to detail
Ø300mm reclaimed steel streetlight pole beam fixed to column to engineer's detail
Teflon tensile roof to specialist spec. fixed to Ø50mm steel purlins on Ø50mm steel battens, fixed to Ø100mm tubular steel frame, fixed to beam, to detail
Solar Atrium
curtain wall with solar collection panels to detail
balustrade to detail
water spout to detail
water pond with Derbigum waterproofing to specialist spec. and tile finish to later spec
75mm permeable paving to later spec.
350x150mm galvanised recycled steel I-beam fixed to columns to detail
base Ø300mm reclaimed steel streetlight pole used as columns fixed to base to engineer's detail
Basement for parking and water & PCM storage
reinforced conc. column base to engineer's detail
water capture and drainage channel with 30mm screed on Derbigum waterproofing membrane to detail
250mm reinforced Hempcrete surface bed with 50mm screed finish
500mm reinforced conc. retaining wall with 10mm plaster and paint interior finish to later spec.
DPM
Ø150mm perforated PVC subsoil drainage pipe
gravel layer
DPM with extruded polystyrene protection board on gravel footing
19mm drainage matt
s to engineer's detail
foundations to engineer's detail
1920
2920
2900
2900
3305
1315
1790
500
470
2800
2610
1895
2615
2500
1180
1000
2475
2270
62.5°




Detail Section Through Facade
Approximate Scale 1:50
(scaled down from 1:20)

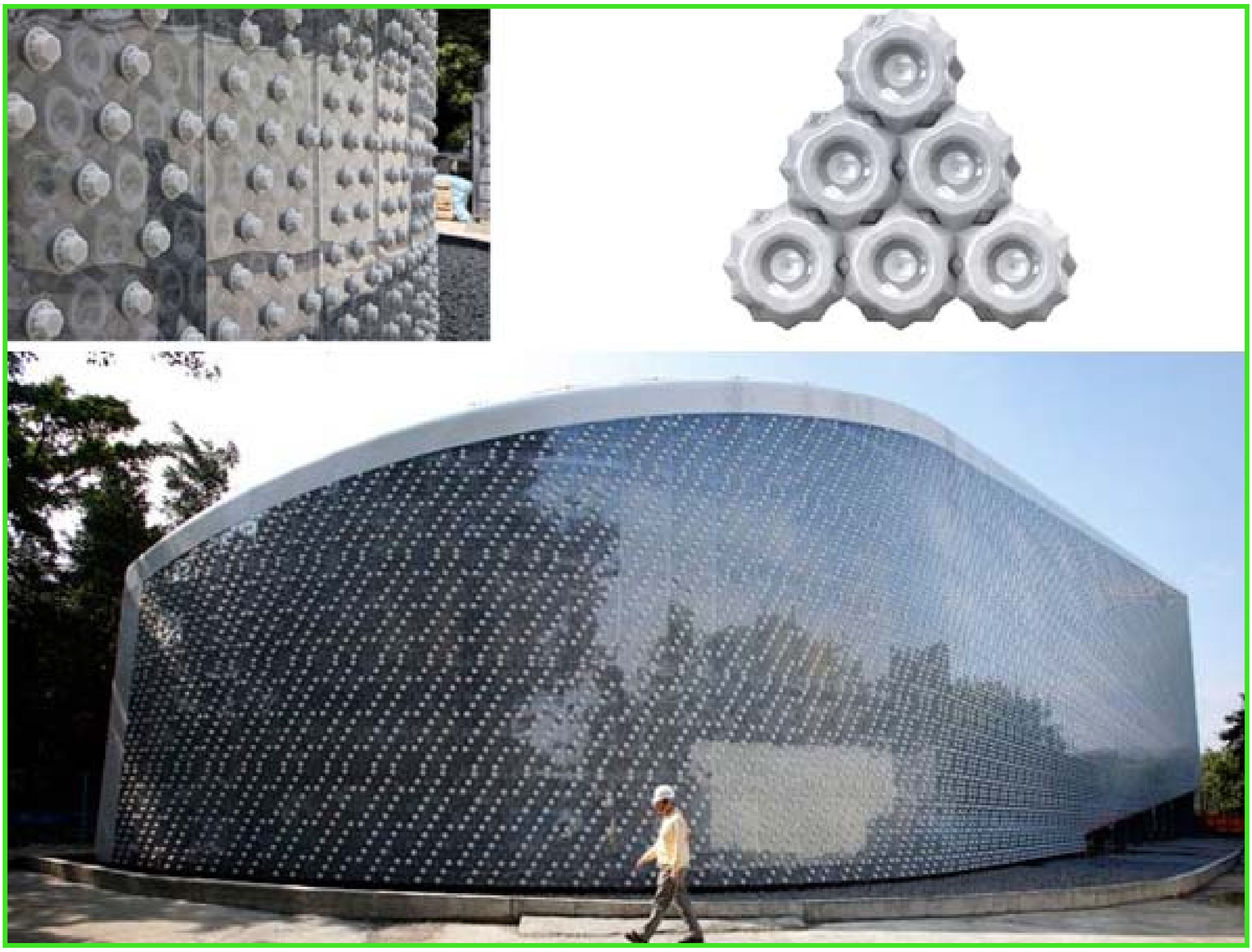


Fig. 5.34: Polli-bricks made from recycled PET bottles can be made to look appealing and modern. (Source: Sundance Channel, 2010)

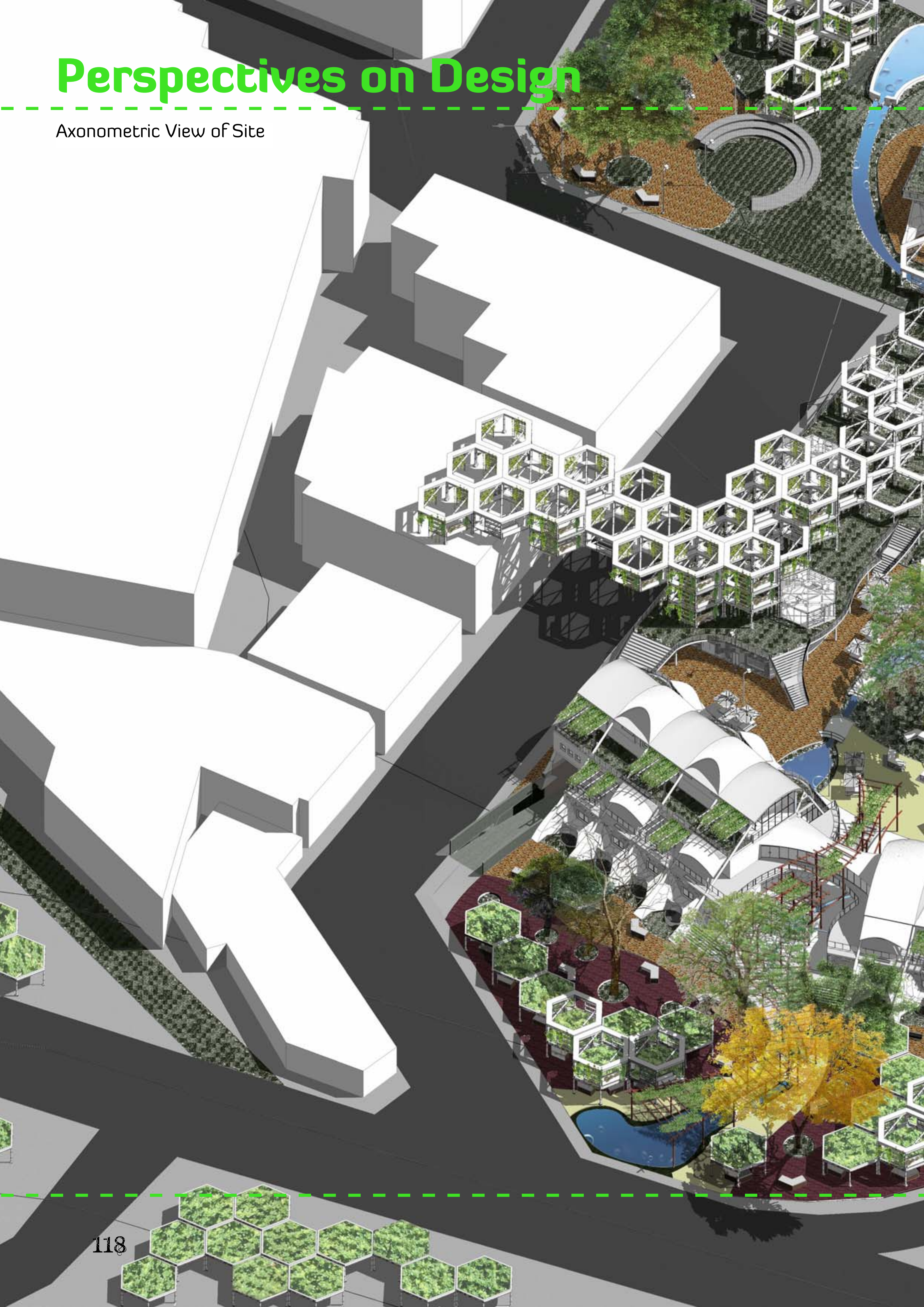
The columns will be recycled hollow tubular steel street-light poles. Certain walls will be made from rammed earth to aid in thermal mass. This is also a low embodied energy material and can use local resources. Divider walls in the building will be made from Polli-bricks. These are plastic bricks made from recycled PET bottles and moulded into interlocking hexagons. They can be filled with phase change materials or lit up with LED lights if colour or illumination is required. The bottles can be recycled 100% again at the end of the building's life.

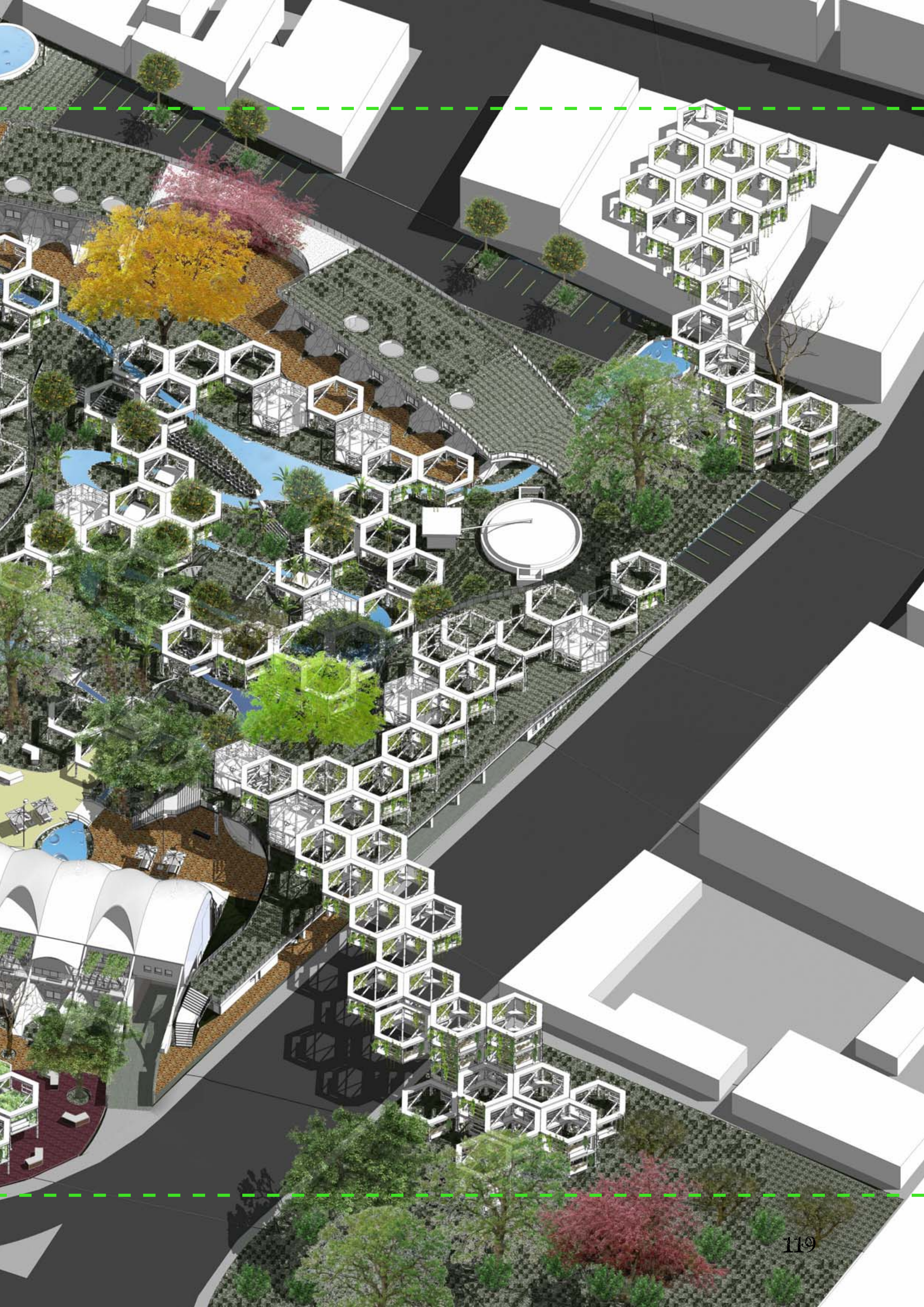
A difficulty with Polli-bricks is that because they are clear they might require  regular maintenance. As a result I have used them only on the inside of my building design so as to limit the amount of dirt that could gather on them. In my design they act as divider walls. Planters inside the occupied spacers bring users into direct contact with nature, improving the mental state at work.

The technical aspect of this design shows a low embodied energy design, and multiple closed loop systems. By recycling as many materials as possible this design closes loops in the city which are otherwise open ended. It is important to close loops so as to reduce waste and pollution. As mentioned earlier in this thesis, the death of one thing can be the life and fuel for another thing.

# Perspectives on Design

Axonometric View of Site

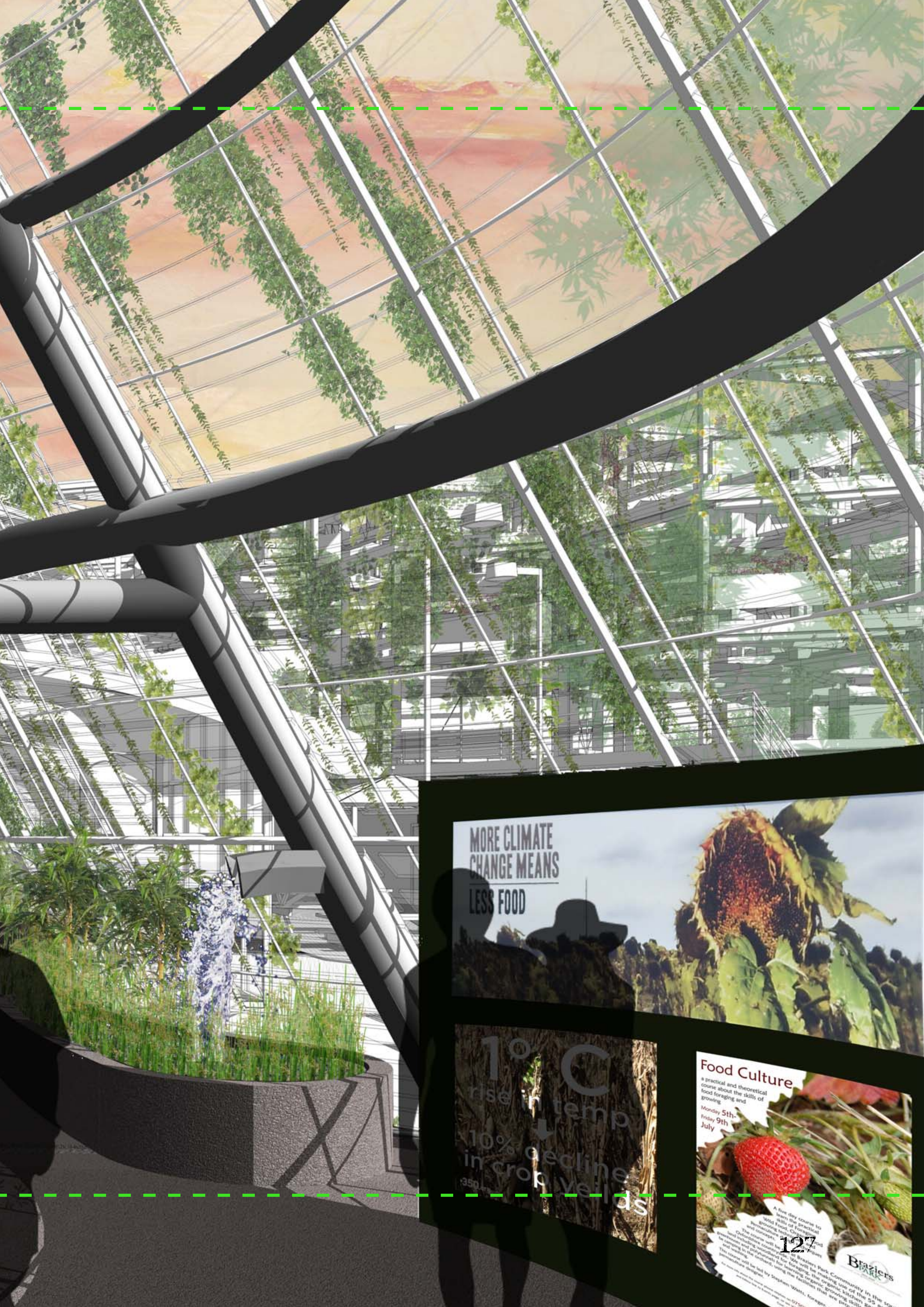




South East Perspective of Main building and Market

Entrance Pergola and Thoroughfare

Solar Atrium

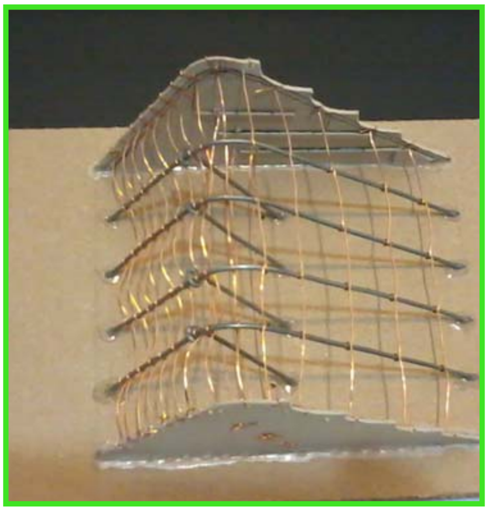

MORE CLIMATE
CHANGE MEANS
LESS FOOD
1° C
rise in temp
10% decline
in crop yields
Food Culture
a practical and theoretical course about the skills of food foraging and growing
Monday 5th-
Friday 9th
July
Braziers
PARK

Aquaponics Hall

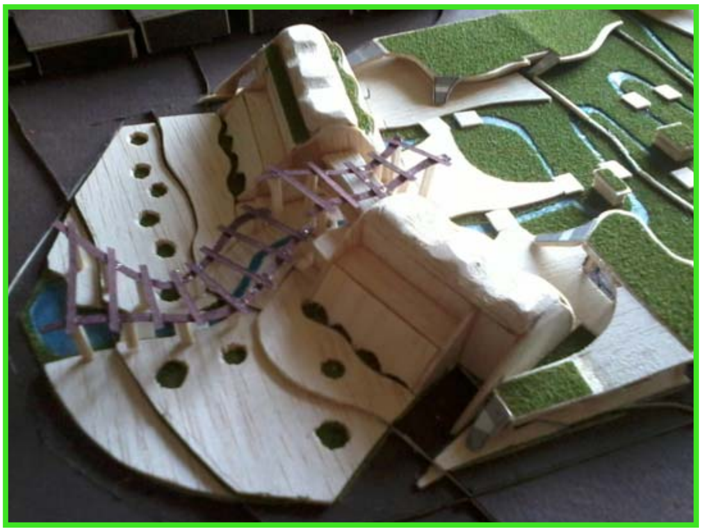
# An Urban Agricultural Model

Left: Sketch design model. This design was based on using hexagon modules throughout which resulted in interesting but difficult spaces.

The layout and waterway were shaped in a spiral in order to aid in the flow of water for irrigation and collection since a spiral is a very efficient fluid flow form.



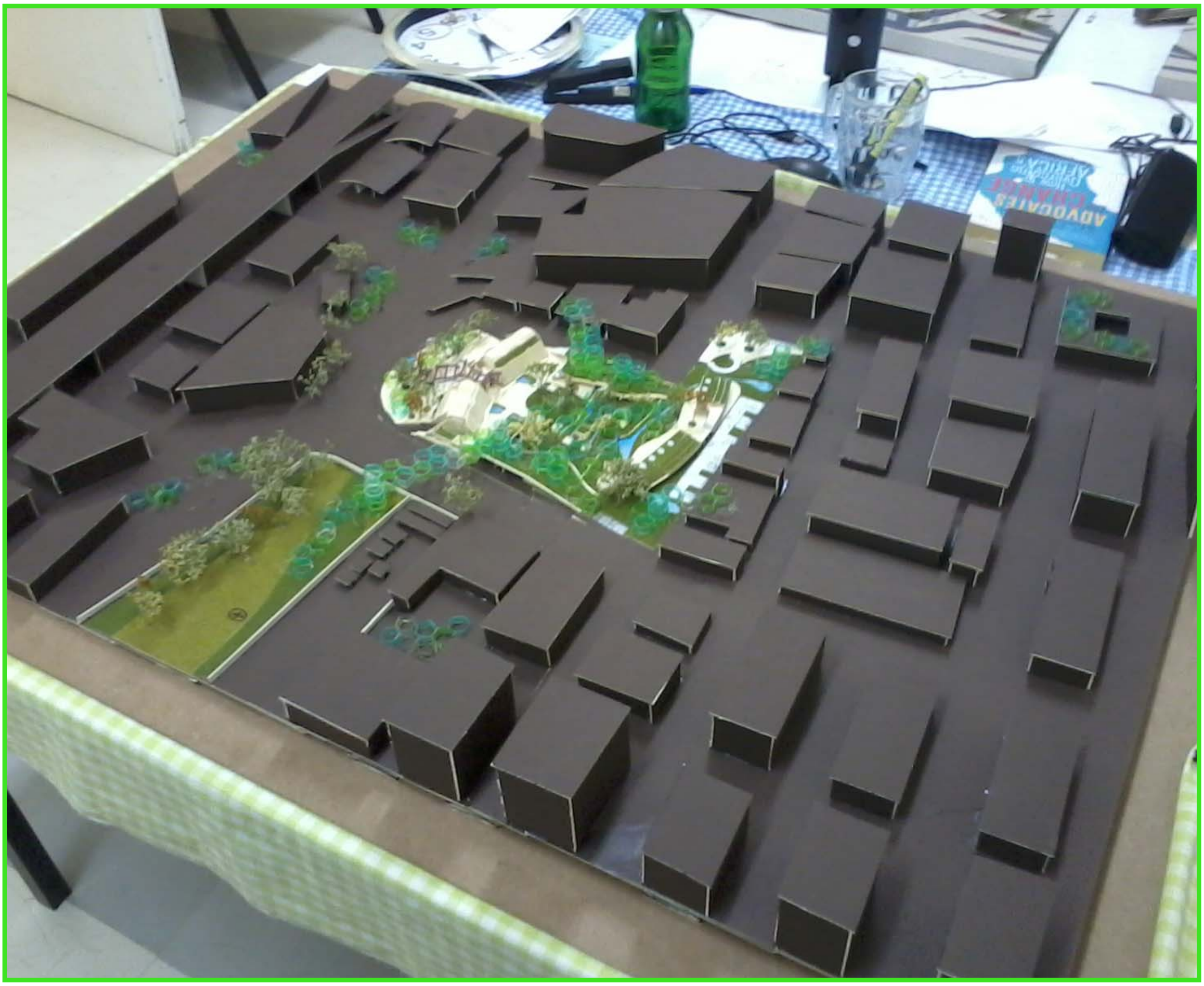
Above: A sketch model of the structure of the final design of the main building.



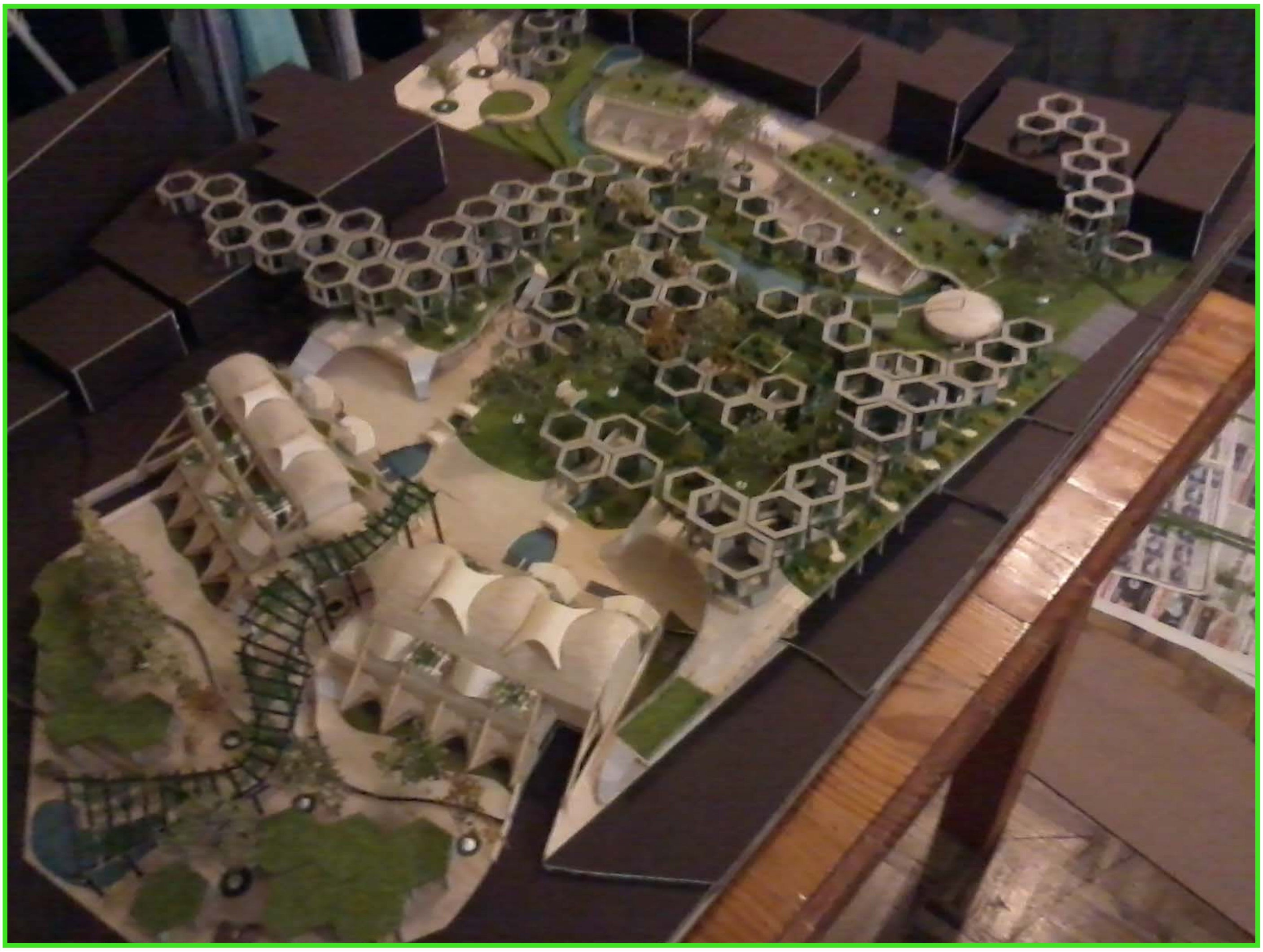
Above left, above right, left: Close-up photos of the 1:500 model in progress.

Left: The 1:500 model showing the broader context, before the hexagonal farming modules were added. I proposed that the bus depot to the east of the site be converted into further farming land.

Below: The finished 1:500 context model. The hexagon modules in the model show the intentions of the modules to use any left over space in the city. They also show the flexibility of the hexagon.



All of these photos show the progress of the 1:200 model.



Above: The completed 1:200 model.

Below: My presentation setup on the day of my oral exam.