Graduation Plan

Tamale city expansion - dwellings with a self-sufficient water supply

Phillipa J. Elliott
1364839
09 - 01 - 2013

P2 date: 16th of Januari 2013
### Personal Information

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### Studio

**Theme**
Closed water and nutrient cycles integrated into an architectural design

**Teachers**
- Main mentor: Robert Nottrot
- Building Technology: Andy van den Dobbelsteen
- Research mentor: Alexia Luising

**Argumentation of choice of the studio**
Through this studio I have the opportunity to do research on the subject that fascinates me ((closed) water cycles within architecture) and form a design in which the sustainable water aspect is most important. This is in contrast to former projects where sustainability either played a minor role to be added at the end, or where the attention was on a bigger scale of sustainability. The studio Explore Lab makes it possible for me to focus on one smaller aspect of the sustainability scala and incorporate that into a design.

**Date P2**
16-01-2013 - 14.30 - 15.30

**Title**
Title of the graduation project
Tamale city expansion - dwellings with a self-sufficient water supply
Background fascination
We live in a time where the amount of people in the world is increasing quite rapidly and so is consumption and use of finite materials and resources. The logical conclusion is that one day these materials and resources will be depleted, such as fossil fuels and intensively used nutrients. This is a problem that has been receiving more and more recognition over time and we are slowly adapting to it. On the other hand there is still a lot to improve and so also within the field of architecture.

When looking for example at dwelling complexes or offices, the energy, waste and water processes are designed linear. Energy, clean water and products come in. Unusable energy, soiled water and wastes go out. Especially concerning energy there has been a lot of attention to designing energy efficient buildings with an optimal natural light entrance, insulation, orientation, natural ventilation, building materials, etc. Waste and water treatment however, if at all present, are centralized systems and more difficult to address within the building premises.

My fascination lies within a combination of water and architecture, not just visually but also functionally. I find it extremely interesting how the Earth with everything on it has been working for a few billion years through amongst others closed cycles and interrelated systems, while the humans manage to deplete resources within such a short timespan. For me it is a challenge to combine the architecture of a common building, the single family dwelling, with a water system that fits within its environment and is as much as possible a closed system.

Problem statement: Tamale, Ghana
In the Netherlands the water supply is steady and well organised. In many other parts of the world this is not so. In the case of my location, Tamale in Ghana, the accessibility to, and sometimes the lack of, clean drinking water result in serious issues.

The situation did see an improvement in the past years to a point where now 91% of the people in Ghana have access to clean drinking water. However, roughly two thirds of this number consists of wells, boreholes and some surface waters. (Unicef, 2012) A lot of people therefore still have to fetch water from other places than the house and this task is mostly done by children and women. The time put into this activity is at the expense of schooling and development. Of the other two sources, surface water is vulnerable to contamination and boreholes deplete deeper water sources that take anywhere from decades to millennia to replenish and with a sinking of the water table, the risk of sinkholes increases.

The second problem that Tamale is facing are floods. Tamale has a clear dry and wet season and the wet season brings a lot of rain that has nowhere to go. The area in and around Tamale is relatively flat and the
ground is very dry and tamped. Therefore it is difficult for the rainwater to infiltrate quickly. There is a lack of rainwater harvesting in Ghana, while this would be very useful to cover the following dry season.

A third problem currently is that many people in Tamale depend on one organisation for water, the Ghana Water Company Limited. This company provides daily clean drinking water to amongst others restaurants, businesses and dwellings with water pipelines. If GWCL encounters problems and fails to deliver enough water, many people will feel the consequences. This has happened relatively recently in February of 2012, when the water station did not receive enough power and failed to meet the daily quota (Gyebi, 2012).

Design assignment

For the project I shall focus on decentralised rainwater harvesting and decentralised closed water systems integrated with the architecture of a single-family dwelling. In other words: a single-family dwelling that is self-dependant in its own water needs. The problems mentioned above arise because the drinking water services are not sufficient and the buildings and surroundings have not been designed for harvesting rainwater and re-using water.

A part of the design will be in a larger, urban scale to show possible water filtration plants, rainwater harvesting slopes, other urban interventions and the dwellings in their larger composition. The other part of the design will zoom in to one dwelling to show in more detail the design and implemented solutions. It is important to focus on both scales as the functioning of some systems and methods depend on a certain amount of water, use or people.

This integration of water into the design should not only lead to practical improvements but also give the opportunity to enhance the surroundings aesthetically and climatically. To improve the quality of a design, the people who live there or use the environment must enjoy it. If they care about their surroundings, it results in a feeling involvement and a need to protect not only the building, but all that happens to make it possible (DeKay, 2011).

The final part of the design assignment is about awareness. In order for the design to work, it needs to be designed in such a way that the local people can see the cycles, the systems and in general what is happening, in order for them to experience an increased awareness. In combination with the aesthetical qualities, the result would be local people actively caring and participating in the uphold of the surroundings.

Three qualities the final result should have are:

- As much as possible a closed water and nutrient cycle
- Adaptability towards the environmental conditions and the different seasons
- The design should generate awareness concerning the implemented systems and the water and nutrient cycle
Research Questions

To avoid having a design that is solely based on the technical aspects of water systems, I have formulated two research questions. One for a more technical research and the other for a more architectural research. Each with its own set of sub questions.

Research question 1
How can the integration of closed water cycles into the architecture of dwellings, lead to a more sustainable household water system in urban areas with drinking water and sanitation problems?

Sub questions
- Which water and nutrient flows are present and in what quantities?
- What water flows can be connected to create (a) closed water cycle(s)?
- What nutrient flows can be connected to create (a) closed nutrient cycle(s)?
- What resources, methods and means are there to achieve closed cycles?
- Which criteria are relevant for the choice of system?

Research question 2
What effects will the integration of closed water cycles into the architecture of dwellings have on the qualities of the design as a whole?

Sub questions
- What are the spatial implications of the chosen elements for the closed water cycle, in connection to the design location?
- Which criteria are relevant for the architectural design?
- How can the integration between water systems and architecture enhance the spatial qualities of its surroundings?
- How can you create more awareness of the water system through the use of architecture?


Project Goal

Research Goal

The research is divided into several parts, some to answer the more technical questions and some delve into the architectural aspect. Later on in the research phase they will join.

For the technical research the goal is to create an overview of the usable information which I can implement into the design, a “guidebook”. This guidebook describes the different stages in the water and nutrient cycle, together with their flows and volumes. Secondly it describes the possible techniques or methods to achieve these cycles and includes their capacities and their spacial implications such as size and appearance (through images). Thirdly the guidebook will show possible interrelations between the different parts in the system as useful tool for when I start designing the composition of buildings and inside spaces.

In the guidebook I can retrace which possibilities I have and what their position is within the system of the water and nutrient cycle. Therefore when I start designing I have the right information to base the design on.

For the architectural aspect the goal is an overview of aesthetical and visual qualities of the different elements and how they can be integrated into an architectural design. Via hand drawn sketches, analytical drawings and photographs these qualities will be displayed and placed in a constantly growing file, which will function as guide and personal memory during the design process.

Design Goal

To describe the goal of the design, it is best to look once more at the three qualities mentioned in the design assignment:

1) As much as possible a closed water and nutrient cycle
2) Adaptability towards the environmental conditions and the different seasons
3) The design should generate awareness concerning the implemented systems and the water and nutrient cycle

The main reason for this project is to research the possibilities of integrating decentralised closed water systems with architecture in such a way that it becomes both a functional and aesthetical design. The three qualities together should achieve this.

1 - The more technical goal of the design will be to have (theoretically) functioning water and nutrient systems, integrated within the architectural design. This includes the different stages such as storage and filtration, the transportation of liquids and solids, and correct capacities. Where possible, the different components and elements have to fit together to form cycles and if not possible, it has to be clear either from the
design or in the presentation where the liquids/solids go next or come from.

2 - Just like any other design, this design should fit its context, and considering the theme of my project, the environmental and climatic aspects especially. I have to take into account orientation, sun angle, wind direction, temperature, depth of groundwater, rainfall, etc. to take advantage of the location where possible and to provide protection where necessary. One aspect that is particularly of influence is the difference between the dry and wet season, because of its vast differences in rainfall. Whereas in the dry season there falls hardly any rain, there is too much in the wet season and floods are not uncommon. Therefore adaptability to these different circumstances is one of the goals. A simple example would be a roof surface designed for optimal rain harvesting in the wet season and shading from sun and dust winds in the dry season.

Besides this, the design has to fit the target group and match the social and economic situation. A design has no point if it cannot be used.

3 - The third goal of the design is to successfully make visible the water and nutrient cycles through the use of architecture in a way that is understandable to the local people. This is of great importance as the system depends on participation by the inhabitants. To achieve participation, the inhabitants have to understand what is happening and feel a positive connection with their surroundings. This is why the system has to be integrated into the surroundings in a way that it is aesthetically appealing, useful and people can interact with it.

In conclusion, the goal of the design is an area with single-family dwellings, supported by their own rainwater harvesting and closed water and nutrient cycles. The measures are integrated within the architecture of the surroundings and dwellings, to such extend that the combination enhances the space and generates awareness. Inhabitants are self-sufficient in their water needs, understand what is happening and feel part of it.

Research Process

Method

Literature research - For the technical part of the research a large proportion shall be literary research. A lot has been written about closing water and nutrient cycles and the varying aspects that are involved. Through the reading of both older and recent published works, I can make a scheme of a closed water and nutrient cycle and create a list of possible elements for each of the different categories, such as transportation, storage and usage of water*. During the design phase, literary research will also be done while studying different building materials, their construction types and details.

*Later on referred to as: ‘Option Tree’
Talking with experienced people - To receive feedback on my project, the gathered information and the research products I have formed, it is wise to talk to people with experience. They have more knowledge about the subject, can view my project from a different and objective angle and help steer the research and design in the right direction. The contact with experienced people will hopefully be recurring throughout the project, both in preliminary design phase as the definitive design phase.

Lectures and previous projects - In the past years at the architecture faculty I have followed several courses that taught about water sustainability, using water to improve the indoor climate and closing water cycles. From these courses the lectures are still very informative and useful for both research and design.

Location analysis - Gathering knowledge about the location and understanding the location are crucial for a design. The location analysis is done at the beginning of the project, during the research phase, to set up location criteria for amongst others climatic conditions, average dwelling and plot sizes, orientation, composition, accessibility and target group. These criteria will later on be combined with the 'options tree' to sort out which elements in there are possible to implement in the design and which ones are not.

Research through design - research through design will be used to combine the technical research with the architectural design. Through sketches and analytical hand drawings I can effectively experiment with what is possible concerning the implementation of different elements into an architectural context. There will be a back and forth motion between the technical research and the drawings, where both the functionality and architectural aspect are of great importance. The result should be a design in which the technical and architectural are integrated into one design.

Case studies - To be aware of what is architecturally possible with closed water cycles and water systems, much can learned from what is already built. For this I shall do some case studies of plans, existing buildings and existing larger plans and focus on what has been done with water, both systematic and visually. The results of these studies shall be in sketches, which I can use as support during the design phase.

Literature and General practical references

DeKay, M. (2011) *Integral sustainable design – transformative perspectives*, London: Earthscan, 490p - This book explains an integral sustainable theory that not only focuses on the systematic and technical side, but also explains the importance of the social aspects and the ‘lovability’ people feel for a building, through the use of aesthetics.

Pötz, H., Bleuze, P. (2012) *Groenblauwe netwerken voor duurzame en dynamische steden*, Delft: Coop for life, 608p - This book has a very systematic and organised overview of ways to work with water on an urban scale. It explains amongst others rainwater harvesting and water filtration and adds a quantity/quality graph for each of the possibilities.

Different scientific articles from Google Scholar and the TU Delft Library

*People with experience*

I have contacted professors at the Unesco-IHE and aim to ask for a meeting again in the future. The Unesco-IHE in Delft carries out Research, Education and Capacity Development activities in the fields of Water and the Environment.

*general practical experiences*

AR0085 - Sustainable Development Programme (TIDO)

AR0532 - Smart & Bioclimatic Design Theory (TIDO)

WM0944TU - Sustainable Innovation in Practice - for this project a group of students designed and build structures that had to do with sustainability. Afterwards they were presented to a large crowd at the Llowlab island at Lowlands 2012. My project was the design of a hot tub with a closed water cycle, filtration system and fully functional on sun-energy for power and warm water. Although a hot tub might not be much, it all worked properly and is one of the most important experiences I have so far.

**Phillipa Elliott (2012) - schematic drawing of the hot tub system**

**REFLECTION**

**Relevance**

This project came to be out of a feeling that we way we see architecture and design, needs to change to meet the future challenges. In the next few decades the amount of resources and materials will decrease, while the population increases massively and the thought that we might still be flushing our toilets with drinking water is something which should not be. The use of energy inside buildings is already greatly reduced through
the use of natural ventilation, heat and cold aquifers, sun shading, a minimum daylight entrance, insulation, etc., but the waterflow in most buildings is fully linear and monofunctional. In the more prospering countries this is not so much of a problem as the central water filtration systems are very reliable. A city like Tamale however, or for that matter any less prospering country facing dry seasons, could greatly benefit from small closed water systems to supply drinking and usable water.

Hereby I feel the integration between architecture and the water systems can be of importance. Firstly, within the next 50 years there will be a massive growth in population, from 6.7 billion now to 9.2 billion in 2050 (UN, 2007). This means the percentage of built environment will also increase, which for example is currently happening in Tamale. Especially in the more arid regions the amount of available water might not be enough and the accessibility worsened by the spread of dwellings. The use of boreholes would not be an option as it takes away water from sources which take decades to millennia to replenish. If that water is taken away, the water table sinks, increasing the risk of sinkholes.

It seems only logical that people will need to find ways to use and implement cascading waterflows and recycle water on smaller scales. This decreases the risk that comes with dependance on one central facility and, especially in the less prosperous zones with wells only, increases accessibility to water. For the women and children of Tamale and other similar situations this would give them more time to spend on education and personal development.

Because most water is used inside the building plot, the building plot seems like the right place to regulate water flows, including cascading flows and water filtration. If generic solutions can be found to achieve this goal, they could very easily be implemented into other buildings as well. Then, when a city expands, it automatically also expands its rainwater harvesting surface, water supplies, water drainage system, water cleaning facilities and water infiltration sites. It could be extremely useful to areas suffering from dry seasons or bad accessibility to water. Through the research and design process I want to discover more about the possibilities.
**Time Planning**

**Graduation Plan Phillipa J. Elliott - 1364839**

- **22 Oct 26 Oct**
  - P1 presentations
  - Basic construction for 'option tree'

- **29 Oct**
  - Location analysis - physical location / climate / social situation. Set up criteria

- **5 Nov**
  - Develop concept for the design, a programme of demands with criteria for the 'option tree'

- **12 Nov**
  - Fully expand the 'option tree' with detailed flows, means, methods and resources - literature / references / talk to people

- **19 Nov**
  - Case studies -> spatial implications (pos/neg)
  - Scale, shape, other requirements

- **26 Nov**
  - Design concept drawings
  - Section / persp. / floorplans

- **3 Dec**
  - P1 presentations

- **10 Dec**
  - Compare options to the set criteria

- **17 Dec**
  - Choose feasible options (spatial implenz.)

- **24 Dec**
  - Design holiday

- **31 Dec**
  - Presentations

- **7 Jan**
  - Finish "guidebook" and Presentation of research

- **14 Jan**
  - Preliminary design
  - Final design

**Technical aspects**

- **Q3/4**
  - January
  - Q1/2 February

- **Q3/4**
  - March

- **Q1/2**
  - April

- **Q3/4**
  - May

**Presentations**

- **Q3/4**
  - Presentations

**Other**

- **Christmas holiday**

- **P4 presentations**

Continue research where necessary: Literature / references / visit places / talk to people @ TU Delft / Unesco-IHE
Source


