DIPLOMARBEIT

ADOBE IN ETHIOPIA

Implementation of earth building projects in the development context: problems / strategies

ausgeführt zum Zwecke der Erlangung des akademischen Grades
eines Diplom Ingenieurs / Diplom Ingenieurin
unter der Leitung von

Ao.Univ.Prof. Dipl.-Ing. Dr.phil. Andrea Rieger Jandl

und der Mitbetreuung von
Senior Scientist Dipl.-Ing. Dr. Ulrike Herbig

E 251-1 für Kunstgeschichte, Bauforschung und Denkmalpflege
Fachgebiet Baugeschichte und Bauforschung

eingereicht an der Technischen Universität Wien
Fakultät für Architektur und Raumplanung von

Denise Kießling
00307838

Wien, am 28.09.2017

ABSTRACT

The good availability and its material characteristics make earth an ideal building material in arid and hot regions of the planet. In the third world countries earthen architecture is still particularly widespread, because its extraction is dependant only on time, with no financial outlay. Despite these positive aspects, earthen architecture is rarely used in development cooperation projects. Lack of experience with the building material and image problems may be possible explanations for this.

Through the scientific monitoring of a development project in the Afar-Region in Ethiopia I will examine where the problems in the implementation of such a project are. The field sample after the design of Katharina Schoenher is particularly suitable since it is also used to establish a new, sustainable technology for this place through the use of clay bricks as a building material.

The goal of my work is to record and analyse the difficulties in implementing such a construction project. Based on the case study, specific problems such as the lack of availability of building materials and other resources, the language barrier and the cultural and social differences will be examined. These are compared with other earth building projects in the development context and strategies for problem solving are documented. This documentation can serve as a guide for the realization of future similar projects.

fig. 1: Adobe wall of the Afarkindergarten-project in Mai 2015

KURZZUSAMMENFASSUNG

Lehm eignet sich durch die große Verfügbarkeit und seine Materialeigenschaften hervorragend als Baustoff in ariden und heißen Gegenden der Erde. Vor allem in weniger entwickelten Ländern ist dieser noch weit verbreitet, da dessen Gewinnung nur mit zeitlichem, aber keinem finanziellen Aufwand verbunden ist. Trotz der genannten positiven Aspekte wird Lehmarchitektur selten in Projekten der Entwicklungszusammenarbeit eingesetzt. Mangelnde Erfahrung mit dem Baustoff und Imageprobleme mögen eine Erklärung hierfür sein.

Durch die wissenschaftliche Begleitung eines bereits im Bau befindlichen Entwicklungsprojektes in der Afar-Region in Äthiopien werde ich untersuchen, wo die Probleme bei der Umsetzung eines solchen Vorhabens liegen. Das Feldbeispiel nach dem Diplomentwurf von Katharina Schönher eignet sich besonders, da durch die Verwendung von Lehmziegeln als Baumaterial auch eine für den Ort neue und nachhaltige Technik eingesetzt und vermittelt wird.

Das Ziel meiner Arbeit liegt in der Erfassung und Analyse der Schwierigkeiten bei der Umsetzung eines solchen Bauprojekts. Anhand der Einzelfallstudie werden konkrete Problemstellungen wie die mangelnde Verfügbarkeit von Baumaterialien und anderen Ressourcen, die sprachlichen Barrieren und die kulturellen und sozialen Unterschiede untersucht. Diese werden mit weiteren Lehmbauprojekten im Entwicklungskontext verglichen und Lösungsstrategien dokumentiert. Diese Dokumentation kann als Hilfestellung zur Realisierung ähnlicher Bauvorhaben dienen.

TABLE OF CONTENTS

GLOSSARY

General:

CIS:	Corrugated iron sheets
EiABC:	Ethiopian Institute of Architecture, Building Construction and City Development
ETH Zurich	Zurich University of Technology
NGO:	Non governmental organization
TU Vienna	Vienna University of Technology

Earth:

Lean soil:	Not very cohesive soil
Rich soil:	Soil with strong binding characteristics

Afarkindergarten-project:

AK-project:	Afarkindergarten-project
APDA:	Afar Pastoralist Association
Chikka:	Designation of a widespread building technique in Ethiopia, where a wooden substructure is covered with earth
Deboita:	Mobile house of Afar

NESTown-project:

CTC:	Community training centre
ITA	Integrated Town Agriculture
NEST:	New Ethiopian Sustainable Town
RWU:	Rainwater-unit

SRDU-project:

RHR	Rural Housing Research
SRDU:	Sustainable Rural Dwelling Unit

1. INTRODUCTION

The whole process of traveling, filming and researching for my master thesis was long and challenging, but it gave me the opportunity to gather many experiences for my life.

fig. 2: Fieldwork in Logia/ Afarkindergarten-project

1.1 Research Question

The focus of my thesis is the construction with adobe bricks and important things you need to know about this material before starting a building project. The main questions have been:

* What are the motives of building with earth, especially with adobe bricks?
* How can I improve the acceptance and the image of earth construction methods within the population?
* Do cultural differences affect the work on a construction site?
* How do I know if the soil on the building site is suitable for construction?
* What are essential rules of construction for earthen buildings?
* How can I ensure durability?
* What are the biggest challenges during construction?
* With respect to the three projects compared in this thesis, what are the different approaches in realizing construction projects using adobe bricks?
* How can I transfer the knowledge about adobe construction so that the local people apply the technology independently?
* And finally, how can I present the topic of adobe construction in a documentary movie?

1.2 Theme finding

In December 2015 I received an email from Professor Andrea Rieger-Jandl about a building project in Ethiopia of two former architecture students of Vienna University of Technology. It was about an education complex that enables children from the countryside to visit high school. They were searching for volunteers on the construction site, and there was also the option of writing a master thesis in this context. As I was still searching for a topic and had the desire to go abroad for some time, I was interested in this project. Additionally, I was very fond of the building material earth they wanted to implement. In January 2016 I visited the project presentation of Katharina Schönher and Alice Eigner. The idea of making a documentary movie about the construction process came very fast, and two months later, I was already in Ethiopia. As everything happened very fast, I was rather unprepared when I arrived and had no clear vision about the detailed content of the movie and also the written thesis. I thought if I was on the construction site for some time and worked with the people, finally the ideas would come. And somehow it all worked out quite well.

First I wanted to concentrate my research only on the construction of the education complex. I imagined the documentary movie would end with myself accompanying the children moving from the countryside into their newly finished home. After some time on site, I realized that this objective is rather unrealistic, because the progress on the building site was very slow. So I came to the idea of a comparison with other construction projects using adobe bricks in Ethiopia.

1.3 The three projects

The three projects described and compared in this thesis are located in completely different regions of Ethiopia and have different functions. Their main similarity is the building material; adobe bricks.

* **The Afarkindergarten-project** (AK-project): This project is about the construction of an education complex in the Afar-Region, one of the hottest and driest areas of Ethiopia. The focus is on the construction of one hostel building.
* **New Ethiopian Sustainable Town** (NESTown-project): A new town is rising up in the village of Bura in the Amhara-Region. It will enable sustainability, independence and income security. The Rainwater-unit (RWU), the accommodation of the future inhabitants, is described in detail.
* **Sustainable Rural Dwelling Unit** (SRDU-project): The goal of this project was to create a new form of rural housing, which better adopts modern standards. It had been realized in different areas of the Gurage zone, a part of SNNPR-Region. The design is strongly oriented on the traditional house.

fig. 3: Afarkindergarten-project

fig. 4: NESTown-project

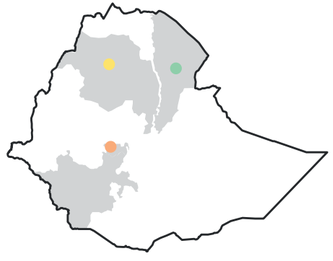


fig. 5: Map of Ethiopia with the three building sites and the corresponding region

fig. 6: SRDU-project

1.4 Scope and delimitation

The main focus of this master thesis is to analyse the application of the building material adobe bricks in three different construction projects. In particular, the strategies and problems within this context are documented and compared. Additionally, the thesis contains background information about the three building sites and the country Ethiopia. The material earth is also discussed, as it is very important for general understanding. Soil has dozens of application areas in construction, but I limited the research to building with adobe bricks and earth wall finishes, with a focus on renderings.

1.5 Aims and objectives

One aim of my master thesis is to design guidelines for the successful use of adobe bricks in construction, especially in the development context. With this overview I want to facilitate the implementation of future similar projects.
In order to achieve this aim I:

* Worked for three months on a building site to gather real-life experience
* Visited and documented two other building projects in Ethiopia
* compared the three sites in order to find out about the common problems of such a project
* collected information about the strategies that have been used for successful implementation
* Researched the properties of earth and the rules of construction with adobe bricks

The second aim of my master thesis is to spread the knowledge and principles about adobe construction to a wider audience by creating a documentary movie.

1.6 Methodolgy

This master thesis contains two parts. One is the theoretical work; the comparison of the three building projects in Ethiopia using adobe bricks for construction. The other part is the presentation of these projects and the building technique in a documentary movie. The methodology for these two parts was different, but also went hand in hand. The shooting and making of the documentary movie was mainly determined by fieldwork and the theoretical part by documentary analysis. However, I could use the information I gathered for the theoretical part also for the movie and the material I collected for the movie for the written part. The following qualitative methods were used:

* Observation: A large number of my observations happened when I was shooting the video. The pictures I took for the movie I could also use for the description of the different projects.
* Hands on construction: To really understand earth construction you need to work with the material. The voluntary work on the building site helped me very much to understand the processes and also to see the main problems on a construction project in Ethiopia.
* Interviews and conversations: Talking to people also gave me a lot of information. On the one hand I had conversations with people working for the different projects, on the other hand I was interested in what the society thinks about them, especially with regard to the building material adobe bricks. For most of the interviews I followed a semi-structured format. Many of the interviews I was also filming, so I could also use the material for the movie.
* Research: For my theoretical research, the two editions of the Building Ethiopia publications of the Ethiopian Institute of Architecture, Building Construction and City Development (EiABC) in Addis Ababa were very useful. There I found a lot of general information about construction in Ethiopia and also details about two of the projects presented in this thesis. The people responsible for these projects gave me additional information and also pictures. Concerning earth as building material, I found the book of H. Houben and H. Guillaud especially helpful.

1.7 Work plan

The first journey to Ethiopia: In March 2016, about two months after I first heard of the construction project in the Afar region, I had already arrived in Logia and joined the team. We worked on site six days a week and Friday was our free day. We spent lunchtime in the compound of the NGO APDA (Afar Pastoralists Association), where we had been invited to live during our voluntary work. I used the first days to acclimatize and to get to know the team.

On my third day I started filming. As well as the work on the construction site, we also did two little journeys; one to Asaita, the former capital of the Afar region and one to the countryside and to Afdera, a small town situated next to a big salt Lake. From the car window I could see the traditional huts of the Afar, the semi-nomadic people living in this region and got a first impression of their traditional lifestyle. Before we left the building site in May 2016, we finished a shadow roof that was important for brick production and erected the wall of the hostel building until the 12th row of bricks, which was much less than expected. It was decided to continue construction in October 2016. At this time I did not know if it would be possible to come to Ethiopia again and there was also no guarantee that the hostel would ever be finished. So I started to think about an alternative plan for my thesis and the documentary movie.

During the last three weeks of my journey I planned to travel and to get to know the country. My first stop was Addis Ababa, where I joined the SCUPAD Congress (Salzburg congress for urban planning and development) from May 12th to May 15th 2016 at EiABC. The topic was Cities beyond tools and the urbanization processes in Ethiopia was a large element. Luckily I met two lecturers of EiABC who were involved in projects using adobe bricks in Ethiopia. Behanu Gebrewold was part of the research team of SRDU-project and gave me a long interview. Fasil Giorghis was one of the founders of NESTown-project. He gave me the contact of the deputy town coordinator Bizuayehu Jembere, who I met a few days Later in Bahir Dar. He showed me around on the building site and gave me a lot of important information.

The rest of my Journey I visited the most famous tourist sites of Ethiopia; the rock-hewn churches of Lalibela, the steles of Axum and the castles of Gondar. I also did a two-day hiking trip to the mountains around Lalibela.

Shooting the documentary movie: As I did not know exactly what to expect in Ethiopia, I only had a vague idea of the contents of the movie. So, at first I just tried to shoot everything I thought might be interesting for the documentary. By doing that I took into account the general rules of making a movie. If possible, I did a wide shot as the establishing shot of the scene, and also some medium long shots and close ups. After some time the story of the movie became clearer and I worked out a cut list that I then followed. As I was filming on my own with only one camera, it was often difficult to get all the pictures I wanted. Interviews were especially challenging, because I had to talk to the people and also control the camera. The equipment I used was rather modest:

* Camera: To organise a professional movie camera for a three month period was not possible. So, I decided to work with the little camera I already owned, my Nikon 1 J2; a compact digital camera with interchangeable lenses. Using a tripod the quality was not so bad, and I was told that having a good story and arranging good shots is more important than a good camera. With the small camera, I also had a big advantage in that I could film rather inconspicuously and so was less interesting for thieves.
* Tripod: The tripod is very important for making a movie, especially if you don't have a professional camera. For this purpose I also used what I already had at home: the old, heavy and indestructible Velbon tripod of my father.
* Quick release coupling system: As the tripod I used was very old, it did not have an integrated quick release coupling system, which saves a lot of time when you are preparing for a shot. So I bought it additionally.
* Lenses: Apart from the standard 11 to 27.5mm focal length, which I used quite often, I also had a 10mm wide angle lens, which was very useful if the light situation was bad, e.g. in indoor rooms. The third lens I bought especially for this movie was the 30 to 110mm zoom lens. I did not use it very often, but on my trips to the countryside it was very useful to get good shots of the Afar villages from far away.
* IPhone 5C: My smartphone was also a very useful tool. When I did not have my camera with me or if it would have been too conspicuous to use it, I filmed with the IPhone. As my camera did not have the possibility to use an external microphone, I also used the IPhone to record the voices of the interviews with the help of a Lavalier condenser microphone for smartphones.
* Lavalier microphone: To record interviews with the IPhone I decided to use a microphone with a better quality; the Shure MVL.
* Extra batteries and memory cards: I wasn't sure if there would always be electrical power to charge the battery of the camera. I also didn't know how often I would be able to use a computer to save my files. Therefore, I bought some extra SD Cards and batteries before the trip to be prepared, and it turned out to be a good idea.

The second journey to Ethiopia: My second trip to Ethiopia in November 2016 was only for three weeks and I was much better prepared. I already had a relatively accurate idea of how the documentary movie should be structured and which pictures I still needed.
The first five days I spent in Bahir Dar and visited NESTown project again, followed by a three day trip to Gurage Zone, where I visited the sites of SRDU-project. The last 10 days I spent in the Afar region working on the building site again. This time I mainly constructed the casements of the windows and shot the process of plastering. I very much wanted to visit an Afar village and see the traditional houses from the inside, but this plan didn't work out the way I wanted, so I could only shoot pictures from far away.

Back in Austria, the editing and cutting of the documentary movie and the writing of the theoretical part went hand in hand.

The theoretical part: in January 2017 I started the research for the theoretical part of the master thesis. I decided to describe all three projects in the same structure, so they are easier to compare. First I explain the initial problem, the reason why the project even started. Then I describe the surroundings of the building site, the vernacular architecture and how people normally live in this area. After that I explain the project, the construction, the use of earth and the problems and strategies in implementation.

Editing and cutting the documentary movie: After sorting all the shots, I started to think about the final storyboard and the best way to switch between the three projects. For the beginning of the movie I decided to show a typical workday at the building project in Afar region, where the viewer soon gets to observe adobe brick production. The main part is described in a similar way to how I describe every project in the theoretical part of my work. First I explain the initial problem, then the region and how people live there, then give an overview of the project, describe the construction with a focus on adobe bricks and then problems and strategies. The main focus is on the Afarkindergarten-project, and the knowledge transfer to the local team, as I spent most of the time there and gathered a lot of material. One problem was that I didn't have a lot of video footage of the villages where the Afar people traditionally live. Luckily I could use the material my supervisor Ulrike Herbig shot on an excursion of TU Vienna in 2011. Also for the end of the movie, where I show the finished hostel, I had no material because I wasn't in Ethiopia at this time. For this part I used the video footage of Matthias Kraßnitzer and Katharina Schönher. The biggest difficulties in editing the movie were the transitions between the projects, because it was not always so easy to find pictures fit for this purpose.

fig. 7: Camara used to shoot the documentary movie

fig. 8: 10mm and 30-110mm lenses

fig. 9: Tripod with quick release coupling system

fig. 10: IPhone 5C with Lavalier microphone

fig. 11: Batteries and SD cards

2. APPROACHES TO ADOBE BRICKS IN CONSTRUCTION

This chapter is about adobe bricks, the building material used for the three projects presented in this thesis. Adobe bricks are sun dried earth bricks and are

“(...) one of the oldest materials humans used to construct dwellings”

“(...) an extremely versatile material and can be adapted to the widest possible range of socio-economic circumstances.” **Houben/ Guillard 1989: 180**

In all three projects, the technique of producing adobe bricks was not common to the people and had to be implemented. Earth construction is often regarded as symbol of poverty in developing countries, so it is not always easy to convince people about them. For this reason, it is very important to be aware of all the rules of producing adobe bricks and of constructing a brick wall before you start a building project, because errors in the handling of the material may lead to an amplification of these reservations.

fig. 12: Soil in a dry riverbed in Logia/ Afar region with a high amount of clay and suitable for construction purposes.

2.1 Earth as building material

Earth is a mixture of clay, which has the function of the binding agent and other components like silt, sand and pebbles. It is a product of the chemical and physical weathering processes of rock. Depending on the parent rock, climatic conditions and the transportation of the material during the weathering process, the composition and characteristics of earth can be very different. (Houben/ Guillard 1989; Röhlen/ Ziegert 2011)

fig. 13: Regions in the world using earth for construction

For millennia men are using earth as construction material. As moist earth is a malleable material, people developed many different construction techniques. Hand formed earth bricks have been produced since about 9000 BC in the eastern Mediterranean region, like in Turkey. The Early Neolithic site Çatalhöyük, one of the earliest towns with about 8000 inhabitants, had been constructed with adobe bricks. Especially in river valleys like the Nile valley you can find soils very suitable for construction purposes. The Egyptian dynasties used this material since about 2900 BC for different kinds of construction. They also left detailed descriptions of the production and building with adobe bricks in hieroglyphs. In 300 BC also Athens was constructed entirely of adobes. In China rammed earth walls were widespread. For this technique earth is compacted in a formwork. It was also used for the construction of the great wall about 200 BC. In more humid regions like in Europe, timber was the preferred building material, but often openings between wooden studs have been filled up with different earth building techniques. (Houben/ Guillard 1989; Rael 2009; Schroeder 2016)

fig. 14: Egypt, Thebes, Tomb of Rekhmire - 15th Century BC - Adobe making (Drawing of the entire fresco)

Earth construction methods can be classified in different ways, for instance in load bearing and non-load bearing techniques. Load bearing walls can be made of bricks or be constructed as monolithic structure, like as rammed earth or shaped earth walls. (see fig. 15, fig. 16) One technique for shaped earth walls is cob. For this kind of wall construction, earth will be mixed with fibres. Balls are formed out of the malleable mass and stacked on another and then temped with hands or feet.
In comparison to the other load bearing construction techniques with earth, adobe bricks have some decisive advantages. Cob and rammed earth walls need longer to dry and there is the high risk of material failure during this time. Using adobe bricks it is possible to sort out damaged bricks before wall construction, what makes it easier to plan the construction process. There is also no formwork necessary like you need it for rammed earth, and if the soil quality is good for producing adobe bricks, there are also no additional substances needed. For cob walls e.g. need fibres, which can be a problem in desert region. (Rieger-Jandl 2017)

For non-load bearing construction techniques, earth will be only used as covering or filling material for an existing structure (see fig. 17). It is also suitable as mortar or plastering material. (Houben/ Guillard 1989, TU Berlin 1998, Rieger-Jandl 2017)

In regions with appropriate soils, earth has been the prevailing building material for a long time and most time it has been a self-build material. To construct with earth, a high degree of manual work is necessary. With the industrial revolution, mass production in factories became common. After around 1850 the production of fired bricks increased, and also their quality was improved. Additionally new construction materials like concrete and steel came up in the end of the 19th century. Through these developments, earth got slowly displaced in industrialized countries. (Houben/ Guillard 1989)
Today there are still many living in earthen dwellings, the majority of them in the rural areas of developing countries. The main reason is that the material is available for free and it is easy to process. It also has a good influence on the room climate. In recent time, also in the industrialized countries the building material earth has a revival, because there is a desire after an environmental friendly and healthy lifestyle. Conventional building materials often produce a lot of emission through the production process and consume a large amount of resources. Earth can be extracted and processed directly or near the building site. As the binding forces of clay are reversible, the material can also be reshaped and reused, or it simply goes back to earth when the building is not needed anymore. Materials like glass or steel need a large amount of energy to be renewed or recycled. Another advantage of earth is that it can improve health and comfort by balancing the humidity of indoor spaces. Through its high sorption capacity, earth is absorbing moisture in the room, and if the air is too dry the moisture can be released back into the room. (Houben/ Guillard 1989; Röhlen/ Ziegert 2011)
The greatest weakness of earth as construction material is its sensitivity to water. Therefore it is extremely important protect the building from rain and moisture. Also maintenance is necessary, which is often a problem in modern context. In earth quake zones special care in construction needs to be taken, as earth is not as strong as other materials. The image of earth as weak construction material for poor people is still widespread. In order to improve this image, people working with this material should aware its characteristics to ensure the durability and strength of a building.

fig. 15: Rammed earth wall under construction

fig. 16: Cob wall under construction

fig. 17: Different examples of earth used as filling material

2.2 Material properties and composition

Composition: If you work with soils for construction it is extremely important to know about the raw material. Especially clay, the binding agent, plays an important role regarding its characteristics. The cohesive forces of the clay minerals are holding together the other components, which are responsible for the compressive strength. These other components in order of the grain size are:

* pebbles 20 to 200mm)
* gravel 2 to 20mm)
* sands 0.06 to 2mm)
* silt 0.002 to 0.6mm).
* clay < 0.002mm

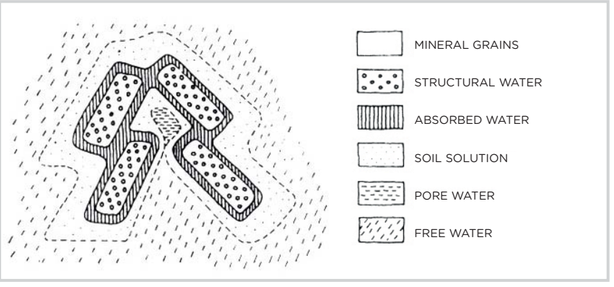
The relative proportions of clay and the other particles in the soil determine the properties of the malleable mass. (Davies 2016; Houben/ Guillard 1989; Röhlen/ Ziegert 2011)

The properties of soil are also strongly dependent on the air and moisture content of the material. There five are different categories of water in the soil (see fig. 18). Three of them can be eliminated at normal room temperatures. There is the free water moving around the particles, the pore water saved in the fine pores and the soil solution, which is a film around the solid grains. These three categories have influence on the properties of soil. Soil solution is the water that is added additionally, e.g. when the material is prepared. It is attracted by the clay minerals and makes the soil malleable. It is also responsible for swell and shrinkage. The two other categories of water can only be eliminated by high temperatures. Absorbed water is a thin film covering the grains inside and outside. Structural water is bound in the grains and can only be eliminated by temperatures above 600°C. This process is irreversible and takes place when firing bricks. (Houben/ Guillard 1989; TU Berlin 1998)

Not all earth mixtures are suitable for construction. Organic matter for instance is not good for soil in construction. A concentration above 2 to 4 percent can lower the mechanical stability. Also the amount of salt in the material should be not too high. There is a critical level of salt concentration that should not be exceeded, because soluble salts increase the moisture content and can lead to building defects and damages. If soil is free from these substances, it is important to determine its binding forces. There are mixtures with strong binding characteristics, called “rich” mixtures, and mixtures which are not very cohesive, called “lean” mixtures. (Houben/ Guillard 1989; Röhlen/ Ziegert 2011)

Generally, a high amount of clay in the soil is an indication for strong binding characteristics. Clay minerals are silicates with a flat tetrahedral or octahedral form. The extraordinary thing about these minerals is their large specific surface, which enables them to bind other substances like water to them. Depending on the kind of clay minerals in the soil, more or less water can be bound. Clay minerals can be arranged in two to three layers. The charges on the surfaces of these layers influence the binding forces of the clay minerals. There

fig. 18: Structure of clay minerals



are three main kinds of clay minerals, which have very different characteristics:

* The kaolinite group contains minerals with a two layer structure. Their particles are rather large and the specific surface small compared to other clay minerals. So, they are relatively weak as binding agent, but have a low degree of swell and shrinkage.
* The illite group contains minerals with a three layer structure. The size of the particles is smaller and the specific surface is larger. The amount of swell and shrinkage is higher.
* The montmorillonite group has similar properties as the illite group, but the swell and shrinkage are much higher. Soils containing a lot of these clay minerals are highly expansive and can only be used for construction by the addition of additives, e.g. sand. (Houben/ Guillard 1989; Röhlen/ Ziegert 2011)

Soil tests:[1] If you want to construct with earth, you should be aware of a few basic properties of the material, so you can decide if it is suitable for construction purposes and which technique would be the best. These properties can be determined through field and laboratory tests.

The first thing to do is the visual examination of the soil to get a first impression of sandy and fine proportions. You can also determine the colour, which can range from white to black or can also be beige, brown, yellow or red, but gives no indication of the properties of the earth. Immediately after the extraction of the soil, also a smell test should be done. If it has a musty smell it is an indication for organic matter, and the soil may not be suitable for construction purposes. The soil should be odourless. For the nibble test, the tester should choose a clean space to extract the soil and takes some of it into his mouth. If it grinds between the teeth it is sandy. Soil with a high amount of clay will be rather smooth or floury. For the touch test soil will be rubbed between the fingers and palm of the hands. If a rough sensation is felt when the material is moist and there is no cohesion it is rather sandy. If it lumps in dry condition and resists crushing it is rather rich. In moist condition it becomes plastic and sticky. For the washing test you try to wash the moist soil off your hands. They more difficult you get the soil off your hands, the more clay is inside. (Houben/ Guillard 1989)

The distribution of the grain size can be determined in different ways. To get a first impression, the sedimentation test can be done. A glass bottle will be filled with one part of the soil sample and three parts of water and mixed very well. After about eight hours, the fractions of the different particles can be measured, with the biggest particles on the ground (see fig. 19, fig. 20). A very precise determination is possible with a combination of a sieve and sedimentation analysis in the laboratory. Particles smaller than 0.002mm will be classified as clay fraction, all above as silt, sand, gravel and stone fractions. If there is a high amount of clay minerals one can make assumptions, e.g. of the

1: see movietext scene 27

fig. 19: Result of the sedimentation test carried out on the site of Afarkindergarten-project

fig. 20: Distribution of particles

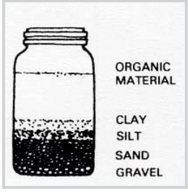


fig. 21: Binding force test on field

cohesiveness of the soil. But because of several reasons, these assumptions are not always right. In the classification, only particles smaller than 0,002mm are listed as clay minerals, but some clay minerals like kaolinite also have bigger particles. Another reason is that there are also other particles like quartz, feldspars or metal oxides that also have a grain size less than 0.002mm. The third reason is that the binding strength is also depending on the kind of clay minerals as they have different properties. For construction purposes, especially the binding forces are relevant. An easy field test to determine the cohesiveness is the **ball test**. A ball with a diameter of about 4cm is formed out of naturally moist soil. The ability to form the material gives a first indication of plasticity and cohesiveness. Then you let the ball fall on a flat, hard surface from a height of about two metres. If the sample only squashes flat it has very good binding forces, if it disintegrates it is very lean, if it has some cracks or breaks apart a bit it is a lean to semi rich soil. There is also a **binding force test** called figure-8-shape test, which can be done in the laboratory or on field (see fig. 21). The soil for this test needs to be prepared in a longer process.[2] Finally at least three moist samples will be shaped into a mould in figure-8-shape. In a naturally moist state, they will be suspended in a measuring apparatus and a load will be attached to it. Depending on the mass that was attached at breakage, the material can be classified on a table. (Houben/ Guillard 1989; Röhlen/ Ziegert 2011)

2: see Houben/ Guillard 1989: 62-63

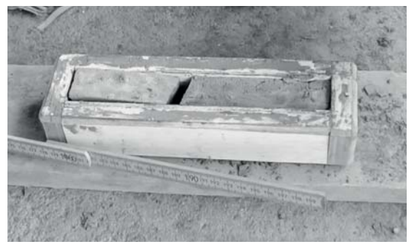


fig. 22: Linear shrinkage test carried out on the site of Afarkindergarten-project

Classification of earth mixtures according to binding force (g/cm²)

very lean	50	-	80
lean	>80	-	110
semi rich	>110	-	200
rich	>200	-	280
very rich	>280	-	360
clay	>360		

If the sample breaks under a mass of 50 g/cm² it is unsuitable for construction purposes. (Dachverband Lehm 2002)
To measure the **shrinkage** of the soil the moist mixture will be filled into a mortar prism with a length of 160mm and a height and width of 40mm (see fig. 22). When the sample is dried out you see the amount of shrinkage. If it is very high there may be some additives required to make it less rich. For plaster and mortars for instance a low shrinkage less than 2% would be good. (Röhlen/ Ziegert 2011)
Generally it is important to take samples from different places of one site, because the soil can have different qualities within a small area. Also the first layer of impure earth and humus, which can have different dimensions, has to be removed before you take the samples.

Some properties of the construction material earth compared to other building materials:

* Primary energy content: Depending on the on the use of machinery and the way of transportation, earthen construction materials have a primary energy content of 0-30 kWh/m³, concrete or reinforced concrete 450-1500 kWh/m³, burned bricks 1350-1750 kWh/m³
* Bulk density: Light earth (earth with a high amount of additives like straw) 300kg/m³, Earth blocks: >700 kg/m³, Earth mortar: 1400-1800kg/m³. Rammed earth 1800kg/m² to 2400kg/m³, concrete ~ 2400kg/m³
* Thermal conductivity: The thermal conductivity is strongly related to the bulk density: conventional insulation materials: 0.03 to 0.06 W/mK, light earth: lowest value 0.1 W/mK, massive earth building materials about 0.95 W/mK, heavy rammed earth: 1.4 W/mK, concrete 2.3 W/mK
* Heat transfer coefficient: The heat transfer coefficient describes the amount of heat transferred between the air and the component surface. For most construction materials this value is very similar. For concrete, wood, lime plaster and burned bricks the value is 4.6 W/(m²*h*K), for earth it is a lower value of 1.85 W/(m²*h*K). This is why earth plaster is very suitable as indoor plasters, because low temperatures in a room are considered less disturbing.
* Drying shrinkage: Usually earthen materials have a high shrinkage. Rammed earth: 0.5%. Plaster and mortar: up to 2.5%. The drying shrinkage is strongly dependent on the proportion of highly sorptive three layer clay minerals in the mixture. Very rich earth can have a drying shrinkage of 4-10%. Concrete only has a drying shrinkage of 0.04 to 0.09%.
* Compressive strength: light earth: 0.6 N/mm², earth blocks 2-4 N/mm² to max 12 N/mm². Concrete: 30-45 N/mm².
* Dynamic moisture sorption: "(...) is a measure that describes the water vapour absorption capacity of layers of a building element." (Röhlen/ Ziegert 2011: 36) If there is a higher amount of tree layer clay minerals inside the mixture, earth materials have a very high moisture sorption compared to other materials. Earth blocks: up to 130 g/m², concrete: 30 g/m². (Röhlen/ Ziegert 2011; TU Berlin 1998)

2.3 Material preparation

Processing: To process the raw soil so it can be used as a building material can be a very labour intensive procedure. As alternative it is also possible to buy factory-premixed mixtures, as you need experience to create the perfect mixture for the respective purpose. The first step after the excavation of the material is the mechanical processing. It can be done by machines or with methods of natural processing. One of these methods is to let the material soak. By resting in wet condition, the clay minerals begin to disperse in the water. Another method is weathering, where the soil is exposed to different levels of ambient moisture. It can be done in summer or winter time, where the soil is additionally exposed to freezing and thawing. Methods of mechanical processing are sieving, grinding, crushing or mixing. (Röhlen/ Ziegert 2011)

Stabilization: In previous time it was common to use only earthen building methods that are possible with the locally available soil. Today it is preferred to improve the characteristics of the available soil if it is not suitable for the chosen technique. Through stabilization of the soil it is possible to achieve better mechanical characteristics like compressive strength, a better cohesion, a reduction of shrinkage and swell, waterproofing, and reduction of surface abrasion, e.g. by the wind. Stabilization is necessary for instance if the building is very exposed to the weather, but it is important to be aware that a poorly designed architecture in terms of the rules of building with earth cannot be easily compensated with a good stabilization. (Houben/ Guillard 1989)
One way of stabilization is the mechanical compaction of the soil to increase the compressive strength. Another

way is to add aggregates or additives to modify the mechanical and physical properties so you can use it as building material. (Houben/ Guillard 1989; Röhlen/ Ziegert 2011)

Aggregates: Aggregates have no effect on hardening character of the soil; they will only be bound or enveloped by the soil.
Mineral aggregates can be crushed stones, gravel, grit or sand. The main reason to add these aggregates is to lean down a mixture. Mainly fine particles are used to avoid shrinkage cracking. The strength of the mixture will be improved by adding stony and sandy particles. Like it is usual for mortars or concrete, all stone fractions should be present in equal proportions. Not too many stone and sand aggregates should be added, because the strength of the material suffers if binding agent is too small.
Organic aggregates: Plant fibres like straw are also added to lean down the mixture. Additionally fibres strengthen tensile forces and reduce shrinkage cracks. They act as reinforcement In case of earth plasters and the addition of plant fibres improves the pliability of mortars. Fine fibres in earthen materials also reduce the sensitivity to water. The sorption capacity is better if you add fibres, because you can use soil with a higher content of clay in the mixture. By adding a lot of fibres it also helps to improve the acoustic "(...) as soft and open pore surfaces reflect less noise than hard, closed surfaces."[3] Through the high volume of the fibres, straw is also improving insulation properties. The stabilization effects of fibres can be improved letting straw rot inside the moist soil for a period of several weeks. Lactic acid will be produced through this fermentation process. (Röhlen/ Ziegert 2011)

Additives: Additives added in small quantities influence the hardening characteristics of the earth mixture. Powdered clay can be added if the mixture is too lean. By enriching the binding agent in the soil, the strength will be improved.
Mineral binders like lime or cement are added to improve the strength and water resistance. The hardening process is performed by a chemical transformation of the soil. This process is irreversible, that means the ability of reusing the material by crushing and soaking it will be lost. Lime should be only used for rather rich soils and cement for lean soils with a high content of sand.
Organic binders: Organic binders like dung are a historically common additive. The fibres eaten by animals form a paste through the heat and chemical processes in the digestive system. The addition of dung can improve strength and decrease moisture sensitivity. (Houben/ Guillard 1989; Röhlen/ Ziegert 2011)
Mixing: The mixing of all components can take place with or without water, depending on the cosen technique. It can be done by hand, with tools like agricultural hand tools or by simple mixing machines. Most times the mixture also has to soak or rest for some time to achieve better binding characteristics through the clay minerals. (Röhlen/ Ziegert 2011)

3: Röhlen/ Ziegert 2011: 28

2.4 Adobe bricks

"Adobe" is a Spanish word, derived from Arabic "ottob", which is related to "thobe", the Egyptian term for sun-dried brick. Usually a thick malleable is mud is used to form a brick by hand, in moulds or by machines. There are also other methods of production, like rammed- or compressed earth bricks or extruded earth blocks. The hand shaped bricks can have numerous shapes, like pyramidal bricks, the oldest form of sun dried brick that has been used in Jericho since 8000 BC and is still used in West Africa. Parallelepiped bricks, which can have many different sizes, are the most common form of adobe bricks. (Houben/ Guillard 1989)

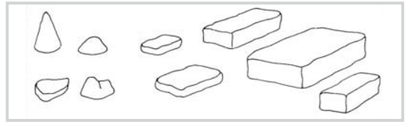


fig. 23: Different shapes of adobe bricks, made only by hand or with a mould

The use of sun dried bricks has a lot of advantages. The production of the bricks is independent from the construction of the building. It is also easy to learn how to produce them, so it is possible to engage unskilled workers. As the bricks are already dry before they are built in, their quality can be controlled beforehand. There are numerous possibilities to use them, e.g. to construct a load-bearing wall, for the construction of vaulted ceilings or domes or only as filling material for a wooden framework. They are also extremely easy to recycle or to re-use and contribute to a good indoor climate.
But it is important to be aware of the disadvantages. Adobe bricks are less strong than burned bricks or cement bricks, so the construction needs to be considered very well. Due to the vulnerability to water, it is very important to protect the bricks, also during production. A lot of space for drying and to storage the bricks is also necessary. Though the production is quite easy, it needs a lot of experience to find the right mixture by testing and experimenting with the soil. Also the mixing itself is a very labour intensive process. Additionally, the masonry of the wall can be complicated and must be executed accurately.
As already mentioned, there are many different methods of adobe brick production, and the kind of production is also influencing the structure and the properties of the bricks. Also a big scale production with machines is possible. (Houben/ Guillard 1989) But as for all three projects examined in this work the bricks have been produced by hand with a mould, I will focus on the description of this technique.

Production: For the production of bricks with a mould, either liquid or plastic soil can be used and the texture should be rather rich and cohesive. Too large stones or pebbles in the earth might cause a brick to crack, so the mixture should be free of them. Often fibres like straw are added to the mixture to improve tensile strength and reduce shrinkage. The mould can be made of timber or metal, but for small scale production wood is more common. It can have a compartment for only one brick or for more bricks and should have handles, so it is easier to lift it. (Houben/ Guillard 1989, Romero/Larkin 1994)
There are three different techniques to produce hand-moulded bricks:

* For the sand-moulded technique, the bricks will be produced on a table and the mould has a bottom, which will be dipped into water and sprinkled with sand. The mould will be only filled once with rather plastic soil and the excess will be removed. Then it will be turned around and shaken until the brick comes out.
* The slop-moulded bricks are produced on the ground. To facilitate the removal, the mould will also be soaked in water first and then it is filled several times with soft soil. By doing that the mud will be compressed to drive the air out. To remove the brick, a short vertical jerk can be necessary.
* Poured-earth bricks: For this technique rather liquid mud containing sandy aggregates will be poured into a mould. It has the disadvantage of a high shrinkage during the drying process that can cause cracks. It also needs a lot of know-how to find the right consistency. If the mixture is not liquid enough it will stick on the form during removal, if it is too liquid the brick can collapse after removal. (Houben/ Guillard 1989)

Independent of the chosen technique, the preparing of the mixture is very labour intensive. It is often done

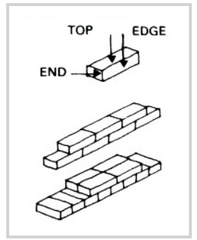


fig. 24: Surfaces of a brick, wall made of stretchers and wall made of headers and stretchers

with the feet or hands or with simple tools, but you can also use animals like donkey, horses or oxen or machines like vertical mixers for this purpose. Finally, a homogenous inner texture of the brick is important, so the material needs to be mixed and also soaked well. Also an extensive production area is necessary. Fresh bricks are still fresh and malleable after construction, so they also have to be protected from being touched, e.g. by animals until they are dry. They also should be protected from direct sun when they are still moist. (Houben/ Guillard 1989; TU Berlin 1998)

Depending on the weather, after about two weeks the bricks are dry enough to be used for construction. They should be largely free from cracks and the edges should be intact. Before they are built in, a few tests can be performed with them. To test the moisture behaviour, the dip test can be carried out (see fig. 25). An earth block will be dipped into water for about ten minutes. The material that is left in this water can be measured and compared to other brick samples. It would be good if it would be not too much material. The suction test is determining how much water a brick takes up through capillary action in a certain time. It is simulation e.g. the situation of water entering bricks through cracks in the wall or in the plaster. The result is good if the brick does not soften or crack open too quickly. One test which is especially important if you want to construct a load bearing wall with adobe bricks is the compressive strength test. It will be carried out in a press and the force must act perpendicular to the bearing surface. The compressive stress when the brick is breaking will be measured. At least three samples should be tested and the mean value should have at least 2.0 N/mm². (Dachverband Lehm 2002; Röhlen/ Ziegert 2011)

fig. 25: Dip test carried out on the site of Afarkin-dergarten-project

fig. 26: Mixing wet soil

fig. 27: Mixing with the feet

The bond: The bond is the designation for the way the bricks are laid in the wall. A brick has six surfaces, a top and a bottom, two edges, and two ends and the bond is named after the surface that is visible on the wall (see fig. 24). Stretcher and header bond are most common. Stretcher bond means that the edges appear on the surface of the wall and header bond that the end appears at the surface of the wall. The bond of a wall made with adobes hast the same requirements as for a stone or a burned brick wall. It needs to be worked out carefully, especially the position of the joints. Most important is that, if possible, all the joints are overlapped. The distance between two cross joints should be not less than a quarter of a stretcher. Three-quarter and half-bricks are also used, especially for the corners, but they should only be used if really necessary. A good structural bondage is essential for the stability of the wall. Especially the construction of the corners is important, as it has a great significance for the stability of the whole structure. If the bon is poor bond, structural faults like vertical cracking are likely. The thicker the wall, the more difficult it is to execute with adobe bricks. If the wall is e.g. thicker than 60cm, a lot of material will be needed and it would take a long time to lay all the bricks, so it becomes less economical. In this case, a different construction like a cob wall or a rammed earth wall may be better. (Houben/ Guillard 1989)

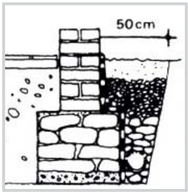
The mortar: The mortar is connecting the bricks in order to create a stable wall. Mortar made of soil can be also used for stone walls or burned bricks. Also fine fibres can be added as a kind of reinforcement. Its quality is extremely important for the strength of the wall. The mixture of the mortar should be sandier than the one of the bricks and not too liquid, to reduce the risk of shrinkage cracks. The maximum grain size should be 5mm and the mixture should be tested first to make sure mortar and bricks have the same compressive strength and erosion resistance, which is important. The horizontal- and cross joints should have a thickness of 1 to 1.5cm; 2cm are the maximum for adobe bricks. All joints of the bricks need to be filled with mortar. If the vertical joints are not filled well, the compressive strength of the wall can be decreased by 20 to 50 percent. (Dachverband Lehm 2002; Houben/ Guillard 1989)

Construction principles: As the strength of an earthen wall is dependent on the moisture content, the most important thing is to prevent moisture penetration. The most fragile points are the top and the bottom of the wall.

* Foundation: The foundation should be made of a solid material like stone, burned bricks or concrete to protect the wall from splash water. The height depends on the overhang of the roof and the amount of rainfall. A peripheral drainage generally helps to keep the water away from the building. There should be also a horizontal damp-proof layer to prevent capillary rise at the base. This can be made e.g. of bitumen or of a layer of burned bricks on the plinth.
* Termites: A moisture-free wall at the base is also an important protection against termites. Though they prefer timber, they also can go into masonry, especially when the material is damp and the temperatures are hot. Generally, the structural timber should be isolated from the soil. White colour at the base course helps to detect termites, because boreholes become visible.
* Wall: Surface cracks in the bricks or in the plaster should always be repaired because these damages enter a path for water to enter through the surface of the wall. The wall should also be allowed to breath, so it is not recommended to make the surface of the wall impermeable. As the water vapour is moving inside the wall it would condensate on the cold surface of the wall if it would be prevented from exit.
* Floor: At least 5 cm of the wall material above a finished floor, there also should be water-insoluble course in case of water spillages.
* Roof: It is very important to protect the top of the wall, because it is particularly vulnerable to water. (Houben/ Guillard 1989; Röhlen/ Ziegert 2011)

During the whole construction process, it is important to ensure a continuous weather protection. Higher cost should be calculated for this purpose beforehand. R. Niemeyer has developed 10 rules of weather protection, of which I want to mention some. It is important that there is always enough covering material on the site, and the sensitive parts should be covered every evening, even when the weather is fine. It should be taken care that the water running off the cover does no harm and it the cover is protected against storm. Until the weather side of the façade is covered with plaster, it should also be protected. And there should be one person that always controls the weather protection regularly, also at nights and on weekends. (TU Berlin 1998)

fig. 28: Foundation with a periphal drainage and a horizontal damp proof layer



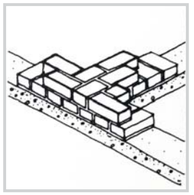


fig. 29: Bonding between walls

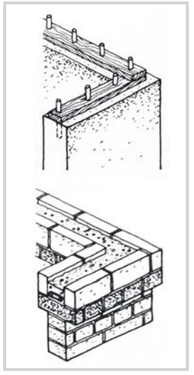


fig. 30: Ringbeam made of wood and reinforced concrete

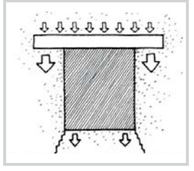


fig. 31: Problems if there is no sill

Apart from the protection against water, there are other important construction principles for load bearing adobe walls. Generally it is recommended that only people who are professional experienced persons in load bearing earth constructions should be supervising and instructing the erection of such building structure. The mechanical behaviour of earth materials needs to be taken into consideration. They function well under compression but have low tensile, bending and shear strength. Off-centre loads, bending and point loads should be avoided.

* Stiffening walls: All stiffening walls should be erected at the same time by an open, interlocking brick bond (see fig. 29). There should be also taken care that there are enough stiffening walls in the building to transfer all loads.
* Strengthen walls: Especially in earthquake-prone areas, it is recommended to reinforce adobe walls additionally. Vertical ties are used most frequently. Their position should be in the weakest points, like the corners.
* A ring- beam is also essential. It ensures an even load distribution and prevents different rates of settlement, rotation, shear stress or strains due to floors. It can be made of wood, steel and concrete and needs to be anchored with the brick wall to be effective (see fig. 30).
* Openings: In an adobe brick walls, there should be not too many and not too big openings and they should be not too close together. The distance of the first opening to the corner of the wall should be at least 75cm and the total length of all openings should be not more than 35% of the length of the wall. The lintels can be made of concrete, wood, stone or brick. Their support in the wall must be at least 25cm. Arches can be also used for bridging openings. Care must be taken with the reveals of the openings. If they are made of a different material there may be different settlements in the wall. Care must be also taken with the sills. The loads admitted by the jambs of the window frame must be taken up. Either the sill can be lengthened or the reinforcement is added under the sill. (see fig. 31) (Houben/ Guillard 1989; Röhlen/ Ziegert 2011)

2.5 Plaster

Earth wall finishes: As earthen materials are very vulnerable to water, it is very important to protect an earthen building structure from severe weather conditions. At first a good design that prevents most of the water from even coming to the sensitive parts is essential. Additionally there are different kinds of earth wall finishes, which can also improve the appearance of the wall and the thermal comfort. "A good protective coating should adhere well to the support without provoking the loss of wall material, be flexible in order to allow for the deformation of the support without cracking, be impermeable to rain, be permeable to water vapour in the wall itself, be frostproof and, finally, have a colour and texture compatible with the local environment." (Houben/ Guillard 1989: 333)

The coating can be a rendering but can also a covering attached to the wall and fixed on the substructure. This covering can be made of materials like wood or corrugated iron. Also facings are possible. The inner part of the wall can be made of adobe bricks and the outer part of burned bricks or stone (see fig. 32). But with this method there is the danger of an unequal subsidence of the adobe part and the facing, because the strength of the wall may not be uniform. (Houben/ Guillard 1989)

Renderings: If it is decided to use a rendering as coating, it is very important that it is compatible to the soil. Different materials can be used:

* Non-hydraulic lime: A rendering with lime is an old method of covering soil structures used in many countries. An extremely fine powder of hydrated slaked limes brings the best result. It will be mixed with sand. Traditionally it was often improved by additives like fresh bulls blood to enhance waterproofing.
* Cement: Cement has the disadvantage of a bad adhesion to earth walls, with the result of cracking or blow-ups. A layer of wire netting between the soil and the plaster reduces the cracking, but does not improve the adhesion.
* Plaster: Plaster made of soil is only recommended for inside walls, because it is easily affected to erosion. The advantage of this circumstance is that it is also easy to repair if it's moistened and it also has a very good adhesion. The plaster can be applied in a single or several layers. Generally, multi-layer renderings have a better performance. If it is necessary to use earth plaster for outside, at least the last layer should be either stabilized or impregnated. A good stabilizing additive can be animal dung, urine or blood, fibres (20 to 30kg to 1m³ soil) or plant juices like of the agave cactus. Also lime can be added to rich soils or cement to lean soils. Impregnation substances can be casein or oils that harden upon contact with the air and dry quickly, like linseed oil or. Chemical substances like silicon are also used for impregnation. (Houben/ Guillard 1989)

Preparation and application: The soil chosen for plaster should be not suffering from swell and shrinkage, like clays of the kaolinite type. It should contain no particles smaller than two millimetres and should be rather lean. Most times 1 part of clay and 2 to 3 parts of sand are usual proportions for a plaster mixture. The soil has to be mixed very well with the additives and water and also needs to soak.
Before application, the surface of the wall needs to be prepared. It is important to wait with the rendering until the wall is completely dry and the shrinkage has stabilized, in case of adobe walls at least for two to three month. Also the settlement of the wall needs to have already taken place. All loads like floorboards, roof etc. need to be completed. The wall should be clean and free of dust and crumbling material should be removed. The joints of the brickwork should be roughened with a jointer first to enable a better anchoring of the plaster. If the surface of the wall is too smooth, a wire netting or reed mats can be fixed as plaster base. For the inside walls only one or two layers of plaster are necessary, outside two to three layers of plaster are needed. The first layer should have a higher content of clay to have better connection to the underground through better adhesive forces. The underground needs to be moistened a little bit, so that it does not absorb the water contained in the rendering. The earthen rendering can be applied by hand or by conventional masonry tools like trowels. It will be thrown energetically against the wall. With the palm of the hand or a tool like a float the surface will be smoothened then, but excessive compression should be avoided. The first coat of plaster should be rather rough and can be e.g. scored with a rake or another tool in moist condition to enable a better adhesion of the next layer of plaster. Also plastering machines like pneumatic blowing machines or rendering pumps can be used. One wall should be finished on one day, but plaster surfaces can be also separated by a thin vertical cut with the trowel. (Houben/ Guillard 1989, Dachverband Lehm 2002; Romero/Larkin 1994)

"Finally a coating which is not suited to the earth, or which is ineffective because it has been poorly executed, can be more harmful than if it had not applied at all."[4]

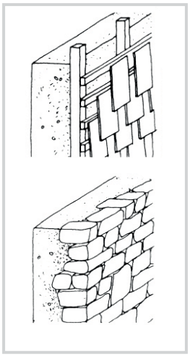


fig. 32: Coatings executed as covering or facing

4: Houben/ Guillard 1989: 333

3. BACKGROUND INFORMATION

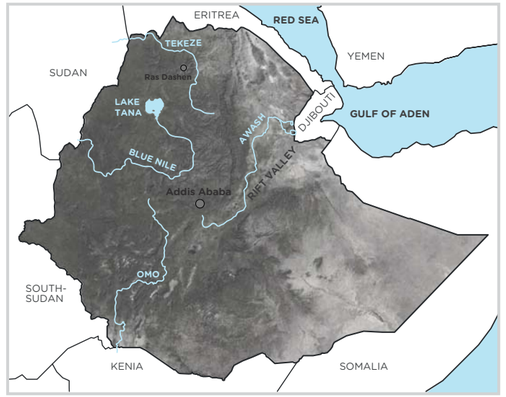
Ethiopia is known as one of the poorest and least developed countries in the world. Many people don't know that Ethiopia is also one of the oldest countries of the African continent. The cultural development goes back very far in time and has left many fascinating historical sites.

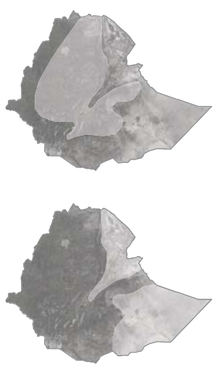
Today the country is changing a lot, the population is growing very fast and many inhabitants want to change their traditional lifestyle to the modern standard they see on television.

For this reason natural resources are exploited to build houses, produce food etc. The question is how long this process can go on without leaving any lasting damage.

fig. 33: The imperial compound of Gondar with the modern town in the background

3.1 Location and climate





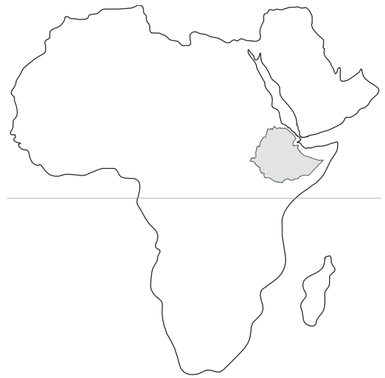


fig. 34: Map of Ethiopia with neighbouring countries

fig. 35: Map highlands

fig. 36: Map lowlands

fig. 37: Map Africa and Ethiopia

Location: Ethiopia is located in the east of the African continent and is part of the horn of Africa. It has a total area of 1 104 300 km², which is about 13 times the area of Austria. It borders to the Eritrea in the north, Djibouti and Somalia in the east, Kenia in the south and South Sudan and Sudan in the west. The capital is Addis Ababa. (Der neue Fischer Weltalmanach 2017)

Landscape: The landscape is a complex relief of extremely different altitudes and vegetation. It is dominated by highlands and lowlands. Ethiopia is the highest situated country of Africa with about 50% of the total area with an altitude above 1200m. The highest mountain is Ras Dashen (4533m). But also one of the lowest areas of the world, the Danakil Plain, is located in the north-eastern part of Ethiopia and drops as low as 144m below sea level. This versatile landscape has been created by the tectonic activities of the Rift Valley, which is part of the East African Rift system (see fig. 34). (britannica.com; Hooge 2015)

The biggest lake of Ethiopia is Lake Tana in the northern Highlands, which is also main reservoir of the Blue Nile. Other important Rivers are the Omo, which springs in the southern Highlands and flows in southwestern direction, the Awash River which also springs in the southern Highlands and flows in eastern direction and the Tekeze, which flows in the northern region. (Hooge 2015)

Climate: Not only the landscape, also the climate is very different and mainly dependent on the altitude. It varies from average temperatures in the highlands of about 10°C to average temperatures in the lowlands of about 20°C. Generally there are three seasons, a long dry season from September to February, a short rainy season in March and April and a long rainy season from June to August. Depending on the regions these seasons are varying. The southwestern part of the country has the highest amount of rainfall with about 2000mm a year. The eastern lowlands have the lowest amount of annual rainfall with about 500 to 1000mm, in the Danakil Plain it can be less than 500mm or no rain at all. (britannica.com)

Vegetation: The central and the northern part of the country are determined by mesas. The high altitude is good to cultivate crops (see fig. 38) like hop or "teff", the most popular cereal of Ethiopia which is used to produce "injera", the bread which is eaten at almost every meal. Coffee, which is indigenous in Ethiopia, is cultivated in large amounts and is an important good for export. "Khad", a plant with toxic leaves that people consume to get high and stay awake, becomes more and more popular and is also exported. In the south and south-west of the country a subtropical climate with a lot of rainfall is dominating. In these areas plants like "ensete", also called false banana tree, sorghum and corn are cultivated. In the arid areas in the east of the country only profuse vegetation along rivers is possible, this is why many people there still live as pastoralists. But there are also big plantations of sugarcane or cotton in these fertile areas.

Today Ethiopia has a huge problem with deforestation and soil erosion. In 1900, 40 % of the land was covered with woods. Due to the increase of the population there are only about 4% left today. The indigenous acacia tree is more and more repressed by eucalyptus, which had been imported because it is fast growing. But it is consuming a lot of water and exhausts the soil. (Hooge 2015; Liendl/ Leithner 2013)

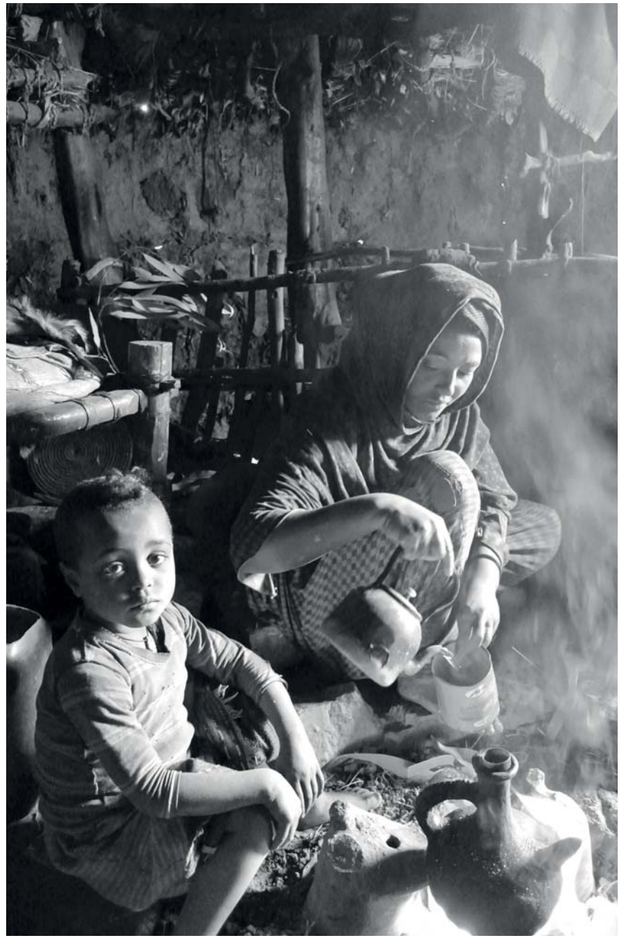
3.2 Social structure

Many Ethiopians still live a very simple life, e.g. as farmers in the highlands, often without electrical power or sanitary facilities. But these structures are changing, because more and more people are moving to urban areas.

Ethnic groups: Ethiopia has more than 80 different ethnic groups and most of them have their own language. The biggest groups are the Oromo (35%) and the Amhara (27%). Other big groups are Somali (6%), Tigray (6%), Sidama (4%) and Gurage (3%). The spoken languages belong to the Omotic, Cushitic and Semitic family, also Italian and Arabic is spoken in some regions. Amharic is the official language. (Der neue Fischer Weltalmanach 2017)

Religion: The majority of the population are Ethiopian Orthodox Christs (44%). The religion was already

fig. 38: Crops in the highlands around Lalibela



introduced in the 4th century, when King Ezana converted to Christianity. 34% are Sunnite Moslems, 29% Protestants and 3% indigenous religions. The Islam was intruded in the 7th century by tradesmen and migrants and is still promoted, e.g. by people coming from Saudi Arabia, who sometimes build mosques and provide food for the people. But generally the two big religions in Ethiopia don't seem to cause conflicts, the people live together quite peaceful. (Der neue Fischer Weltalmanach 2017; Liendl/ Leithner 2013)

Population growth: One of the biggest problems of Ethiopia is the population growth. In 1971, when Eritrea still belonged to Ethiopia, the country had about 32 million inhabitants. Today there are about 102 million inhabitants. That means the population has grown by about 70 million in 66 years. The country is often affected by draughts, so there is not enough food available sometimes. Also the access to clean water is often difficult or connected long walking distances. So, many people are still dependent on the help of NGO's. (Der neue Fischer Weltalmanach 2017; vimeo.com; Liendl/ Leithner 2013)

3.3 Political structure

From 1974 to 1991 Ethiopia was under the rule of a socialist regime until the EPRDF (Ethiopian People's Revolutionary Democratic Front) entered the parliament. After the party was officially elected in 1995 the new constitution became official and Ethiopia became a Federal Democratic Republic. The Government divided the country into Ethnic Zones. Now Ethiopia has nine different regions, which have their own councils and a federal executive authority. Addis Ababa and Dire Dawa have a special status. There are still often conflicts between the ethnic groups about land use and legal matters. (Der neue Fischer Weltalmanach 2017; Liendl/ Leithner 2013)

Administrative Divisions: The nine regional states, locally called "kililoch" are additionally divided into zones, "woredas" or districts, and "kebeles". Kebeles are the smallest unit, the administration in neighbourhood level. Woredas are administrative units with regional governmental duties. They are responsible for planning, coordinating and budgeting of the area. (Eigner 2014; hrw.org)

Current political situation: At the last general election in May 2015 the EPRDF had been elected again and occupies 500 of totally 546 seats in the parliament. In November 2016 a wave of protest started in Oromo Region. The initial impact has been the plan of the government to transfer agricultural land of Oromo region to the fast growing capital Addis Ababa. Soon the protest spread to Amhara Region. The two regions with the most inhabitants of the country felt underrepresented in the government and wanted to have more political freedom and voice. First the protests were peaceful, but after sharp intervention of the state forces they became more and more violent. Hundreds of people died and thousands have been imprisoned. It came to street battles, sacking and physical attacks against foreigners. In October 2016 the government declared a six month state of emergency in the country, which had been extended and finally ended in August 2017. It became easier to arrest people and to control the media. Also the internet was blocked in many regions. To stabilize the political situation the government had been reshuffled. 21 of 30 ministers have been changed out with the aim of a higher representation of the Oromo and Amhara Regions in the government. (Der neue Fischer Weltalmanach 2017)

fig. 39: Family in the highlands araound Lalibela (left page)

fig. 40: Regional states in Ethiopia

3.4 Hisorical and architectural overview

Early history: In Ethiopia, very old evidences of early humans had been found. These findings contribute to the documentation of the development from early humans to the species Homo. The oldest finding was of the species Ardipithecus kadabba and lived about 5.6 million years ago. A sensational finding of 2.8 million years old bones was made in 2013, which could be the oldest evidence of the species Homo. (Hooge 2015)

The pre-Axumite time: There is not much evidence of the history of Ethiopia before the Axumite Empire arises in the first century BC. It is presumed that the northern part of today's Ethiopia had been in contact with the Egyptian empire since about 2000 BC. There is the theory that the legendary empire of punt was located in the Horn of Africa.

The founding of the Sabaean Empire between the 12th and 10th century BC on the Arabic Peninsula was very important for the future history of Ethiopia. Around the 9th century BC the Sabaeans emigrated to the Horn of Africa over the Red Sea and brought their culture, language and religion to Ethiopia.

A remain of this time is the Temple of Yeha, which had been constructed in about 700 BC. It was a two storey building erected on a stepped platform with a floor space of 18 x 15m. It had two side aisles covered by a roof and an open central aisle. It is proposed that the temple had been destroyed by a fire. Today only the outer walls, which are up to 14m high and made of limestone blocks have been preserved. (Deix 2013; Hooge 2015)

The Aksumite Empire: Between the 8th and 2nd century BC the Sabaean immigrants mixed up with the local African population and a new culture developed – the Aksumites. In 183 BC an Arabic inscription first mentioned the Aksumites, which they called Abyssinians. The kingdom extended over a large area from the northern part of Ethiopia to today's Sudan and traded with India, Arabia, Persia and Rome.
Influenced by two Syrian Christians Frumentus and Aedissius, the Axum King Ezana (325-355 AD) established Christianity as official religion around 340 AD. The Ge'ez language derived from the Sabaean language and is still used as church language today and base of the Amharic and Tigrinya language.
The downfall of the Kingdom was connected to the spread of Islam since 700 AD over the Red Sea and Egypt. The existence of the Aksumite Empire was strongly connected and dependent on trade over the Red Sea. As all areas around became Muslim there were no trade connections anymore and it was also the beginning of a long time of isolation of Ethiopia. (Deix 2013; Giorghis 2016; Hooge 2015)

The Aksumites had a characteristic architecture. The remains are still visible in the ruins of palaces like the Dungur-palace near the city of Aksum, (around 400 to 600 AD) which is the best preserved Aksumite palace today. The most characteristic feature of the Aksumite architecture are the so-called "monkey heads" (see fig. 41). The main walls had been made of stone and hold together by mud mortar. Within some interval (approx. about 50cm) the stone layer was interrupted by a layer of timber elements running along in the direction of the wall. It was reinforced with cross-beams perpendicular to the wall. The ends of these round cross beams usually protruded the exterior of the wall and have been called "monkey-heads". Also the wooden frames of doors and windows have these protruding elements, but in a rectangular form. Another feature of the architecture are the terraced platforms on which the palaces have been erected. (Deix 2013; Hooge 2015; Tadesse/ Sultan 2011)

The city of Aksum is famous for its ancient steles, which have been erected between the 1st and the 4th century AD.They have been up to 33.3m high and it is assumed that they have been used as grave markers. The typical characteristics of the traditional walls of Aksumite multistorey-houses are sometimes visible on the surface of the stone steles (see fig. 42). (Deix 2013)

The Zagwe dynasty: Around the 10th century, the dynasty of Zagwe came to power. Their centre of power was the small village of Roha in Amhara Region. The exact number of kings during this period is not known, but the most famous one was Gebra Maskal Lalibela (1190-1225). During his reign most of the rock-hewn churches in Roha have been constructed, and the place was renamed to Lalibela. The Architectural style of the rock-hewn churches spread over large parts of the Northern Highlands. The last Zagwe King Neakuto Laab (1212-1270) had been overturned by members of the Salomonic family.[5]

The rock-hewn churches of Lalibela became a very popular pilgrim site. These churches have been directly cut into hillsides of the soft volcanic tuff. There are three different types of rock churches. Cave churches are built into an existing cave, Tomb churches are structures that are not completely separated from the rock and monolithic churches are completely separated from the rock (see fig. 43). (Deix 2013; Hooge 2015)

The empire of Abyssinia: The time after the Zagwe dynasty, Ethiopia had been ruled by the descendants of the Salomonic family. The country was divided into smaller principalities and there was no permanent capital. One exception was the city of Gondar, where Emperor Fasilidas started to build his palace in 1636. The time of Gondar as capital ended in 1769 and Ethiopia was ruled through regional principalities again.

In 1889 Emperor Menelik II came to power, who also founded today's capital of Ethiopia, Addis Ababa in the 1870ies. He defeated the Italians who started to invade the country in 1894 with an army of 10.000 people in the battle of Adua in 1896. Through this victory Ethiopia remained the only country which had not been colonialized on the African continent. The next famous Emperor was Haile Selassie I, who had been crowned in 1930. The first part of his reign was short, because Ethiopia had been invaded by the Italians again in 1936. This time they occupied the country for five years, until they were defeated by the British army in 1941. Haile Selassie returned from his exile in Britain and re-established his absolute sovereignty. Though the emperor had a good reputation abroad, the population was dissatisfied. 1974 it came to a revolution and a military coup, and the last emperor died in a prison soon after. (Deix 2013; Hooge 2015)

Socialist dictatorship: After the revolution, the Derg, a socialist-inspired Military Coordinating Committee, came to power and Mengistu Haile Maryam became leader in 1977. Landownership was forbidden and soon the resistance within the population grew. Finally the captured Addis Ababa in 1991. (Deix 2013)

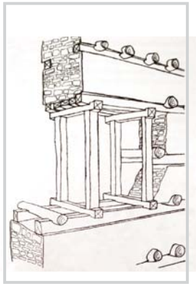


fig. 41: Aksumite style of construction with "monkey heads"

fig. 42: Steles of Axum

fig. 43: The monolithic church Beta Giyorgis

5: The descendants of the kings of the Aksumite Empire regarded themselves as descendants of King Salomon of Jerusalem. There is the Legend that the Aksumite Queen Sheba travelled to Jerusalem and gave birth to Menelik I, son of King Salomon and first Salomonic Emperor.

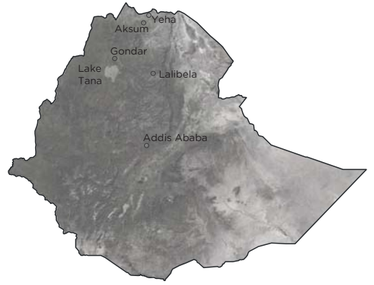
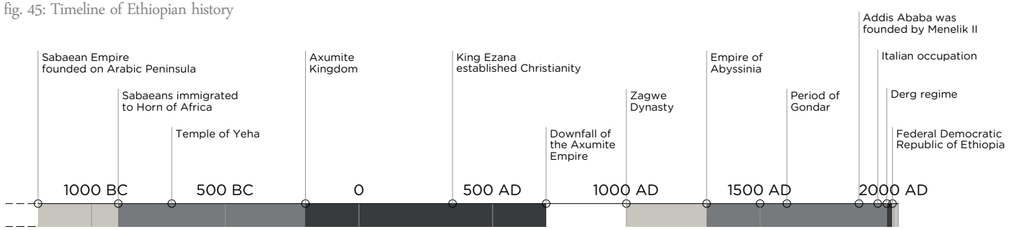


fig. 44: Map of historical places in Ethiopia

fig. 45: Timeline of Ethiopian history



Federal Democratic Republic: After the election of 1995 Ethiopia became officially a Federal Democratic Republic.

Today's architecture is dominated by foreign Influences, which is especially visible in the capital Addis Ababa. Apart from the historical and modern architecture in Ethiopia, you can still find lots of different forms of vernacular architecture in the country, like the "Tukul", a round hut with a thatched roof. Some of them will be explained in later parts of this thesis.

3.5 Earthen architecture in Ethiopia

In Ethiopia three main specific soils suitable for construction purposes can be found:

* Lateries/Lateric soils: Lateric soils are also called ferrisols. They are often found in vast, open plains and clearings and have a good quality for construction. They are easy to cut and harden quickly in the air.
* Black cotton soils (vertisols): They occur in areas with volcanic rocks. They are named after their dark colour and the cotton that often grows on these soils. They have a very high amount of clay, dominated by three layer clay minerals. These soils have a remarkable swell in moist conditions and also a high shrinkage upon drying, but if they are dry, they are extremely hard.
* Alluvial soils: These soils can be found in the wider valleys of rivers and streams. They are exposed to a continuing weathering process and rich in minerals. (Houben/ Guillard 1989)

Though there are so many techniques of using soil in construction employed in the world, the Chikka technique is the only widespread vernacular earthen material used Ethiopia. Chikka is a mixture of soil, straw and sometimes dung that is used to cover wooden substructures. (see chapter 4.2). The material is also used for hearth- and food storage construction. (Gottert 2015, Moges 2012)
Apart from the Chikka technique, earth has often been used as mortar and plaster for stone buildings like the Aksumite palaces, houses in the towns Harar and Asaita or the Tigray farmer's house. All these examples traditionally also have an earthen roof, because there is not so much rain in these regions. Today this roof has often been replaced by a flat cement roof or a roof covered with CIS.

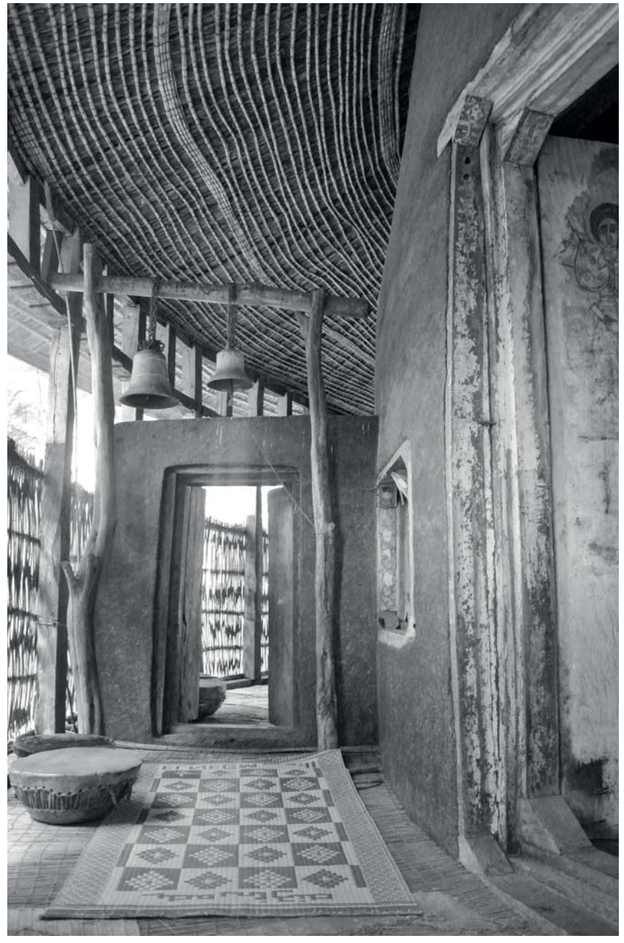
Other examples for the use of earthen materials in buildings are the round churches. Since the 17th century, this typology of derived from the indigenous "Tukul" architecture and replaced the rectangular floor plan that was used for churches in Ethiopia before. Many examples can be found in the area around Lake Tana, like the famous church of the monastery Ure Kidane Meheret, which was built around the 17th century (see fig. 46). (Mayer 2013)
The original thatched roof structure is supported by two rows of wooden pillars which create an arcade. The inner ring of pillars is filled up with earthen material mixed with straw. Some people say that the filling of this structure is often made of adobe bricks, but I could not find any evidence for this statement so far. The church of the monastery Ure Kidane Meheret it is a perfect example of well-constructed earthen architecture, because the building had been erected on a platform so it is protected from moisture from the ground and the earthen surfaces of the wall are completely protected from rain through an arcade. This proofs that durable earthen constructions are also possible in the more humid areas of Ethiopia.

fig. 46: Church of the monastery Ure Kidane Meheret

fig. 47: Building near Adama (crocodile street)

Earth is often regarded a weak building material because it loses strength if it gets wet. Ethiopia is strongly affected by strong seasonal rains, even in average rather dry areas. This circumstance makes it challenging to construct structural applications with earth in this country, but not impossible. (Gottert 2015)

On my way from Addis Ababa to Logia I saw round huts from the car window that seemed to be constructed of adobe bricks and I also got pictures of such houses near the city Adama (see fig. 47). Also Fita Alayu, human resource manager of Wolkite Polytechnic School, told me that there are actually people who produce adobe bricks for the construction of their houses. Unfortunately I did not have the possibility for more research on that.
Generally it would be very important to find a sustainable solution for construction in Ethiopia. Chikka houses are highly unsustainable because of their large consume of wood. There are also building regulations in many towns and cities forbidding the use of earthen materials in construction, so most of the materials like cement have to be imported. The population is growing very fast, faster than the production of housing units, so there is a high demand on residential buildings, especially in the low-cost sector. Well-constructed buildings made of adobe bricks and maybe with a substructure of reinforced concrete, could be a solution for this problem, also in urban areas.



4. AFARKINDERGARTEN-PROJECT

A compound for education and culture

Location: Logia, Afar Region

https://afarhouse.wordpress.com/

fig. 48: Finished hostel building in Februrary 2017

4.1 The Afar and their need for new construction methods

The Afar are an Ethnic group of about 2.12 Million people, living a semi-nomadic lifestyle in an area called Afar triangle (see fig. 49). It extends over the countries Ethiopia, Djibouti and Eritrea. Today the majority of their territory belongs to Ethiopia with about 1.4 million Afar, 234.000 live in Eritrea, 406.000 in Djibouti and about 55.000 also in Somalia. They are all speaking the same language, have the same culture and are Muslim. Through trade and migration from the Arabian Peninsula the religion was brought to the Afar in the ninth century. They converted but still kept some of their pre-Islamic spirits and stories. They are speaking a Cushitic language which belongs to the family of Afro-Asiatic languages. Until the first Afar-English-French dictionary was published 1985 by Enid Parker, they had no written language. In Ethiopia about 90% of the Afar live in the Afar Region in the north-east of the country. They form 1.9% of the whole population and have the lowest population density, which is probably due to the harsh living conditions in this area. (Eigner 2014; Liendl/ Leithner 2013; Browning 2011)

Climate and habitat: The habitat is determined by high temperatures and little rainfall, but the climate varies a lot depending on altitude, air temperature and vegetation. The average temperature is 27.5°C and the average Annual rainfall between 500 and 1000 mm. The East African Rift Valley, which reaches from Djibouti to Mozambique, separates the Afar territory from the highlands of Ethiopia. 23% of the region have an altitude over 900 m, 52% between 400 and 900 m and 35% under 400 m, forming the Danakil Depression, which is up to 150 m below sea level and the deepest point in Africa. As it was once covered by the sea many salt lakes can be found. It is also one of the hottest areas in the world with temperatures up to 48°C. As in the Area of the Afar triangle is a so-called triple junction, where three tectonic plates are moving away from each other, many volcanos can be found and there is a high risk for earthquakes. Regarding vegetation about 48% of the land is covered with exposed soil, sand or rock, 32% are shrub land, 15% are covered with grass and 5% with forest, rivers and cultivated land. The lifeline of the region is the Awash River. With a length of 1200 km it is the second longest river of Ethiopia after the Blue Nile. Awash River has its spring in the highlands of Ethiopia in 3000 m altitude and ends at the border of Djibouti in a braided stream. Rainfall is seasonal and determined by deep low pressure zone over the Arabian Sea and Indian Ocean. There is a big rainy season from mid-July to end of September which contains 60% of the annual rainfall, a dry season from November to March and a small rainy season from mid-March to mid-Mai that contains 30% of the annual rainfall. Sometimes one or more rainy seasons stay out, which can lead to a draught. Since 1960 there were 2 big droughts. In the one between 1972 and 1973, the Afar population was reduced by 20 to 30%. Also the temperatures vary within a year. Generally it is cooler during dry season, especially at night. (Eigner 2014; Schönher 2015)

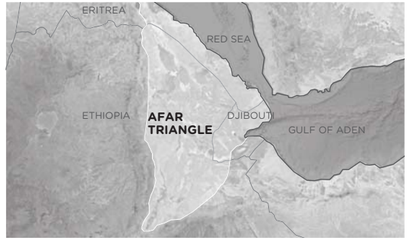


fig. 49: Afar triangle

fig. 50: Moving Afar with a mountain of volcanic rocks in the background

History: Afar region is known for being one of the cradles of humankind. The famous human ancestor Lucy has been discovered here, belonging to the species Australopithecus Afarensis, named after the region. She was probably one of the first upright walking primates living about 3 million years ago and is one of the most complete skeleton findings of this age ever. (Eigner 2014)

It is supposed that Afar migrated 4000 BC from the Arabian Peninsula to today's Horn of Africa. For centuries the Afar territory was leaded by several sultanates. Most of them disappeared during the time of colonialism in Eritrea and Djibouti and because of governmental pressure, but the most powerful sultanate of Aussa still has a lot of political influence. Afar Region has always been an important trade route from the high lands to the Red Sea. Lots of goods were transported through caravans. Afar profited from it by serving as guards and sultanates took trade taxes or acted as middlemen. Most important good for export was salt from salt lakes and salt fields. In former times salt blocks were also used as local currency. With the opening of the Suez Canal the Horn of Africa became very interesting for colonial powers who wanted to control the route through the Red Sea. Italy and France took over the Afar territories along the coast by founding Eritrea and French Somaliland, today called Djibouti. The people of Afar got split over three countries and lost a lot of their political power. In early 1930's the caravan routes lost importance because of the construction of the railway from Addis Ababa to Djibouti and the road from Addis Ababa to Assab in Eritrea. After Italian occupation from 1936-1941, Ethiopian state took control over Afar region and after losing their political power they also lost a lot of their autonomy. Since 1960 the intervention from the state became more because they were interested in the salt deposits in the Danakil Depression and potential agricultural areas along Awash River. During communist regime of the Derg from 1974 to 1991 the Afar Liberation Front (ALF) was founded, mainly by members of the Aussa Sultanate. With the new constitution of 1994 the Afar in Ethiopia got back some autonomy as they are since then responsible for the administration of Afar Region. But there are still problems with corruption, tribalism and intra-ethnic conflicts. After ongoing disputes with Eritrea that ended in a civil war 1998-2000, the border was closed and Afar lost access to the market. Since then the highway from Addis Ababa to Djibouti got expanded and became most important trade route of the country. (Eigner 2014; Liendl/ Leithner 2013)

fig. 51: Awash River

fig. 52: Salt lakes and fields in Afdera

Pastoralism: Traditionally Afar are raising livestock on natural pasture, that's why they are called pastoralists. Depending on rainfall and pasture condition they move with their animals, so there is also a nomadic element in their lifestyle. Ethiopia is a perfect habitat for pastoralists. 60-70% of the land are arid or semi-arid areas , where environmental conditions are not suitable for agriculture and settlement. Estimated 9.8 million people of different ethnic groups live as pastoralists in Ethiopia. That makes 13% of the total population, with Afar being the third biggest group after Somalis and Oromo. The Afar are migrating dependent on dry season and rainy season. During rainy season grasslands in higher elevations are used for pasture while the rivers in lower altitude get flooded. In the dry season these wetlands of the rivers are used for grazing. The distance of moving can be different, that's why they use a split-herd system where livestock and household are divided. The so-called dry-herd is moving during rainy season, often several hundred kilometres away from the main settlement. It is composed of mainly non-lactating and male animals. A satellite camp, called "magida" is constructed when they reach the pasture. The lactating herd, including milking, pregnant and young animals stays with the rest of the family in the main settlement, called "homa". This rotating grazing system allows the land to rest and regenerate. The kind of livestock is different, depending on local ecological conditions and wealth. Small animals like goats and sheep are very common; the big animals are mostly cattle and camels. Livestock is very important for Afar, as having many animals guarantee enough supply of food and stands for a high social position. Camels have the highest value, because they are perfectly adapted to life in desert areas. Normally pastoralists produce enough food for their own substitute, but population is constantly increasing and pastures are getting less. Today most of them exchange some of their animal products or sell animals to buy goods like grain and sugar on the market. To help people who lost many animals, for instance through a drought, there is a social practice called "zakka". In the end of Ramadan they give 10% of their earnings, respectively livestock to the poor. (Eigner 2014; Liendl/ Leithner 2013; Schönher 2015)

Social structure: In Afar society the social structure is determined by clans and tribes. They are separated into two big sections, the "Ashimarra", which means the red people, and the "Adohhimarra", which means the white people. Originally the Ashimarra live in the area around the Awash River and the Adohhimarra north of Afar triangle up to the coast of the Red Sea. The Afar have more than 100 different clans. They are composed of people who are related by descent and live together in a clan territory. Decisions are made by clan leaders together with the elders. Marriages are usually arranged, mostly within the same social group, but

fig. 53: children caring for small animals in a satellite camp "homa"

fig. 54: Afar watering cattle at Awash River during dry season

sometimes within another. A connection within the direct family line, like between brother and sister or uncle and niece is forbidden. But a marriage between cousins is quite usual. It is also possible for men to have up to four wives, if they can afford it. The duties within the household are traditionally divided based on gender, age and other values. The husband has all rights and is mostly responsible for herding, selling the animals on the market, decision-making and defence of livestock and family. Women have lower status in Afar society. Their daily duties are collecting water and firewood, baking bread and prepare food and taking care of children and lactating and small animals. Furthermore they are responsible for construction of the mobile houses. Children are herding the small livestock. Due to socio-economic change the roles of some Afar families have changed. When the husband goes to work in a town or a city the wife sometimes has to take care of the herd. But generally women have a lower status in society; they mostly have no access to education or health care. Also female circumcision is still practiced on many women in Ethiopia, independent of their religion. This surgery, where women's exterior sexual organs get partly or completely removed takes place when they are between 4 and 8 years old. It causes pain for the rest of their life; some women even die from it. (Eigner 2014; Liendl/ Leithner 2013)

Afar village:[6] People living together in the main settlement (homa) normally belong to the same family of different generations. It is consisting about four to 18 households and is normally located close to a permanent water source to provide water for the animals. It is where women, children and older people live in semi-permanent houses to take care of the lactating, pregnant or young livestock. In case of an emergency the village can move to another place, but normally the position changes only about once a year. On an excursion of the Vienna University of Technology in February 2011 a building survey in the Village Ali Aydayto in Uwwa woreda has been done. Many of the following information on the Afar compound and houses are based on this survey. (Eigner 2014; Rieger-Jandl 2013)

Afar compound: An Afar village is organized in compounds formed by one family. Only when the second baby is born men and woman get their own compound, before that they are living with the mother of the wife. Most times a compound is surrounded by a fence with a round or oval ground plan. These fences are made of stones or thorny branches and are necessary to protect the house from animals that would eat up parts of the houses that are covered with grass or mats of palm leaves. One compound can contain housing units for one or more families (see fig. 56). Irrespective of the size, the important elements of a compound

fig. 55: fence surrounding a compound made of thorny branches

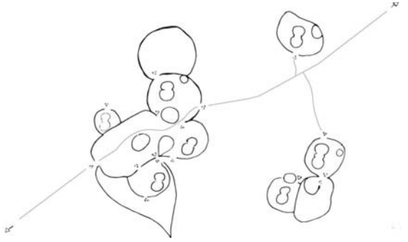


fig. 56: Schematic illustration of a part of an Afar village showing fenced compounds of different sizes and a different number of housing units

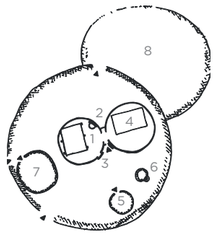


fig. 57: sketch of one compound containing the family house [1], a fireplace inside [2], a window [3], the guest house [4], a fenced area for praying [5], an oven for smoke perfuming [6], a pen for young animals [7] and a pen for lactating animals [8]

fig. 58: place for smoke perfuming

fig. 59: Family- and guest house connected directly

fig. 60: Family- and guest house connected by an additional tent

are almost always the same (see fig. 57): There is at least one house, sometimes combined with a guest house, fenced areas for small and lactating animals, a place for smoke perfuming and a place of praying. Afar traditionally pray outside, not in a mosque. The place of smoking is a small clay oven for women to clean their bodies with scented smoke (see fig. 58). If a family has two houses, there will be a mobile family house and a semi-permanent guest house, sometimes connected to each other directly (see fig. 59) or by a connecting tent (see fig. 60). The entrance of the tent is very small, only 30-40cm wide and 80-100cm high and its orientation is usually aligned with the wind. The reason for the small size of the opening is to keep heat and wind out and it also guarantees people slow down before entering the house; so that people enter the house with respect. The family house sometimes has window called “loita”, which can be closed by a mat, wood ore a stone. The only fix inventory is a bed and a fireplace. The bed is a wooden frame resting on stones or wood, covered by a bed base made of palm sticks sewed together with animal skin, called “aloita”. The function of the fireplace inside the house is not for cooking but for heating water for coffee and tea.
Afar diet traditionally contains mainly goat- or camel milk and bread, which is baked outside. As there is no opening in the housing structure to let the smoke out, the inside is covered with soot. This is necessary to make the mats made of palm leaves that cover the house waterproof and more durable. It is also good to keep vermin and bugs away, but the air quality is suffering from it. Household appliances like pots are hung up on the inside structure of the house.
The function of the guest house is to welcome visitors and to have an additional sleeping place, and it is also a cool resting place during day. When the family moves to another place the guest house is left behind, while the family house and the bed will be transported on the back of two camels. (Schönher 2015; Weber/ Einhell 2013)

The construction of an Afar house: The Afar call their mobile house “deboita”, which means family house. Though the basic elements of the building are always the same, they vary in size, height, form and material depending on local tradition, environmental conditions and available resources of the region. The primary structure is a very simple construction of bent wooden sticks dug into earth or fixed by stones that is covered with different materials. This kind of dwelling is one of the most ancient building forms, called armature tent. It already existed in Upper Palaeolithic times and appeared and still exists on different continents, but mostly among sedentary cultures. It is rather special that Afar beside the sedentary guest house also developed a mobile structure. (Eigner 2014; Rieger-Jandl 2013)

Afar houses are traditionally constructed by women. The wooden sticks for the primary construction are usually collected, sometimes also cut off from a tree. But Afar are not allowed to cut a whole tree. Before these branches are used the first time they have to be soaked in water for several days to get more pliable and flexible. Then they are anchored in their final position, dry out and will then keep their shape. For the mobile house it is important to have uniform branches so they are easy to transport. It also makes it easier to arrange the framework in a regular pattern so it can be dismantled and rearranged quickly. The system to arrange the framework is very simple. First one row of Arches is placed, then the second row is added rotated 90 degrees. The stability can be improved by adding a second system of smaller arcs (see fig. 61). The branches are connected to each other by lines, textile pieces, leather stripes or plant fibre. To cover the house 20 to 30 mats are needed. They are woven and made of bamboo fibres or palm leaves. The connection to the substructure is made by thorns, leather strips or ropes. The mats are not available anywhere, they need to be traded. Sometimes materials like plastic, animal skin or blankets are used additionally to cover the mobile house (see fig. 62).
The construction of the guest house is a bit different to the construction of the mobile house. The framework of the substructure has no recognizable pattern, the branches are arranged irregularly. Also the house is thatched with bundled tufts of grass (see fig. 63) instead of mats. This thick layer of grass has a better thermal insulation than the mats, so it’s providing a comfortable living environment during day. Both houses, the family and guest house are additionally fixed from outside with ropes or branches that are wrapped around the entire house, to give more stability to the structure and cover. (Eigner 2014; Schönher 2015; Weber/ Einhell 2013)

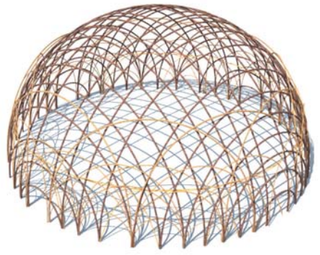


fig. 61: construction scheme of a deboita

fig. 62: cover with mats of palm leaves and other materials fixed with ropes

fig. 63: grass cover fixed with branches

Problems of Afar: Though the lifestyle of Afar is perfectly adapted to the environment , many of them give it up and move to the cities. The reasons can be different:

* Ecological change: Climate change leads to higher temperatures and less rainfall. It is harder to find grazing areas or water and Afar have to move further away with their herds. Especially the number of big animals decreased because of drought. Since 1999 there have been seven major droughts that reduced the livestock to 40% of the size it had ten years before. The most important water source, the Awash River is polluted by the waste of factories. Another problem is the invasive plant Prospis Juliflora, called "woyane" by the Afar. It was introduced in the 1980 for reforestation purposes, but it did not work out as expected. The local plants were supressed by it and the big thorns are hurting animals and people. The seeds spread out very easily to other areas through animal droppings, so this plant has taken over big areas of former grazing lands along Awash River.
* Economical change: In the wetlands of Awash River many plantations for cash crops like sugar cane or cotton have arisen, dams and irrigation channels have been constructed. All these areas Afar cannot use for grazing their animals anymore. Also the Afar have less income. The prices for the animal products they exchanged on the market stayed the same while the prices for clothes and grains increased.
* Political change: Since a long time Afar are in conflict with another pastoralist group, the Issa-Somali. They populate dryer pastures in the northeast of Ethiopia. But when there is a drought they move west and get in conflict with Afar about grazing and watering areas for their animals. Afar have lost huge areas of territory to Issa-Somalis. On both sides many people and animals died. There are also conflicts with areas that border to Amhara region. In case of a draught Afar bring their herds to these areas to find water and food, and so it happens that they eat crops from Amharic farmers.
* Image problems: The image of pastoralists among Amhara people is not very good, the see them as inefficient land users and blame them to overgraze and damage farm land. They think they are living a backward way of life. Also some young Afar want to live a modern life with more comfort and leave their villages. (Browning 2013; Eigner 2014; Liendl/ Leithner 2013; Schönher 2015)

7: Browning 2011

8: Browning 2013: 197

APDA: The NGO APDA (Afar Pastoralist Development Association) was founded 1993 by Valery Browning and her husband Ismael Ali Gardo. The Mission is to enable the Afar to develop within their own capacity and to improve their living conditions. The main issues are medical care, education, women's rights, environmental protection, water management, animal welfare and water management. There's a special focus on education, because the majority of Afar are illiterate. As Valery Browning said; "If you are illiterate you will not do anything that is not in your tradition."[2] You have to educate people before certain things can change from inside. Due to the mobile lifestyle schools and also clinics cannot serve Afar. So APDA developed a programme that trains local people to health workers, community teachers and women extension workers. They are equipped and become mobile workers selected by their community leaders and serve them. This model is "(...) built on the Afar culture itself using the traditions of local healers and Koranic teachers in that the teachers and health workers come from the community they serve, move with the community and the programme is directed from the position of clan law and Islamic belief."[3] Another important focus is water management which is developed since 1999. Constructions of cisterns and retention dams are done and people are supported to build traditional steam wells. Also pasture rejuvenated by seeding natural grass seeds. The health programme is focused on primary health education, basic treatment, vaccination, mother-child care and HIV prevention. The mobile women extension workers also belong to core issues, because women are least developed. They do domestic intervention for disease prevention, safe motherhood, stopping harmful practices and female income generation. Since environmental balance is an important issue for Afar and APDA, the NGO does also support sustainable construction methods for town buildings. (Browning 2011; Browning 2013, Schönher 2015)

The need for new construction methods in Afar Region: Due to the numerous challenges Afar have to face in their traditional semi-nomadic lifestyle there is a transition process to sedentariness going on. Many towns emerged along trading routes like Addis Ababa Djibouti Highway that offer opportunities for jobs and income. Not only Afar but also people from the highlands were attracted by these towns. They came to work in administrative jobs or as traders and also established their building technique, the so-called "chikka" houses, which are now the dominating housing construction in Afar towns. The deboita is not suitable for a modern life in a city. There is a need for larger living space and also a need for other building types like shops, administrative buildings or schools. Due to its structural grid the traditional Afar house cannot provide the bigger space that would be required. But chikka houses are highly unsustainable as they are consuming a lot of wood. Every tree is extremely valuable in arid regions. So an alternative system for construction is needed. (Browning 2013; Rieger-Jandl 2013)

Asaita: It is not entirely true that Afar do not have a permanent construction method that is also suitable for town houses. In Asaita, the former capital of Afar Region that is only 25 km away from Djibouti border, Afar are living in stone houses with flat roofs (see fig. 64). The façade is plastered with earth and coloured differently, what makes a very atmospheric and friendly impressions. It is one of the oldest towns of the region that emerged next to the Awash River. Though it is not situated along the Addis Ababa Djibouti Highway, the town has always been important for trade. Every Tuesday is market day were Afar from all over the region come to sell and buy products. Asaita also grew a lot in the last years. 2012 it had 20.545 inhabitants and also people from the highland came there and brought the chikka houses with them. It is clearly visible that in the old town centre nearly all the houses are made of stone, while to the edge of the city chikka houses are dominating. It is sad the tradition of building with stones did not continue, especially because the material is available everywhere and there is no need to cut off so many trees. But chikka construction is simply faster and easier than building a house of stones. I could not find out if the Afar themselves constructed these houses, but from fieldtrips to Kori and Teeru (see fig. 65, fig. 66) I know that in stony regions there are Afar villages with mobile deboitas and simple permanent stone houses. Also fences for animals are sometimes constructed as dry stone wall. (Eigner 2014)

fig. 64: Stone houses with flat roofs in Asaita

fig. 65: Stone houses in Afar village in Kori

fig. 66: Stone house in Afar village in Teeru

4.2 The development of Logia

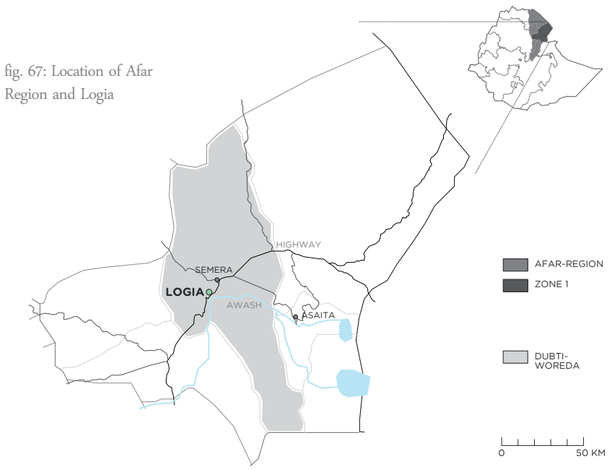


fig. 67: Location of Afar Region and Logia

fig. 68: Aerial view of Logia 2016 with Addis Ababa-Djibouti Highway [1], Logia River [2], Awash River [3] and irrigation channels [4]

Site situation: Logia is situated in the Middle of the Afar Region in Zone 1 in Dubti Woreda, about 420 m above sea level. The landscape is flat with little vegetation, the climate hot and dry. The highest temperatures are between Mai and September. The annual rainfall is below 300mm a year. If it rains water evaporates very fast because of the high temperatures and the soil structure. In comparison to the surrounding cities Logia has a lot of groundwater in a good quality. Before the city started expending so much, there has been a wood along the Logia River. Most of it was cut down for timber. Water is creating the natural boundary of the town, with Logia River in the north and an irrigation channel in the south (see fig. 68). Further south of the channel Awash River is floating, which has water all over the year, while Logia River is often without water. Another characteristic element of the city is the Addis Ababa Djibouti highway which divides the city into two parts and creates a lot of traffic. (Eigner 2014)

Development: Logia is one of the biggest towns in the Afar Region. It is not documented when exactly the settlement emerged. It can be assumed that the rapid development started along with the construction of the Addis Ababa Djibouti highway in the mid-seventies, like it was the case for many other urban places in the region. The name Logia has its origin in the Italian language, so the settlement may have already existed during time of Italian occupation. According to one of the inhabitants, the oldest Mosque of Logia was built around 1960. (Eigner 2014)

The Afar region has a rather high urban growth rate of 4.3%. This is also visible in Logia, where the population almost tripled during the last 15 years. There are three major reasons for this rapid development. The most important one is the influence of Addis Ababa-Djibouti Highway. Nearly all import and export goes over this road. Truck drivers often stay overnight in Logia and take a rest, which was encouraging people to come to Logia to open restaurants, hotels and shops.
Another reason is the neighbouring town Semera, which was established as capital from 2003 to 2004 and is only 5 km away from Logia. Before the formation of Semera, Logia had only 7000 inhabitants. Since then it grew about 8 % a year. 2012, the time of the last official population census, the number of inhabitants was 19.719 people. In contrary to Logia, which grew in a natural way, Semera was planned by the National Planning Institute. The structure is completely different, with mostly rectangular plots and linear streets. The construction of Chikka houses is forbidden there, so most of the buildings are made of concrete or metal. As the town is not finished yet it seems empty in most of the parts.
The third reason is that many people come to the rapidly growing urban centres to find work, Afar as well as Amhara people. Statistics show that most of the urban residents in Afar Region are Afar (52 %), the second largest group are Amhara (30%), the rest are others (17%). Amhara men often work as salesmen and women as maids. Afar settle down because pastoralists life becomes harder and harder. Sometimes the livestock dies because of a draught or also floodings. When a heavy rain comes rivers emerge out of nowhere and the herd gets washed away. A nomad without a herd has nothing left and is forced to move to the city to find income. A lot of Afar living in Logia are also refugees from Eritrea. (Eigner 2014; Eigner 2017)[9]

9: see movietext scenes 19-20

City structure: Based on the city structure it is easy to comprehend how the Logia developed. The town has a liner character with no real centre. There is a kind of small square called “Piassa” in the eastern part of the city near the Logia River. It can be regarded as main square. It is the place where the oldest buildings like the first mosque can be found and also the place where Logia started to arise. The development continued along the highway, where the built-up structures are very dense. Most of the infrastructure like shops and restaurants are concentrated along this road and a linear structure was defined through it. Away from the road the density decreases more and more, here residential areas are located. It is also visible that the spreading to the south and north-east slowly reaches its limits, because of the natural border of the irrigation cannel and Logia River (see fig. 69). (Eigner 2014; Rieger-Jandl 2013)

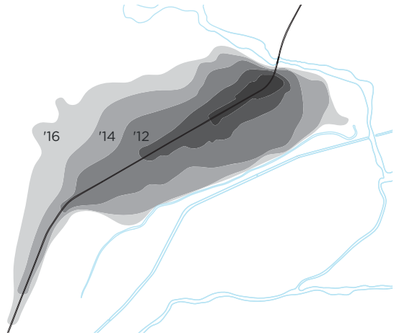


fig. 69: Development of Logia

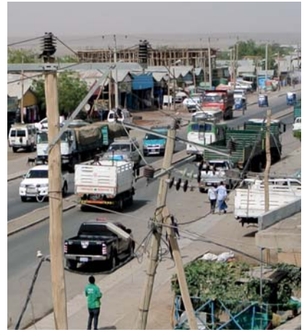


fig. 70: Highway in Logia

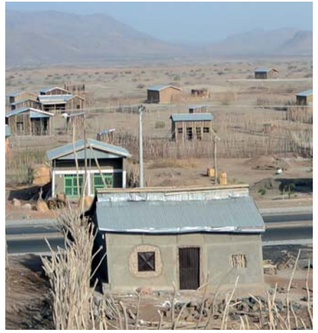


fig. 71: Lower density in the outskirts of Logia

4. AFARKINDERGARTEN-PROJECT

Logia 2012

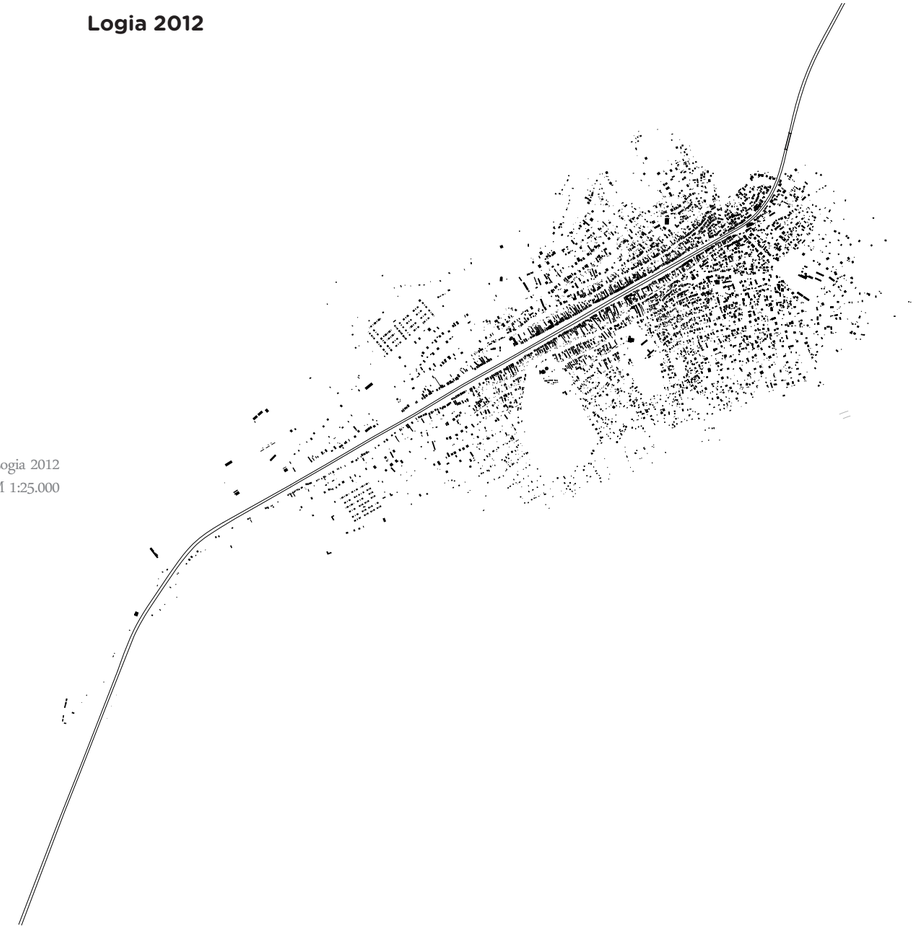


fig. 72: Logia 2012
M 1:25.000

Logia 2016

fig. 73: Logia 2016
M 1:25.000

4. AFARKINDERGARTEN-PROJECT

Apart from the main road, nearly all roads of Logia are unpaved. 2016 it was started to plaster the road from the highway to the high school, as their also is a lot of traffic there. Many goats and sheep are living in the streets, because many people are former pastoralists. In the outskirts of Logia people are still living as pastoralists in deboitas on no costs. But many of them have the aim to build a real house in the city. (Rieger-Jandl 2013)

Many problems are connected to the fast development of Logia. There are ecological issues like sanitation, garbage disposal and deforestation. Nearly every household has its own toilets consisting of simple pits that are dug into the ground. Today they are most times protected by cement walls, but they are not for sure leak-proof. Soil and groundwater are not protected from contamination. Waste is burned or just thrown on the streets. Sometimes collected by donkeys and brought to the dry riverbed until the water comes and brings it away. Though the ground water in Logia is said to have good quality there are already health issues with it, especially for foreigners. The residents of Logia are used to parasites resulting from water, but foreigners can get seriously sick from Amoeba. (Eigner 2014)

The people and how they live: Many people living in Logia are Afar. But not all of them changed completely to a sedentary lifestyle. A lot of them are still moving from town to town, searching for work. This is one of the reasons why it is hard to get reliable information about population size. Also, the last census was made 2012, where there was a number of 19.719 inhabitants. By now there have to be a lot more, as there have been many buildings constructed in the last few years. By counting the houses you can estimate a number of about 27.500 people living in Logia in 2016.[10]
Most of the houses in Logia are one storey rectangular houses with a CIS (corrugated iron sheets) roof, usually constructed in chikka technique. Only a few houses are constructed in concrete. About 62% of the people living in Logia have a household size of 4 to 8 people, 34% less and 4% more. Houses are always fenced as a zoning between public and private is important in Ethiopia. Buildings on the main road often have shops or restaurants in the front and living rooms in the back. (Eigner 2014)

Chikka houses:[11] In Logia chikka houses are constructed by contractors from the highland. All houses have a rectangular floor plan and usually only one floor. They have a wooden substructure, constructed in a very simple way. First a framework of vertical and horizontal wooden poles will be erected, including the substructure of the roof. There is no foundation; the long wooden poles are put directly into the ground. The next step is to finish the vertical substructure of the wall with smaller pieces of wood, also put into ground one after the other with only a little distance and fixed with horizontal pieces on the inside. If the vertical poles are not straight enough they cut them a bit to adjust them (see fig. 75). After the all vertical elements of the wooden structure are placed they will be fixed from the outside with horizontal elements. Then the roof construction will be finished and covered with corrugated iron sheets (see fig. 74). Nearly all parts are only connected with nails or wire. There are no diagonal bracings that protect the building from horizontal forces like wind. That's why some chikka houses are crooked. Sometimes a stone wall with a height of about 20 to 50 cm and a depth of about 60 cm is build outside around the wooden poles for a better stability (see fig. 76). It looks like a foundation and also protects the house from water when there is a flood after a heavy rainfall. After the construction of the substructure the plaster will be prepared. It is a mixture of soil from the riverbed and straw that has to soak for about one week. It is important to mix the material from time to time. When the consistency is right, the wooden walls as well as the space between the poles will be covered with mud, beginning on the inside of the house. On the outside

10: Own calculations by linear extrapolation oft the number of houses and an average household of 3.1 people per unit

11: see movietext scene 34

there will be two layers of plaster. First there will be one layer of mud plaster. Notches will be pressed into the soft material to get a better underground for the second layer, which can also be mud plaster, but most times it is cement plaster to make it more durable. As cement is not connecting with mud very well, it is also possible to fix wire mesh between the two materials to get a better adhesion. The floor construction is most times made of compacted soil covered with a decorative plastic, sometimes it is also a cement floor. (Eigner 2014)

The older chikka houses were constructed a bit differently. They used local wood, not Eucalyptus like they do nowadays as they already cut down all trees in Logia. They were constructed simpler and had a flat roof made of twigs and several layers of earth (see fig. 77). These roofs had to be maintained regularly, or else they got leaky, that's why they replaced them with CIS. (Rieger-Jandl 2013)
The big advantage of chikka houses is the short construction time of two to three month. Also most of the materials used can be recycled. As the roof is constructed before the plaster, the mud is protected from rain during construction time. But chikka houses have a lot of disadvantages. A high amount of wood is needed for construction. It has to be imported from the highlands. They are also not durable. The eucalyptus wood used today is not resistant against termites, so most of the houses will collapse about 5 to 7 years after construction. Also the roof overhang is often too short so the plaster gets destroyed during rainy season. (Eigner 2014)

fig. 74: Finishing the roof before plastering

fig. 75: Vertical poles adjusted by cuttings

fig. 76: "Fake foundation" and first layer of plaster

fig. 77: Chikka houses with flat roof in Asaita

4.3 The Afar Kindergarten Project

fig. 78: Logo

The Afar Kindergarten Complex was planned by Katharina Schönher as part of her Master Thesis at the Vienna University of Technology. It is a compound for education and culture that offers rural students to visit governmental high school. Also a kindergarten for local children is planned. APDA will be owner of the education complex and is responsible for management and maintenance. The construction was done by local people, mainly Afar. They were supervised, directed and educated by Katharina Schönher and other volunteers from Austria and Italy. (Schöher 2015)

Project kick-off: The Idea of a building project in Afar Region already began in 2011 in course of an excursion of Vienna University of Technology, department of Building Research to Ethiopia. A part of the journey was a five days stay in Logia at the compound of Valery Browning of APDA and a Village in Uwwa Region, where a building survey was done and soil samples were taken. Back in Vienna the students had to do a sustainable design for an education complex. Two of them, Alice Eigner and Katharina Schönher were also participants of this excursion. First Alice Eigner had the idea of a design-built project with earth as construction material. As it was recommended to do a building survey first, she went on a three month fieldtrip to Logia in 2012 and finished her Master Thesis about urban development of Logia in 2014. After that Katharina Schönher was interested to do a design-built project as Master Thesis and also went on a research journey in 2015 with the support of Alice Eigner. APDA provided the building site and organized volunteers that have been educated in earth construction methods and other skills. The construction of the first hostel building finally started in March 2015.

Main principles: The main principle was not just to construct a building with sustainable materials, but also to educate Afar in these techniques. Currently Afar are not involved in the construction business of urban areas, it is all done by contractors from the highland. By participating at this project they learn environmental friendly, cheap and durable building techniques. Later on they can use these skills on other construction sites and have a good chance for a regularly income and improved living conditions. (Schöher 2015)

Key partners: The project is a cooperation of Vienna University of Technology and the NGO APDA. It is planned to establish an association for the future organization of the project.

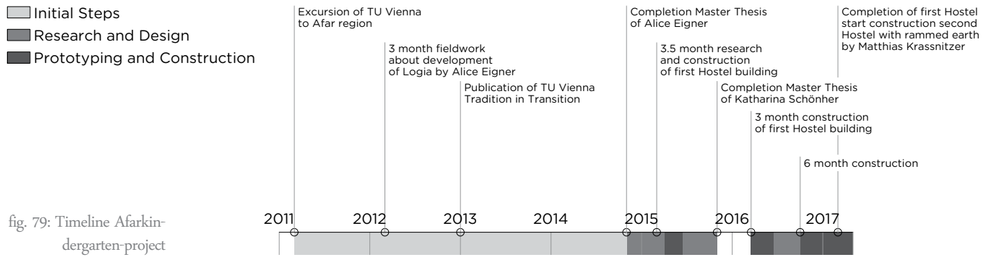


fig. 79: Timeline Afarkindergarten-project

Financing: In the beginning of the project materials and tools were financed by private donors and sponsors, voluntary workers were organized by APDA. Katharina Schönher did some kind of fundraising, she made a homepage and talked to a lot of people about the project, so she could collect enough money to start the project. Later on the project got funded by development aid money from the Australian Embassy, which APDA applied for. Also Katharina Schönher could acquire development aid money from EZA Vorarlberg. The students coming from Austria had to cover their expanses by themselves or go a funding from the foreign office of Vienna University of Technology. APDA offered all people coming from abroad a place to sleep and free meals. (Schöher 2015; Schönher 2016)

4.4 The education complex

Education of Afar: The reason of the formation of this project is the bad education conditions of Afar living in rural areas. Almost all of them do not speak Amharic language. That means they are excluded from governmental schools in villages and towns. Also most of them are pastoralists and often move to different places. APDA developed a programme with mobile teachers to fill this gap. They are teaching Afar language, Amharic and English, environmental science and numeracy. But mobile education is only possible on basic education level from grades one to four. To attend school levels five to eight the children already need a place to stay. For Valery Browning "education is and continues to be the key to a self-determined lifestyle." So it is an important Issue for APDA to enable this higher education by the construction of Hostel buildings. (Liendl/ Leithner 2013: 189)

Site plan: The building site is located in the western part of Logia on the north side of the Highway (see fig. 80). The linear distance to the local high school is only 200 m. The site plan was a "(...) product of the existing conditions on the site, the result of the solar and climatic analyses and urban planning and landscape design factors."[12] It was important to take under consideration the watercourses and flooding areas on site. Due to the rich soil the ground can often not absorb the high amounts of rain coming down in a very short time. Temporary rivers are emerging until water seeps into the ground. On the building site are 3 rainwater channels that mount into one (see fig. 81). Their position had a major impact on the site plan. Also the buildings already on site, an old bakery and another smaller Chikka house were taken under consideration. (Schönher 2015)

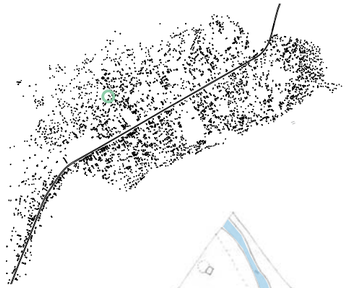


fig. 80: Location of Afarkindergarten-project in Logia

fig. 81: Watercourses on the building site

12: Schönher 2015: 60

In the final masterplan the following buildings are planned:

* 4 Hostels buildings with beds for 56 children (28 girls and 28 boys)
* 1 Kindergarten with 4 groups for 60 children and an Afar-structure as playground
* 2 Staff houses with four rooms.
* 1 sanitary block with 2 showers and two toilets
* 1 guard house at the border from public to the private area of the compound.
* 1 Kitchen with communal space
* Gardens for small scale farming
* Small organic wall to keep the water away from the hostels

The old bakery that was already on site will be renovated and used as kitchen later. Now one room is occupied by Abdu, the guard of the building site and his family. The other room is the storage for tools and other materials we need for construction (see fig. 83). At the backside of the building a shadow roof for brick production was constructed (see fig. 84). Later on it will be used as dining- and communal space for the children. One hostel and the sanitary block (see fig. 88) have been completed spring 2017. Another hostel made of cement bricks was constructed by a contractor (see fig. 86) and Matthias Krassnitzer, also student of Vienna University of Technology, started building the third hostel February 2017. He used rammed earth instead of Adobe bricks (see fig. 87). (Schönher 2015)[13]

13: see movietext scenes 25-26

fig. 82: site plan of the education complex with the four hostel buildings [1], the kindergarten [2], the Afar-structure playground [3], staff building [4], sanitary block [5], guard house [6] and kitchen [7]

M 1:2000
M 1:10.000

fig. 83: Storage in the old bakery

fig. 84: Shadow roof

fig. 85: Finished hostel building / stairs

fig. 86: Hostel constructed by a contractor

fig. 87: Hostel made of rammed earth

fig. 88: Sanitary block

4.5 The Hostel building

Design: As Valery Browning urgently needed space for rural students to visit high school, the first part of the building complex to construct was a hostel building. For the designer Katarina Schönher it was important to find "an architecture which builds on the traditional building construction"[14] and that is suitable for the climatic challenges in Afar Region. Also social aspects, uncomplicated techniques, the use of ecological materials and low costs were important aspects. A new kind of design was necessary, as you need space for the children, light and fresh air. These things a traditional Afar house cannot provide.
Due to the climatic conditions a main aspect of the design was to provide different climatic zones within the building. The walls of the ground floor, where the beds and stores are situated, are 45 cm thick brick walls that act as thermal buffer. An earthen ceiling also keeps the heat out. It takes a long time for the temperatures inside the room to change. So there is a warm space to sleep at night and a cool space during lunch time to hold a siesta. As there are windows and doors on both sides, cross ventilation is possible (see fig. 89). The walls of the upper floor are only a framework covered with mats and there is an additionally ventilated intermediate ceiling to keep away the heat from metal roof. It has a low thermal inertia and cools down very quickly. As the inside space is light and a lot of air is circulating it will be used for studying, reading, playing and communicating during day and evening and as safe sleeping at night during summer. Normally Afar often sleep outside on mats in the hot season. This causes problems because of dangerous animals like scorpions.

14: Schönher 2015: 6

Also mosquito nets, which are very important because of malaria risk, cannot be fixed outside.
To optimize building shape and arrangement of the houses a solar study was done during design process (see fig. 90). The impact of the roof overhang, orientation, additional shading elements and position of the houses has been examined. Also an illuminance simulation has been done beforehand to provide enough daylight inside for studying.
When two houses are completed they will be connected by a fencing structure. A kind of courtyard is created so there will be one compound with two houses for girls and one for boys. (Schönher 2015)

Construction: Within the building two different kinds of construction are used. The ground floor is a massive, load bearing wall supporting the upper floor, which is a light wooden framework covered with mats.

* The Foundation: The hostel building has a stripe foundation made of natural stone masonry stabilized by concrete, which is a common construction method in Ethiopia. The excavation work was more complex than usual, as the whole footprint of the house, not just the area of the stripe foundation has been hollowed out. This was necessary to extract the soil for brick production, so people can see that the material on the spot can be used and they don't have to go to the river to get the material. The excavation with the size of 11.5 to 5.1 to 0.45 m was done with simple tools like pickaxes and shovels. The masonry work itself was managed with the help of a skilled worker. Stones coming from volcanic mountain about 4 km east of Logia have been hewn directly on site (see fig. 91). Three sections of stone rows of 30 cm height were placed on another. Each row was made of bigger stones with smaller stones between. Gaps were filled up with concrete. In the last section steel bars for the corner reinforcement of the wall are anchored that will reach up to the ring beam. The rest of the excavated area has been filled up with 30 cm nigger stones and 10 cm coarse gravel as capillar break layer. In a later stage the final floor surface of compacted earth will be accomplished.
* The Wall: The wall of the ground floor is a massive, load bearing adobe construction, reinforced with 12 mm steel in the corners. Every third row of bricks a transverse reinforcement was installed additionally (see fig. 92). The stabilization of these weak points is necessary in case of earthquakes. Additionally a ring beam out of reinforced concrete has been constructed. Also the lintels of windows and doors were made of reinforced concrete, because of the danger of termites (see fig. 93, fig. 95). The adobe wall itself is 38cm thick with two layers of inside plaster with 1.5cm each and two layers of outside plaster with 2cm and 3cm.
* The Ceiling: Beams of 8cm round eucalyptus timber are lying on the main beam and the wall. They were covered by mats of 1.5cm palm sticks (see fig. 96, fig. 97). When the walls and the roof were finished one more layer of bamboo mats covered with compacted earth will be added. The weight of the floor is important to burden the wooden framework additionally.
* The Framework: The upper floor was constructed as wooden framework out of round eucalyptus timber (see fig. 99). On the outside it is covered with a light vertical construction made of mats of palm leaves fixed in a wooden frame. The connexions were made with threaded rods, reinforcement steel, drills and nails (see fig. 100).
* The Roof: The roof construction is a very simple system that is common in Logia. Primary beams of 8cm round timber, secondary beams of 5cm round timber and a roof cover of corrugated iron sheets have been used. Additionally there is an intermediate ceiling on the inside to keep away the heat from the metal roof. It is a simple frame construction with bamboo mats in-between (see fig. 101). (Schönher 2015)

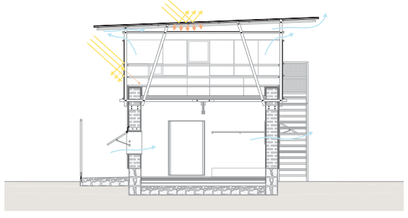


fig. 89: Ventilation and room climate

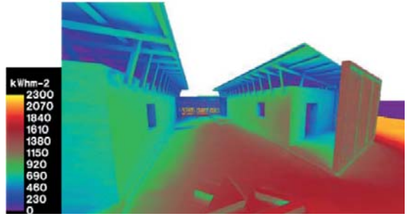


fig. 90: solar study

fig. 91: Mason hewing rocks for first section of foundation

fig. 92: Hoops prepared for transverse reinforcement in every third row of bricks

fig. 93: construction of a lintel

fig. 94: Final position of a lintel

fig. 95: Ring beam with reinforcement before filled up with concrete

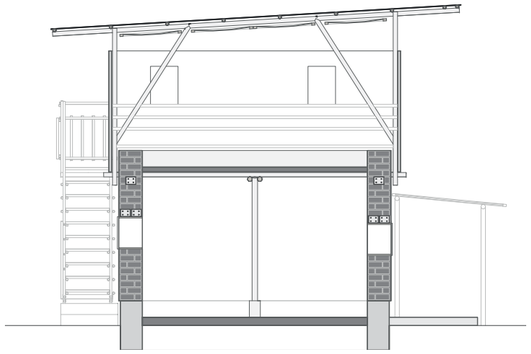
fig. 96: Pillar and beams

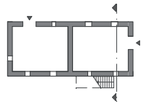
fig. 97: construction of the ceiling

fig. 99: Wooden framework of first floor

fig. 100: Connexions with threaded rods and reinforcement steel

fig. 101: mats of palm leaves in a frame as vertical wall elements and bamboo mats in a frame as intermediate ceiling





SOIL MATERIAL

fig. 98: Section hostel M 1:100

4.6 The implementation of earth

For the construction of the education complex Katharina Schönher decided to use earth as main building material. Soil samples taken in 2011 and 2012 had been tested in a laboratory in Vienna and already showed a good quality for this purpose. It is a capable alternative to chikka construction, because rich soil is available sufficiently nearly everywhere in Logia. You need no transportation because you win the material during excavation and you also don't have to pay for it. Earth construction also has good thermal properties for a hot and dry place like Afar Region. (Browning 2011; Eigner 2014)

For Afar, who live very sustainable and would never cut a whole tree, a construction with earth would fit much better to their tradition than chikka houses. To construct a Deboita nearly all materials are gathered, for a chikka house Afar need to pay a contractor. The material earth can be gathered and you don't need much wood for construction. Building their own houses would also be good for the self-confidence and independence of Afar. There are different massive construction methods with earth. Katharina Schönher decided for adobe bricks, as it is very easy to learn how to produce them and you only need a small wooden form for it. For rammed earth you would need more sawn timber which is very expansive in Afar region and for making a cob-wall you would need a lot of straw, which also has to be imported. Mastering Adobe brick production and construction could open a new economic sector for Afar as they could compete with the contractors from the highland. (Eigner 2014; Rieger-Jandl 2013; Schönher 2015)

The mixture:[15] To find the composition of the right soil mixture for the bricks many tests have been done beforehand. It is very important to consider that the soil composition on site is not always the same. In case of the site of the education campus in Logia 3 soil samples had been taken and tested.

To take the sample the top layer of earth which is mixed with sand, silt and other materials has to be removed. On this building site it is only a small layer of 5 to 10 cm but sometimes it is much more. Underneath is the soil with the high clay content which is used for brick production (see fig. 102). Different kinds of simple soil tests have been made on field to analyse the composition of the material. Some of them are described in chapter 2.2. The conclusion of these tests was that the earth on site has a high content of clay, good binding forces and a relatively high shrinkage. (Schönher 2015)

fig. 102: Layer of rich soil

15: see movietext scenes 27-28

Additionally the finished bricks were tested on compressive strength. For that, 25 examples of different mixtures of soil and sand were transported to the laboratory of EiABC by truck. The compressive strength of best mixture was 22 kg/cm² which a good result for adobe bricks.
There are different steps to prepare the material for the bricks. As the soil has a high content of clay it has to be thinned with sand first. This is important to reduce the shrinkage, to avoid cracks during drying process and to increase the compressive strength. A ratio of one part soil and 0.6 parts sand showed the best results. So, nine wheelbarrows of soil were mixed with 5 ½ wheelbarrows of sand. The sand was taken from the riverbed and brought to the side by truck and it also has to be sieved before it can be used. It is easier to mix soil and sand in dry condition (see fig. 103). The next step is to form a pile of the mixed dry material with a hole in the middle that is filled with water. By shovelling the material in the middle it gets mixed. After that the mountain will be covered with a plastic foil so it doesn't dry out and left for two to four days to soak. Before the material is finally used it has to be mixed again to activate the adhesive forces of the clay minerals and to get good binding forces. The mixing is done by hand and feet with the help of tools (see fig. 104). Unfortunately there were no animals for mixing available. (Schönher 2015)

The mould: First a mould for 3 bricks with handles on the side was used. The size for one brick is 12cm wide, 26 m long and 10cm high. The dried brick has a size of 11.5 to 24.5 to 9.5cm. Two of the moulds were produced in Austria beforehand made of plywood with a very smooth surface and they worked very well. Seven more moulds were produced by different Ethiopian carpenters, but they all did not work that well because of different reasons. So in October 2016 Katharina Schönher brought two more moulds from Austria, one for three bricks and one for six bricks (see fig. 105, fig. 106).(Schönher 2015)

fig. 103: Mixing sand and soil in dry condition

fig. 104: mixing soil with the feet in wet condition

fig. 105: brick proction with a three-compartments mould

fig. 106: brick proction with a six-compartments mould

The production:[16] Because of heat and sun, and also because it can eventually rain, it was necessary to construct a shadow roof for brick production. First there was only a temporary shade construction, but soon there was not enough space. So it was decided for a permanent construction in front of the old bakery that can later have the function of a community space and dining area. The plane cement floor of the shadow roof is a good surface to produce bricks, because they don't connect with the underground. Additionally it is good to spread sand before starting production so the wet soil does not stick on the ground and can shrink without getting cracks. When the mould is placed in the right position, one of the workers holds it to the ground and another throws the pasty loam mixture into it. It is important to throw strong for a better compaction of the soil and to avoid air holes. Then surface is smoothed with a tool and then the mould is slowly removed. The mixture in Logia is very sticky, so it is important to wash the mould after each use very well. It also helps to add some drops of vegetable oil into the washing water to get the bricks out of the mould easier. During the drying process it is good to protect the wet bricks from direct sun so they can dry out slowly to avoid cracks. After two to three days they are dry enough to be stacked. (Schönher 2015)
A big advantage of adobe construction to other massive earth construction techniques is that once the brick is dry you see if it has a good quality or if it has cracks or holes or other defects that would influence the strength. Bricks with minor quality you can still use for half bricks or you can crush and soak them again and produce new bricks of it.

The wall:[17] The bricks produced in Logia had a good stability and good abrasion resistance, so it was possible to make very precise masonry work. As the wall of the ground floor of the hostel is supporting the upper floor you need to have a strong and stable construction. An English bond was chosen as brickwork. Before you can start masonry work the mortar needs to be prepared. With a ratio of 0.25 soil to one sand, which corresponds one wheelbarrow of soil and four wheelbarrows sand, the composition is much more lean than the one of the bricks.
The construction of the wall starts in the corners, where also the reinforcement bars are. The bricks have to be placed so that the metal is in the joints between the bricks. First two opposite corners are placed on a mortar bed. It is important they are in the same height. When the mortar is dry a rope is fixed between them so the bricks can be aligned on it. It is the best to place the whole length of stretchers first to check if their position is right, as it is important for the stability of the wall that all joints are covered by a brick and not another joint. Then you can fix them on the mortar bed and continue with the headers.
When the row is finished all joints are filled with mortar from above. There should be no holes between the bricks. The next row headers and stretches are turned around and shifted half a brick. (Schönher 2015)

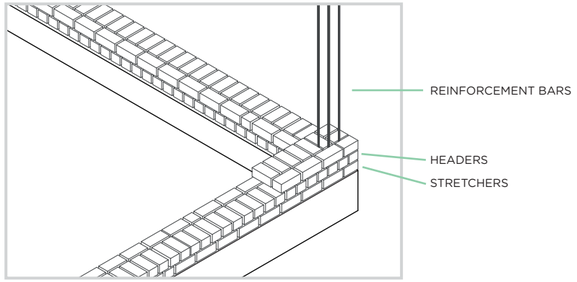


fig. 107: Brickwork of the hostel building M 1:50

The plaster:[18] On the first and second stay experiments with plaster on the walls of the old bakery had been done with different techniques and compositions . It is usual that the first layer of plaster has small cracks, but the second layer needs to have a smooth and closed

16: see movietext scenes 32-33

17: see movietext scenes 35-37

18: see movietext scene 42

fig. 108: Construction of the wall (left page)

surface. The biggest challenge was to improve the water resistance of the plaster. Different kinds of stabilizers have been tried out. Cement brought good results but it won't connect very well with the earth on long-term and would destroy many good features of the earthen material. In the end it was decided to use the same ration of sand and soil like for the mortar for both layers of inside and outside plaster. Additionally the outer layer of the outside plaster was stabilized with vegetable oil and smoothed with a stone. The mixture was thrown on the wall and smoothed and compacted with a trowel. Notches will be pressed into the soft first layer to offer a better underground for the second layer. (Schönher 2015)

Earthen floor: The surface of the ground floor and the upper floor has been covered with compacted soil. First it was planned to construct a rammed earth floor. It did not work very well because the material was too sticky, so it was decided to apply the same technique they used to plaster the wall also on the floor (fig. So, the mixture was thrown on the floor and smoothed with a trowel. The second layer also was stabilized with vegetable oil.

fig. 109: Workshop soil testing

fig. 110: construction of the earth floor

4.7 The education of the workers

The education of local people in sustainable construction methods was an important issue of the project. Especially Afar are dependent on local contractors to construct houses in a town, so learning how to construct with adobe bricks would also bring them more independence. At the beginning of construction APDA organized volunteers to work. After finishing the house they should teach other volunteers the entire construction process and spread the knowledge. They received theoretical and practical lessons in general construction principles, supporting structure and statics, architectural visualization and earth elements and also in timber structures, concrete, reinforced concrete, stones and steel. They volunteers were very interested and thankful to learn, but they were not motivated to come every day and to come on time, which made the work on the building site very difficult. When Katharina Schönher came to site the second time in spring 2016 only one of the volunteers was still in town and available to continue the work. So this time APDA decided to pay the workers as they got a funding from Australian embassy for the project. Again they organized workers in first place because of communication problems. Hummed, the only person left from the workshop the year before also brought some people to work. They again were educated in workshops on different topics concerning the construction of the project, but not as intensive as the first time. (Schönher 2015; Schönher 2016)

4.8 The design in comparison to the local architecture

In form and construction the Hostel building has no similarity to traditional Afar deboitas. But some materials made by Afar came to use. The Afar mats, traditionally used to cover the structure of the deboitas, were taken to build the wall of the upper floor and also as fillings of window-and door frames of the ground floor. They are woven from young leaves of "doum palms" ("hypaene") by women, also during long walks. First they are weaving stripes between eight and ten cm wide, then they putting them together to mats of different size and strength. Afar slatted frames, called "aloita" were used for the construction of the first floor. It is made from palm sticks or sticks from trees that are connected with leather stripes. (Schönher 2015)

Our Afar workers and the people passing by very much appreciated that we used these materials on the hostel building; they said it looks like Afar. Regarding the rectangular form and the roof construction the building also has some similarities with chikka houses.

fig. 111: Afar mats in APDA office

fig. 112: Afar mats as window filling

fig. 113: Afar slatted frame used for the construction of the ceiling

4.9 Problems and strategies

Problems: For the designer Katharina Schönher it was the first time managing a building site, this fact alone is already very challenging. Being additionally in an unfamiliar environment working with people very different from your own culture makes the project much more difficult. So, in first place personal challenges played a role, as everything is different in Afar region. You had to find out the best way to communicate and negotiate with people, where to get materials and tools and many other things. Every day there were new challenges and problems you had to deal with. (Schönher 2015)

* Politics: From October 2016 to August 2017 there was state of emergency everywhere in Ethiopia because of revolts of the population that happened mainly in Amhara and Oromia region. Afar region was not involved, but we also felt the consequences, as the mobile internet has been disconnected for about two month. Normally you have a connection nearly everywhere in Ethiopia and communication with home was easy, but not in October and November 2016.
* Climate: Weather conditions in Afar region are incriminating, especially if you are a foreigner and not used to them. Heat, dust and lack of shadow make it hard to work. The biggest issue regarding the climate was water.
* Water: Water is necessary for construction with earth and also concrete. Until there was a water connection on site water, it had to be transported in containers there. Later they had a donkey carriage coming with two 200 litre barrels, which would have been cost expensive for a longer time. Finally our site got a water pipe shared with the mosque. The times they needed more water, for instance before praying when people are washing their feet, there was no water for us. In spring 2016 there was also a drought with no strong rainy season for 1.5 years. Nothing was coming from the pipe for about two weeks, so they sent a water truck and an additional tank so we could continue construction. One night thirsty people also stole water from our tank. It was hard to use water for construction when you saw that some people didn't have enough to drink. Then finally it started to rain very strong. The water pipes which were running only five to 10cm under the earth got destroyed. Until it got repaired we had again no water from the pipe for a few days.
* Rain: Of course, water is important for people, but bad for construction with earth. We got surprised by an unusually strong small rainy season in spring 2016. Lots of bricks got destroyed because we were not prepared for this case. We had to cover and uncover the whole wall two times a day which cost

fig. 114: Heavy rainfall on the building site in Logia

fig. 115: Bricks destroyed from water

fig. 116: River on the building site after rainfall

4. AFARKINDERGARTEN-PROJECT

us a lot of time. We also could not work on these rainy days, construction stood still. People in Afar region are not used to constant rain. You can compare it to heavy snowfall in Austria. People come too late to work, children don't go to school; it is a kind of state of exception.[19]

19: see movietext scene 49

* Storm: During the strong small rainy season a power pole got destroyed and half of Afar region was without electricity for five days, also Logia. There are two machines we used regularly on site, a small cutting machine and a drilling machine. During this time we had to bring the batteries to the APDA office which had a generator. Especially at lunch break the missing power was hard for us, because we could not use the fan.
* Communication: As no one of us spoke Afar or Amharic language we were always dependent on translators. On site we had between one and three people who could speak both of these languages and English. But their translation was not always the best. Also Afar like to discuss very much, which was tedious sometimes. When there is a problem everyone takes part of the discussion and also the whole construction stands still until there is a solution.
* Workers: It was difficult to find a team you can rely on and that is motivated to come all time. But this was very important for the whole project, because these people should continue construction without our help one day. Afar are often still on the move, most of our workers were refugees from Eritrea who were not sure about their future. Since spring 2016 our workers got regularly payment, but discipline was still a problem. They often did not come on time and sometimes were not motivated to work hard. So the first two month the workers changed a lot, which was one reason for the delay of the project. It needs time to educate the people, so it is not good if they don't stay for a longer time. (Schönher 2016)
* Earth construction: A few problems related to earth construction occurred:
* Different soil on site: When all the soil from the excavation of the first site was used up, we used material from the excavation of the hostel constructed by the contractor. But as we found out the soil there was different, it had a darker colour and also had a higher shrinkage. There was also the suspicion it could contain humus. In Europe you have to remove a layer of about 40 to 60cm to get to the humus free soil. In Afar region humus was not expected, but it occurred sometimes, so we removed the affected soil.
* Mould: The moulds we used for construction were all produced in Austria. But of course we wanted to find a local carpenter to produce a mould for our site. We tried out two in Logia and one in Bahir Dar, who also constructed the mould that was used for NESTown project. None of them brought a satisfying result. As our mixture is really sticky and contains no straw you need a very smooth surface on the mould, a traditional wooden mould for instance doesn't work.
* Maintenance of the plaster: As we decided for a mud plaster there will be maintenance necessary, maybe after every bigger rainy season. The last layer of plaster was stabilized with vegetable oil and compacted with a stone, but we only tested this composition on a small spot, we had no experience on a bigger area and over a longer time. Now that the finished building was exposed to rain there are already damages on the plaster visible. It would be ideal if there would be a person who repairs the surface after every rainy season, but you cannot be sure there will be such a person.
* Termites: A few years ago termites were not a bit problem in Logia. But since they use eucalyptus wood for chikka construction, which is not resistant against these insects, it became a big problem. We also made experiences with termites on our

fig. 117: Breaking brick infested with termites

fig. 118: Detail termites

site. When the team came to continue construction spring 2016 the wooden studs of the shadow roof were already infested and had to be renewed. Since this problem became obvious it was taken care that all wooden parts do not have contact with the floor. Termites also penetrated the thin cement layer on the floor of the shadow roof and we discovered termites inside one of the bricks, what was very disturbing. (Schönher 2016)

* Acceptance: In first place some people of APDA and also the workers were sceptic regarding earth construction, especially in terms of stability and durability. The material and composition were tested on site first and of course the results were not always satisfying. Even Ismael Ali-Gardo lost confidence in the building has he saw the destruction after the rain in spring 2016. He hired a contractor to build one hostel building out of concrete blocks. In many developing countries earth construction is regarded as a building form for poor people and as unprogressive. They would prefer to adopt imported building materials because they are considered to be more durable and also have a higher status in society. Some Amharic people from Semera University visited the site and one of them confronted us with exactly this topic. But it could be an advantage that Afar people do not have tradition with earth buildings so far, as for them it is a new construction technique and they may regard it as innovative. (Rieger-Jandl 2013; Schönher 2015)

Strategies: On a building site like the one in Logia there are every day new problems you have to find solutions for. As Katharina Schönher explains, "There are these moments, when you feel nothing works out. When you doubt that you can achieve this. We learned to deal with it. And after some time we knew that a new challenge is just a little step forward on our way to reach the objective." Different strategies were found to ease difficulties on site.

* Cooperation: The cooperation with the local NGO APDA was necessary and also very helpful, because they had contact persons who could help us. By living in the compound of Valery Browning and Ismael Ali Gardo, who are known and respected in the whole region, we also felt safe and protected in this strange place. Also EiABC in Addis Ababa was important for exchange and to use the laboratory to test the bricks. They also helped to organize business visas.
* Gain trust: As already mentioned people had their doubts regarding the strength and durability of the earthen material. One strategy to gain trust was the laboratory test of bricks done in the capital Addis Ababa. Also the hands-on construction was very helpful. It was important that we as foreign people work together with the locals, so they see it earth is not a material only poor people. Another strategy to get a better bond to the workers was our daily coffee break, the "bunna ba". There we could talk

with them and discuss things, also it was something special they would not get on any other building site. (Schönher 2015)

* Improving processes: It needed some time until the best way to work with the local people was found. Finally every morning the team was divided into groups with defined tasks they were responsible for, and this strategy worked out well. They also had the option of a higher payment if they did a good work over some time, which was also a motivation. Also the wooden mould was improved. October 2016 Mark Ortler and Katharina Schönher introduced a mould where six bricks can be produced at once by three people.
* Cultural mix: For the last three weeks of construction in spring 2016 half of the team changed again. This time it was decided also to hire experienced Amharic workers, as they are used to be on time and to work hard. This has turned out to be a good decision, as they also motivated the Afar workers to be more productive. Amharic workers also had the advantage that they really lived in Logia, they had their families there, so when Katharina Schönher came back to site October 2016 she could continue construction with five experienced members of the former team, which was a big relief. Three of them were Amharic, two Afar.
* Be open for changes in construction: Some details had to be worked out directly on site or have been changed during construction process. After her first stay Katharina Schönher found out that "Planning is good, but the reality often comes in other ways."[20] Here are some examples (see fig. 120):
* Supporting structure: It was planned that the ceiling of the first floor was supported by a trussed beam out of sawn timber. As the sawn timber that you can buy in Logia is very expansive and of a bad quality it was decided for a simpler construction with beams out of round Eucalyptus wood with a supporting pillar in the middle.
* Shade construction: In her master thesis Katharina Schönher planned vertical shading elements in front of the entrance of the ground floor. They should also offer an additional private area and protection from animals. Because of different reasons these vertical elements were changed into horizontal shading elements covered with afar mats. (Schönher 2016)
* Wooden framework: The diagonal bracings that absorb horizontal forces were differently placed than in the original design, because they would have penetrated the floor construction. As this would have been very complicated to build it was decided to shorten them. (Schönher 2015)
* Windows: It was decided to place the stop of the window casement outside the wooden window frame so that the wood can work without impairing the opening mechanism. Also the lintels which should have been made of wood in the first place were changed into a construction of reinforced concrete, so that in case of termites the load capacity is preserved.

20: Schönher 2015: 112

fig. 119: Team Mai 2016

* Construction of the stairs: The stair construction was decided directly on site by making sketches and by trying and discussing different possibilities. Finally it was decided to make the first two stairs out of stone and concrete and to lift up the wooden construction by metal profiles to offer as little surface as possible in case of a termite attack.

It was a long, hard way to finish the first hostel and many challenges were mastered. Katharina Schönher wanted the building to "(...) act as sample stimulating discussions and generating new impulses in the development of urban architecture."[21] There was a big interest within the population of Logia, as many people were passing by the building site and asked what it is about. Some of them could not believe that the bricks produced by the team were made of earth, they thought it was concrete. As concrete houses are associated with a higher status and living standard, I think constructions with adobe bricks have the potential to be accepted and reproduced in future.

January 2017 Matthias Kraßnitzer, also student at University of Architecture in Vienna, started the construction of the third hostel with the rest of the funding of EZA Vorarlberg. Instead of adobe bricks rammed earth was used as wall material, which also seems to be an alternative to wooden construction and concrete. Now that the funding is used up, the finalization of the rest of the building complex is unsure.

21: Schönher 2015: 6

fig. 120: Changes from design (black) to construction (green) of the hostel building. Longitudinal- and cross sections M 1:200, section window M 1:100

5. NESTown-PROJECT

New Ethiopian Sustainable Town

Location: Bura, Amhara Region

http://www.nestown.org/

fig. 121: Finished Rainwater-Unit of NESTown

5.1 The need for new towns in Ethiopia

Population growth: The population of Ethiopia has grown from approximately 48 million people in 1990 to 99 million people in 2015 and will continue growing. This increase is mainly due to the high birth rate, since having a lot of children is a sign of wealth in Ethiopia, but migration is also a reason. Though it is one of the poorest countries in the world, Ethiopia was hosting about 736.100 refugees in 2016, mainly from South Sudan, Eritrea and Somalia. Most of the people in Ethiopia work as farmers in scattered rural settlements. With its fast increasing population there is not enough productive farming land for everyone, also resources like water are limited. Often people have to walk long distances to get access to education and health services. Hoping for a better future more and more people are moving to cites. (Giorghis/ Oswald 2015; unhcr.org)

The history of urbanization: Ethiopia has a very long history as independent nation, therefore also indigenous urban development took place. It started in the Pre-Axumite era 500 BC were archaeological remains and written documents of Yeha prove an urban type of settlement and a level of advanced culture and continued with the Axumite era in the first century AD. The next important urban centre was Roha, the seat of the Zagwe rulers from 1150-1270 AD, now called Lalibela, the place of the famous rock-hewn churches. After a period of wandering capitals during the Empire of Abyssinia, King Fasilades (1632-1667) ended this tradition and Gondar was founded as political capital. Other important urban centres developed in the 17th, 18th and 19th century along important trade routes (Adwa), as seats of independent governors (Ankober) and garrison towns (Debre Markos). But a lot of destructive civil wars in this period affected the urbanization process, political centres got destroyed and regional governors and also their seats lost their power. Through the establishment of military garrisons under Melinek II (1889-1935) the process of urbanization proceeded.

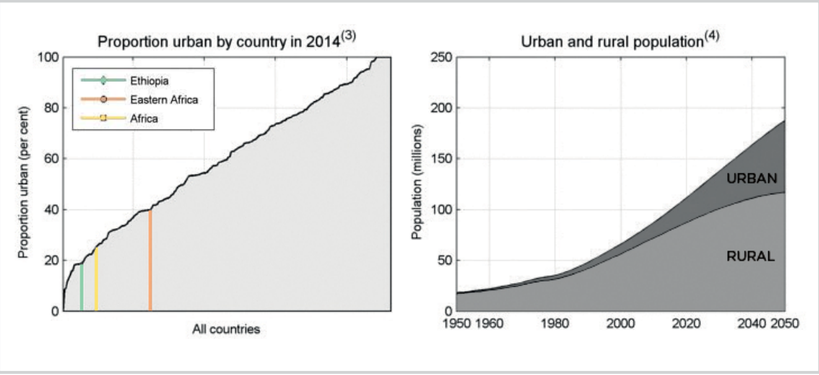


fig. 122: Urban population in Ethiopia

One of them became his seat and is now the capital Addis Ababa. Through the construction of the railway in from the capital of Ethiopia to Djibouti town, Dire Dawa emerged as an urban centre in 1903 and others like Adama followed. The Italian occupation from 1935-1941 also stimulated the development through the construction of highways that connected all towns and the expansion of urban services and infrastructure like schools, health centres, hotels etc. During the Derg Regime private houses were nationalized and people got discouraged in building or repairing them. That's why many rural buildings got in a very bad condition. As part of the Villagization Programme young people were also forced to move to new urban settlements to reduce the density of farming population in the highlands. This brutal procedure left a big trauma and mistrust in the people and makes further urbanization programmes difficult. (Gebreyesus 2015; lecture Oswald 2012)

Urban growth: According to the United Nations World Urbanization Prospects of 2014 only 19% of the Ethiopian population are living in urban areas, but the estimated annual population growth of 2,5% per annum has to be mainly absorbed by these areas. In 2050 188 million people are expected to live in Ethiopia and about 70 million of them are going to have their home in a town or a city. (esa.un.org)

By now 18 million people are living in urban areas, so the country has to prepare for the demand of water, food, energy, infrastructure, shelter, education, health care and jobs for 52 million people in 35 years. Challenging transformations in the economic, social and political structures will be necessary, but these changes also offer opportunities for improvement, as urban areas are centres of creativity, places of diversity and education. (Cherenet/ Sewnet 2012; Giorghis 2015)

Problems with urbanization: Because of this high demand for additional urban space the government has to act and provide infrastructure. Currently most young people are moving to the existing bigger cities in Ethiopia, mainly Addis Ababa. The capital hosts more than 26% of the national urban population and is ten times larger than the second largest city Dire Dawa with only 300.000 inhabitants. This concentration of population in only one or two centres is called urban primacy and a common phenomenon in African countries. It is said that 1200 people are coming to Addis Ababa every day to live there. The government cannot provide infrastructure and services for so many people. Consequences are informal areas, serious environmental problems and poverty. To stop this unbalanced concentration of resources, the strategy is to create a more polycentric urbanization, to strengthen small and medium level towns and also to create new towns. (Giorghis 2015, vimeo.com)

The strategy: The plan of the government is to build 8000 new towns[22] for 25 million people in the next five years to be prepared for the prospected increase of urban population. The question is how to implement so many new settlements in such a short time and which concepts and typologies are to use. For a long period urban development was determined by master plans from foreign architects and planners who did not understand the structures of old Ethiopian towns, for example Axum. The ancient composition of compounds, private streets and a public space in between was destroyed to create straight roads; the city lost its identity. Another problem is the wrong image of the building industry with Dubai and China as references, using modern materials and typologies that do not correspond to the local climate and tradition and is also is highly import dependant. To create towns that are environmental sustainable and also accepted by its future inhabitants is challenging and requires the expertise of professionals. One of the projects facing this challenge is presented in this chapter. (Donath 2016; Giorghis 2015; Giorghis 2016; Cherenet/ Sewnet 2012)

22: Classifications of towns of the Federal Urban Planning Institute (FUPI): 5 categories: small town (2000-20000 inhabitants), medium sized towns (20000-50000 inhabitants), large towns (50000-100000 inhabitants), cities (100000-1000000 inhabitants) and metropolitan agglomerations (more than 1000000 inhabitants), Oswald 2012: 16

fig. 123: Traditional papyrus boat on Lake Tana (left page)

5.2 Kebele Bura

Site situation: Bura-Kebele is part of the Amhara-Region and is situated 500m east of the road from Gondar to Bahir Dar. People speak Amharic language. It borders the Lake Tana, with a size of 3156 km² the biggest lake of Ethiopia and also the source of the Blue Nile. The Kebele has 6835 inhabitants; half of them are below age. 51% percent of the lands are arable, 8.3% pasture, 5.9% forest and 17.8% covered with water. The landscape around the lake, which is elevated 1785m above sea level, is determined by large plains of fertile soil. (NESTown Group 2014)

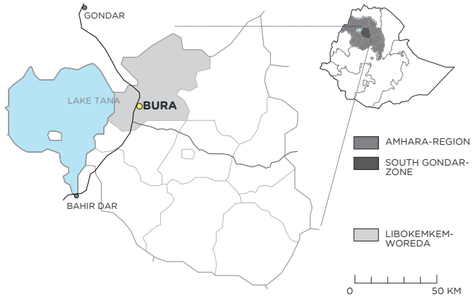


fig. 124: Site plan of Bura

The water issue: In the area around Lake Tana there are two problems related to water. One is the big difference in the amount of rainfall between dry season and rainy season. In the rainy season between June and August the water level rises up to 1.5 m to normal. A lot of rain comes down in a very short time, like a shower. The soil cannot penetrate so much water at once. So some areas get flooded and erosion problems are the consequence. On the other hand, during the dry season between September and May Lake Tana loses 20% to 25% of its volume and most of the rivers run dry. The second problem related to water is the special soil in this area, called "Vertisol" or "black cotton" soil, which is highly expandable when it's getting wet and makes construction difficult, especially regarding the foundation. (vimeo.com)

Construction: The traditional construction material is wood and there are two housing types, the "Corcoro", with a rectangular form and a tin roof, and the "Sar bet", the traditional round hut with a thatched roof (see fig. 125). The wall construction of both types is the same, wooden poles are put into earth, connected with horizontal laths or ropes and covered with mud

fig. 125: Traditional construction in Bura

fig. 126: Inside a "Corcoro house"

plaster on the inside. The carpenter needs 5 days for constructing a "Corcoro" house and 8 days for the "Sar bet", because the thatched roof needs more time. But the building costs of the traditional house are only one third to the one with the tin roof, because CIS is very expensive. (NESTown Group 2014)

The people and how they live: A community of 722 people and 1750 farm animals are living around the building site described in this chapter. 34% of the villagers are still in a "Sar bet". Both house types are used for the same functions, thought in the "Corcoro" type they are more separated and it offers more space (see fig. 127):
Most important is the common space that is where people also receive guests. It is also used for sleeping (1), eating (2), working (3), washing (4) and as shelter for livestock during the rainy season (5). The second part, separated from the other is used as food storage (6), for cooking (7) and sleeping for high rank family members (8).

23: see movietext scene 23

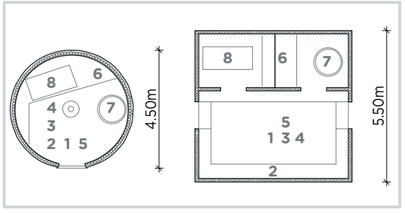


fig. 127: Floor plans of a traditional "Sar bet" and "Corcoro" house M 1:200

5.3 About NESTown

NEST (New Ethiopian Sustainable Town) is a real life experiment about the development and construction of a new type of rural town. It shall enable a sensible transformation from rural-ite to urbanite livelihood of the local farmers and prevent people from migrating to bigger towns or cities. Sustainability in present and future is one of the main targets. The new town shall provide the inhabitants with food, water and everything else they need. (NESTown Group 2014)

fig. 128: Logo of NESTown

Project kick-off: The project began with the lecture "Nets of Urban Capacity Building" given 2007 by Professor Franz Oswald at the Addis Ababa University. It presented an urban town model for the country based on the 4E factors education, ecology, energy and exchange. Professor Fasil Giorghis introduced this idea of a network of towns to local planners and people suggested a real life experiment. The former president of the Amhara Development Association (ADA) Ato Helawi Yoseph was very interested on the idea and helped finding the building site in Bura. (NESTown Group 2014)

Main principles: The main principles are anchored in the Charter of Rural Towns. It provides a shared base of the project and a clarification of the tasks and roles of the two groups of players. These players are the inhabitants that build their town and live in it on the one hand and the administrators who create the preconditions and help them to achieve their targets on the other hand. Mutual trust between those groups is a major requirement.
The charter has seven points. Some of the main issues are self-sufficiency, which means people produce their own food, water and value added products and sustainability by exchange and renewal of regional resources. A dense form of housing instead of scattered single farms is obligatory for an efficient and mixed use of land. As the inhabitants build their own town, they can identify with it, they also get educated in handcrafts and new, future-oriented jobs are created. They are also self-reliant and can decide if they produce for themselves or for export. Rural towns are flexible and can be built in different places, but they can differ in their appearance, depending on topography, materials etc. (NESTown Group 2014)

The 4E factors, created by Franz Oswald, also played an important role planning and implementing the project. They represent the fundamental forces of urban living; education, ecology, energy and exchange.
One of the important tools to ensure sustainability and income in NESTown is ITA- Integrated Town Agriculture. It contains theoretical and practical knowledge in soil, cultivation of plants, the raising of animals etc. It is trained and evaluated regularly. (Oswald/ Giorghis 2016)

Key Partners: In June 2010 NESTown Group was formed with following Partners:

* Ethiopian Partners: ADA Amhara Development Association, BIUD Bureau of Industrial + Urban Development, ORDA Organisation for Rehabilitation and Development in Amhara
* The scientific expert group: EiABC Ethiopian Institute of Architecture, Building construction and City development, ETH-Zurich Faculty of Architecture, Federal Institute of Technology, Zurich, BDU University of Bahir Dar
* European partners: Holcim Foundation for sustainable construction Zurich, Pro Semien foundation Bern; Green Ethiopia Foundation Winterthur, ABZ Allgemeine Baugenossenschaft Zurich. (NESTown Group 2014)

The project is led by a steering committee of about 12 different organizations of regional level. (Jembere 2017)

Financing: The project is financed through cost sharing. Ethiopian and foreign partners agreed in this principle. The BuCTC (Bura Community Training Centre) school building for instance is financed by ADA; the tree nursery, fencing, forestation road and Bu-ITA model garden by ORDA, in collaboration with

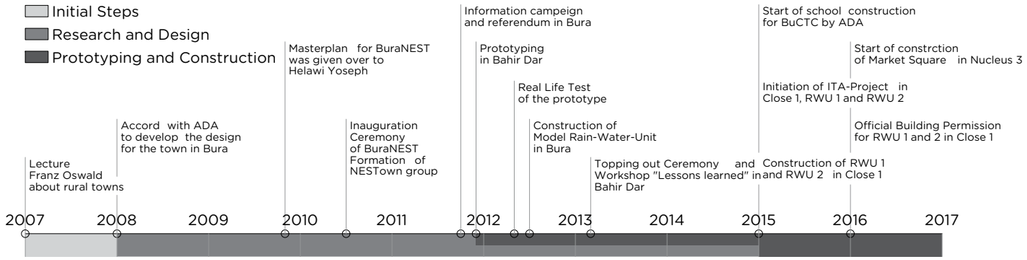


fig. 129: Timeline of NESTown project

5. NESTown-PROJECT

GREEN ETHIOPIA. NESTown group was financing the cross frame construction of the Model RWU, the Market Square, and the construction of the cisterns and stables of RWU 1 and 2 in Close 1 etc. In future the RWU shall be financed and constructed completely by their inhabitants, but by now they still need help and advice from NESTown Group. (Jembere 2016)

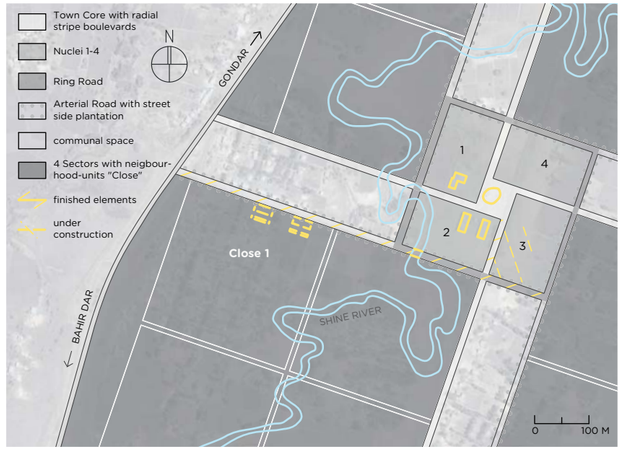
5.4 The components of the Town

NESTown has been designed from the flow of water. "Sustainable water management is actually the prime motivation for building new towns (...)"[24] As already mentioned, there is heavy seasonal rainfall from June to September. It is very important to harvest and save this water to be prepared for the dry season and to ensure food and health security. So the design of the town depends on the flow of the rainwater. The roofs of all buildings, which are located in the higher parts of the site, are used for catching rainwater and collecting the water in cisterns. Fields are in the lower parts where canals, intersections, clap sills and dams are regulating the flow of water. 33% of the area of NESTown is used for houses and infrastructure and 67% are agricultural space, forests and rivers. (Oswald 2012, vimeo.com)

24: Oswald 2012: 22

25: see movietext scene 24

fig. 130: Site plan NESTown-project M 1:10.000



NESTown is organized around a Town Core and is planned for approx. 20.000 inhabitants. It is composed of the following Elements, ordered from inside to outside:

* The Town Core with a central square and a Ficus Tree, which is an important element for Ethiopian communities.
* 4 radial strip boulevards starting at the central square that are going in 4 directions and offer different views.
* 4 nuclei for particular urban institutions that represent the 4E.
* A ring road around the 4 Nuclei with arterial roads with street side plantations starting at the corners.
* 4 sectors of the town, which are demarcated by strip boulevards. These sectors contain neighbourhood units called "Close" for living and ITA. One Close is composed of housing rows with arcades on the front side and gardens in the back.
* The areas between the strip boulevards and Arterial Roads serve as communal space. (NESTown Group 2014)[25]

The 4 Nuclei: "(...) urbanization cannot be defined merely as the coming together of people in one place, for this definition would be too simplistic. Moreover, urbanization is a cultural condition requiring social institutions."[26] All institutions that serve the whole community are concentrated in the Town Centre and separated into four Nuclei, each one mirroring the function of one of the 4Es. They should be built very soon, as they are necessary for early life in town and are a visible symbol of the new lifestyle. (Oswald 2012)

* Nucleus 1 for Education: Containing the CTC, the ITA Model Garden and the Internet Centre. A part of the CTC and the garden are already finished.
* Nucleus 2 for Energy: Containing the Town Factory with workshops, classrooms, a timber plantation, guest rooms, storage facilities and model houses. It was the first element finished in NestTOWN and is part of a long term plan, as components of buildings can be constructed inside during rainy season.
* Nucleus 3 for Exchange: Containing the Market Square and business stands, a bank, a coffee shop, parking space and a bus station. It serves transport and communication.
* Nucleus 4 for Ecology: Contains communal services for recycling and health care, a kindergarten, a home for elderly and public administration. (Oswald/ Giorghis 2016, vimeo.com)

26: Franz Oswald in NESTown Group 2014: 46

The Close: The urban neighbourhood unit, called "Close" is the place of living, farming and animal husbandry. Each has 150 to 180 households with 1200 to 1400 inhabitants. "Close" means enclosed identity, because each Close differs from the other, has its own characteristics. The place for living is called Rainwater Unit (RWU), which is a kind of row-house with maximum 8 households each. (NESTown Group 2014)
2015, the construction of two Rainwater Units (RWU) in Close 1 started.

fig. 131: Model RWU in Nucleus 2

fig. 132: Town Core with central square and Ficus tree

fig. 133: CTC in Nucleus 1

fig. 134: Market in Nucleus 4

5.5 The Rain Water Unit

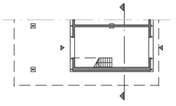
The RWU is the house is for living and protection. The flexible structure can also be used as workshop or kiosk if necessary. As the surface of the roof harvests rainwater one row of houses is called Rain Water Unit. One RWU is for maximum 8 separate households with a base area of 4 x 7 metres with one to three levels. Two households are sharing a cistern with 1200 m³ of water. (Jembere 2016; NESTown Group 2014)

The design: The decisive idea for the design was to get a higher density of living which brings some advantages. You have more farming land, you can share the building costs and through the big roof area you can collect water. It was also important to use the resources you have on site, the materials as well as the proven craftsmanship of the locals. Also technical and functional demands were relevant; therefore the building of a prototype was essential. (NESTown Group 2014)

To increase the living standard of the farmers hygienic facilities like toilets and showers, electricity and a spatial segregation of human and animals are provided.

The construction: To safe costs and material and because of local conditions the main structure of the RWU is a wooden framework.

* The Foundation: Because of the special soil conditions it was necessary to make a pile foundation. The "black cotton soil" has a high amount of clay and swells up to 60% when it's wet and would destroy a conventional stripe foundation. As it would have been too expansive to exchange the underground, they decided for piles that reach up to 3 or 4 metres into the ground. This also makes it possible to separate the frame structure and the foundation, which is a very important prevention against termites. The framework has distance of 10 centimetres from the foundation.
* The Wooden frame structure: The local houses are entirely made of wood. As this material is getting rare, they decided to use a frame structure to save wood. The easy available Eucalyptus wood with lengths of rots of five to ten metres is ideal for building a double storey house. Using connection techniques of old churches of Lake Tana like wooden nails the way of building was more sustainable.
* The Walls: The first idea was to construct vaulted soil structures, which was not possible because of the highly expansive character of the soil. For Bura-Mariam Church, which is 200 years old they utilised "Black Cotton Soil" for adobe bricks with a load bearing frame structure of wood. For this technique you only need a mould and the right mixture of soil, water and different sorts of husks. All these materials are available during harvest time, so they decided for adobe bricks for the construction of walls.
* The Roof: The tin roof which 2/3 of the buildings in Bura are using is the most expansive part of a house in Amhara Region; it makes 40% of the building costs. The technique of the thatched roof became rare, as not many people know how to construct it anymore and the special grass you need is not often available. They did not want to use CIS as roofing material, but there was no alternative. By using the CIS roof as communal roof they could gain advantage of the expensive material. By constructing a two storey row house you don't have to build so many overhangs and need far less m² iron sheet per m² living space than usual. The big roof is also good to catch rainwater and keep the soil underneath dry. (NESTown Group 2014, vimeo.com, nestown.org)



SOIL MATERIAL

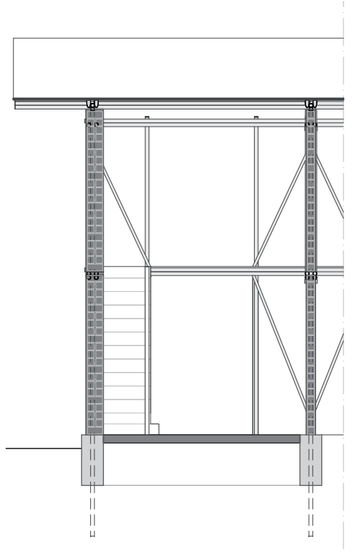


fig. 135: Preconstruction of the frame structure

fig. 136: Pile foundation

fig. 137: Wooden frame structure of a RWU

fig. 138: Future arcade of a RWU

fig. 139: Stairs of a RWU

fig. 140: Section of a RWU M 1:50

5. NESTown-PROJECT

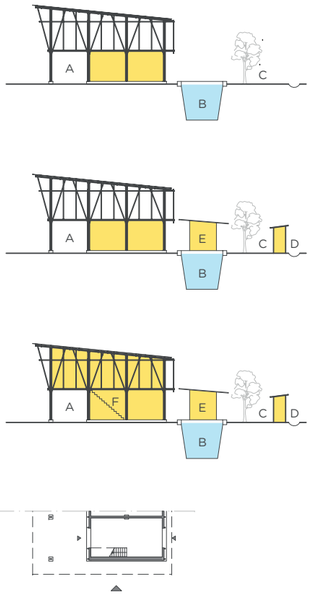


fig. 141: Different levels of finishing F1, F3, F7, M 1:500 [A] arcade, [B] water tank, [C] garden, [D] toilet and animal shelter, [E] cooking place, [F] stair upper floor, [G] gallery

The financing of a RWU: The main element of building NESTown is the participation of the future inhabitants. They get a loan for building the house and can pay it back with different kinds of distributions. The first step is the foundation of a cooperative of farmers that will share one RWU and build it together. Then the using land right will be transferred. Each household has about 500 m² for town agriculture. They can start immediately with the cultivation of their land, so they can profit from the beginning and can already pay some of the loan back. The last step will be the construction of the house and infrastructure for harvesting and irrigation. (NESTown Group 2014)

Because of the insecurity of income of the farmers, the construction of the house is carried out stepwise in different levels of finishing F1 to F7.
F1: The building shell as basic house element, including foundations, bearing structure for two floors and the roof construction and also the cistern and outside walls of the ground floor. With a base area of 42 m² it is ready for occupation for up to 6 people. The costs of this level of finishing can be compared to other offers in the neighbourhood.
F2: additional toilet and animal shelter, F3: outside cooking place, F4: stairs to upper floor and walls for one room in the upper floor (58m²), F5: second room on the upper floor (70m²), F6: third room on the upper floor (86m²), F7: floor gallery with ladder (96m²)

The time to realize the next steps can be chosen freely. In Model RWU 2 in Nucleus 2 tree model houses with different levels of finishing can be visited. So people can see what they get in the beginning and what they can get later on. (NESTown Group 2014)

5.6 The Implementation of earth

Earth was implemented in the form of adobe bricks as filling material for the wooden substructure of the RWUs. All the materials like soil and straw are available nearby, so the production is low cost. As earth is traditionally used for plastering there are already experienced craftsmen who know about working with this material. I do not exactly know why it was decided to use adobe bricks and not another earth construction method. One reason may be that they are well suited as filling material, because you can easily pre-produce them and they are easy to transport and to cut. (Hailu 2016; vimeo.com)

The mixture: To find out the right mixture of the bricks the first step was a laboratory analysis of the components and quality in the soil laboratory of EiABC. They took samples of different areas in Bura. After the evaluation they decided which soil to take for the first test blocks. The first experiment was to produce bricks with a mixture without stabilizer, only soil and silt in different relations. Next they added straw as local stabilizer and improved the brick. In the end they decided for a mixture with less amount of sand and high content of straw. The fermentation of the mixture needs about 11 days. (Jembere 2016; NESTown Group 2014)

The mould:[27] Different dimensions of wooden moulds have been tried out. In the end they decided for the size 13 x13 x28cm which was most suitable for constructing the wall. First a single mould was used by two labourers, but they wanted to increase the number of bricks to be produced parallel. After a discussion between the town coordinator Benjamin Ståhli and chief carpenter Kafyalew Hailu a mould that can produce five and a half bricks at once was constructed and used since. With the same amount of labourers it is possible to produce 60 bricks per hour. (Jembere 2016; Hailu 2016)

The production: An advantage in brick construction is the big workshop space in town factory. It makes it possible to produce bricks and leave them to dry during rainy season. After the maaleable soil had been

27: see movietext scene 40

fig. 142: Mixing soil in the workshop space

fig. 143: Tests with different examples of soil

fig. 144: Watering and mixing the soil

fig. 145: Different moulds

fig. 146: Testing bricks with different mixtures

5. NESTown-PROJECT

fig. 147: Soil inside mould

fig. 148: Soil compressed by hand

fig. 149: Excess gets removed

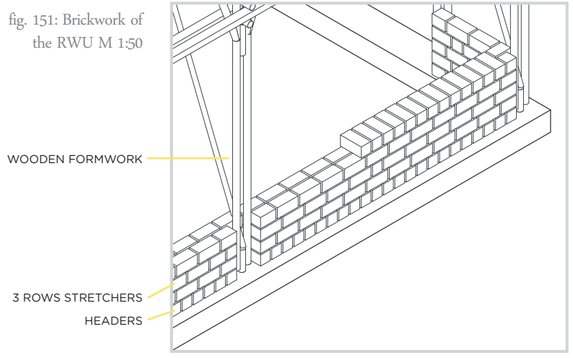
fig. 150: Making a wall as part of the artisan training

filled into the formwork it had been additionally compressed with a flat piece of timber (see .

The wall: As the wooden frame structure is carrying the ceiling and the roof, the brick wall only needs to carry its own weight. A loadbearing bond is not necessary, so they decided to use one row of headers after three rows of stretchers. The walls are constructed starting at the corner.

The plaster: On the inside walls mud plaster was used, but the external walls are exposed to heavy diagonal rains from June to August. After some experiments it was decided to use cement plastering for them to prevent the wall from heavy rain attack (see fig. 152). Because cement is not easily connecting to mud bricks they used chicken wire mesh as lath and then added two layers of plaster. (Jembere 2016)

fig. 151: Brickwork of the RWU M 1:50



5.7 Participation of the inhabitants

The building site in Bura is not an empty space; there is already an existing rural settlement. In October 2011 the project was presented to the people and they voted for it. This legal base was extremely important as participation of locals is part of the real life experiment. Building a new town is a "Learning by doing" process; design and implementation go hand in hand. The future inhabitants were involved from the beginning , as their culture and knowledge made a valuable contribution to the project. Another goal behind this participation in an early stage was to create a productive mutual learning process and to reach a higher degree of acceptance. (Giorghis 2012; Giorghis 2015)

The prototyping: After the voting participation started with building of a prototype. It took place from November 2011 to April 2012 in Bahir Dar, because they wanted to be sure the construction works before the implementation in Bura. Town coordinator Benjamin Stähli led a team of about 15 skilled workers from the area around Bura for building the basic Rainwater Unit. April 16th 2012 the final prototype was finished. Many people did not believe in the construction, because double store houses are not common in this area. They thought it was unstable. So they decided to do a real life test of the prototype by experts from different institutions. The examined the load-bearing capacity, the wind load resistance, the wind uplift resistance, the qualification of the foundation, the wooden frame structure, the mono-pitched roof, the connexions, the execution of the work etc. The people who built the prototype were extremely proud when the prototype resisted the test. (NESTown Group 2014; vimeo.com)

The Artisan training: Parallel to the prototyping the 6 month Artisan training started November 2011 in Bahir Dar. Five carpenters and 6 masons from Bura were taught in basic geometric and static principles, like diagonal bracings, a technique that is wider unknown in the area. Afterwards a one year training programme in Bura with 10 carpenter trainees started. In June 2012, 21 apprentices started with the construction of the Model RWU in Nucleus 2. After practising and learning subjects like construction site organisation and equipment, plan understanding and precision, team organisation and timing etc., they had to build the foundation and frame structure without guidance. May 2013 the 11 workers got certificates as experts in RWU. (NESTown Group 2014; Mersha 2016)

Close One: 2014 the land use rights of Close one have been transferred to cooperative societies. Since then the future inhabitants started cultivation and are also trained in ITA. 2015 the construction of the first two RWU began. With supervision of skilled craftsmen they are building their own houses. (NESTown Group 2014)

fig. 152: Testing plaster on CTC-building

"We as architects should be more attuned to the needs of our society, that is, we should be doing that reflect our culture in terms of space, materials and means of construction. If you build a building, for example, you should know how it is put together and what it takes to maintain it. If you lack this know-how, you are heavily dependent on others."[28]

28: Fasil Giorghis in NESTown Group 2014: 46

5.8 The design in comparison to the local architecture

The local architecture of Bura has already been described in chapter 4.2. The village is composed of traditional round huts with thatched roofs and rectangular houses with tin roofs, which most people prefer nowadays. At first sight the future houses of the people in Bura, the RWU, do not have much in common with the actual building practice but the used materials, wood, CIS and earth. The construction with pile foundation, framework and adobe blocks is completely different from what people are used to, also the structure. It is now dominated from scattered houses with a lot of distance in-between. In future it will be much denser, living in a row house next to each other. I can imagine this will be a big change for the people and might lead to conflicts in the beginning.

When I was visiting Bura in November 2016 I got the chance to see a "Corcoro" house from the inside (see fig. 153). In this case it was not standing alone; it was part of a small compound with additional buildings. There is an old "Sar bet" house [1], which may have been the main house in past and became kitchen later. Now it is only storage because there is no thatching material available to repair the roof. 8 years ago the family built the "Corcoro" house containing a living room [2], a sleeping room [3] and storage [4]. They also added a separate stable [5] and a kitchen [6] when the round hut broke. That shows that there is a requirement for more space and separation from the animals, so change is already happening.

For an easier transition traditional elements like a mud stove (see fig. 155) have been placed in the Model RWU. Also the use of old techniques like wooden nails (see fig. 154) may generate a kind of identification with the project. (Jembere 2016)

fig. 153: Compound in Bura M 1:200

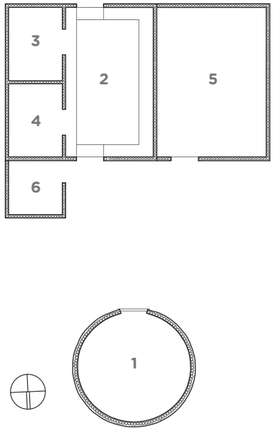


fig. 154: Wooden nails

fig. 155: Traditional woode stove in model RWU

5.9 Problems and strategies

BuraNEST is the first rural town project in Ethiopia, so this experience was new for most of the stakeholders. Naturally there were and still are a lot of complications in this real life experiment. There were strategies to prevent problems since the beginning, but most of them could not be foreseen. As the NESTown is regarded as learning by doing project, the processes are expected to improve after the location and solution of problems.

Problems: There are problems in different areas, and many of them are responsible for the great delay of the project.

* Authorities: The project depends a lot on money and permits from the government, and these are things that are out of control of the project coordinators and managers. There are complications in land transfer issues and to gain the money they were promised to get. They also needed to wait three month for the construction permit of RWU 2.
* Politics: For nearly three month, from September to December work nearly stopped completely on the building site because of state of emergency in Ethiopia.
* Cooperatives: In the beginning they had 20 cooperatives, now there are only 4.This leads to an organisational problem, as all the work like the construction of the RWU has been given to them. Often people don't go to work on building site, especially in harvesting season. Some also don't believe in the building design, as for some of the community members, modernity only means concrete and metal construction.
* Funders: Some funders got money for the project but did not spend it on it.
* Stakeholders: There is a lack of commitments of the stakeholders.
* Religion/Tradition: People in Bura have about 12 days free a month because of religious holidays.
* Infrastructure: There is a delay of construction for basic infrastructure like drainage lines for waste water and a bridge is not constructed completely. Another problem is the transport. The town coordinators and also some of the experts are living in Bahir Dar or Addis Zemen. Most Ethiopians cannot afford to have an own car, so they come to work by Mini Bus. Bura does not have a Bus station yet, so you go to the main road and wait for a bus to come by. The problem is most of them are already full, so if you are unlucky you have to go 4km to the next town Yifac to get a place in a bus. There are also no restaurants in Bura.
* Construction: The black cotton soil destroyed a part of the newly built foundation in RWU 1 of close 1. Also waiting for ordered materials caused delay.
* Acceptance: Some stakeholders and beneficial do not regard earth as appropriate modern building material. They would prefer concrete or burned bricks. So they do not treat mud bricks- and walls as they should. In case of the BuCTC for instance they did not plaster the finished earth block wall before the rainy season and they also left the bricks exposed outside without covering them and they got destroyed.
* Organisation: At my visits at the building site I had the impression it is not clear how different tasks are allocated. Mistakes happened because no one felt responsible for a problem. On example is maintenance of the existing Model RWU, which should be iconic examples for the future Inhabitants. They are not in a good shape anymore. I also discovered a colony of termites on their way to the wooden construction (see fig. 156). Finally they got removed, but long time no one took care. (Jembere 2016)

fig. 156: Termites building their way to the wooden framework

fig. 157: Bricks left outside without appropriate protection

5. NESTown-PROJECT

Trust: A big issue in implementing a new type of town is trust, as you have to interfere with many different stakeholders and the people living in Bura. Ethiopians suffered a lot during communist regime 1974-1991, they do not trust each other. They even share their small houses with their cattle at night because they are afraid someone steals it. So, one of the biggest challenges of the project was to convince the people to help each other building their houses. But it's getting better with the younger generation. Another issue with trust is the trust in themselves, as one of the founders of the project, Franz Oswald is explaining: "So the question of how trust can be generated is central, one that hinges on empowering people to trust themselves. Even though we come to Ethiopia and are seen as missionaries of sorts, our real role is helping to inspire confidence in one's own capacity building."[29] (vimeo.com)

Strategies: Most of the strategies to implement a new town have the target to strengthen the trust of the people in themselves and in other persons or the stakeholders involved in the project.

* Discussion: Information campaigns and discussions between stakeholders, future inhabitants and also among the NESTown group members are very important. (Giorghis 2015)
* Voting: The people from Bura voted for the project in 2011. The democratisation of the process was a crucial step of the process. Therefore, the founding of a steering committee of all 11 stakeholders that has the permission to make decisions was also important. (Jembere 2016)
* Cooperatives: The formation of cooperatives shall ensure a collective responsibility and sustainability of the project.
* Artisan training: Learning new skills improves the self-confidence of the people. Also the construction of the prototype and the positive testing of it created trust in the project and people were proud of it.
* Local materials: On the one hand some beneficials have problems not using modern materials; on the other hand people are used to work with wood and earth. So there is something familiar in the new typology of the RWU. (Giorghis 2015)
* Levels of finishing: Through different levels of finishing it is easier for families to afford living in a RWU.
* Long term plan for construction: The workshop space in the town core enables production of components of the town during rainy season.

One crucial point in the process of the construction of NESTown was when would be the right time for the foreigners coordinating the building site to step out. Ethiopians are used to get advice from outside, from top down. They also believe in what white people say, because most of the holy priests on old pictures in churches are white. The former town coordinator Benjamin Stähli explains the problem like that: "People believe in what I'm saying because I'm white. But it's only a momentary advantage. The risk is that they believe they cannot do it alone. This is the hardest work. To step out."[30] The objective is that the locals build their own town; that they take the lead one day. This process already started. Foreign members of NESTown group are only giving advice via internet and are visiting building site about every 6 month. They are communicating with the two Ethiopian town coordinators that are now responsible for a trouble-free construction process. (nestown.org)

Despite all the difficulties the construction of NESTown had to face so far it has been declared as the Leading Rural Town Project by the Federal Democratic Republic of Ethiopia Ministry of Urban Development and Housing (FDREMUHD) in February 2016. It is definitely a revolutionary project for this country and it will be interesting to see the influence on rural society. (Jembere 2016)

29: Franz Oswald in NESTown Group 2014: 48

30: Benjamin Stähli in vimeo.com

fig. 158: Brick production in the workshop space of Nucleus 2 (left page)

6. SRDU-PROJECT

Sustainable Rural Dwelling unit

Location: Gurage Zone, SNNPR Region

fig. 159: SRDU/ RHR-unit of Hasen Sabir in Wita Kebele

6.1 Reasons to improve rural housing

The “Tukul”, a round hut characterized by a cylindrical base and a conical roof, is the most famous form of vernacular architecture in Ethiopia. You can find it in different versions in the highlands of the country. Depending on the region and the locally available materials, the construction methods looks are varying. Though their architecture is perfectly adjusted to the surrounding environment, the equipment of the house does not correspond to the current living standard that especially young people are wishing to have. Many of them are moving to urban areas and come home for major holidays. Because of this migration rural areas become influenced by urban lifestyle. (Gebrewold/ Kassahun 2015)

fig. 160: Tukuls in the highlands around Lalibela

Especially the inside of the house causes problems in regard of modern demands. I will explain them on an example of a building survey of a traditional house in Agena (see fig. 161), one of building sites of the project described in the following chapter. One of the problems is the lack of daylight inside the building. One reason is the height of the roof that is larger than the height of the cylindrical base, what creates a dim space. It is necessary for the smoke to disperse, because there is an open fireplace in the house and no opening in the roof. Also rooms are intentionally made darker to create areas that are more private and lit ones that are more public. The reason is the lack of privacy in the house. Based on the sketch of the inside organization (see fig. 163) you can see that there are only a few walls for demarcation of different areas. Around the fireplace is an open, multifunctional space used for living, eating and sleeping [1]. There is also a storage area, mainly for food and kitchen equipment [2]. The only private space is the sleeping area for higher family members separated through a wall [3]. The cattle is sleeping inside the house [4] together with the people, so also hygiene is a problem. Additionally there are no toilets and no place for washing. (Endale 2010; Gebrewold/ Kassahun 2015)

Today the vernacular architecture is changing more and more, especially in rural areas close to urban centres. like the place of SRDU project, the Gurage Zone. The inside of the house has become more separated and they have windows and additional doors, but still there is room for improvement.

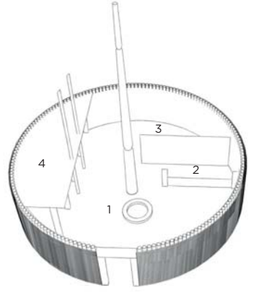
The problem of the low standard of rural housing exists all over Ethiopia. About 80% of the population is living in substandard dwellings. Rural housing is an issue that is often neglected in development projects, though it would be very important to improve the living standard also on countryside. (EiABC 2011)

fig. 161: Traditional Gurage house in Agena

fig. 162: Fire place and storage area in the backgroundonal Gurage house

fig. 163: Spatial layout of a traditional house in Agena

fig. 164: Stable inside with a storage- or spleeping space for kids above



6.2 The Gurage-Zone

fig. 165: The different sites of SRDU project

Site Situation: All sites of the SRDU project are situated in Gurage-Zone, which is one of the 13 Zones of SNNPR-Region (Southern Nations, Nationalities and People) and is part of the southernmost areas of the Central Plateau. The semi-mountainous landscape is characterized by highlands, forests and green valleys. The Zone has about 1.5 Million inhabitants and 2 bigger towns, Wolkite, which is the capital (approx. 52.000 inhabitants) and Butajira (approx. 61.000 inhabitants). (csa.gov.et)

The people and how they live:[31] The name "Gurage" comes from the people living there, as they are an ethnic group with their own language. They are known for the cultivation of "Ensete", a crop that is also called "false banana tree", and their daily life revolves around the annual circle of this plant. Gurage people are hard workers; they have good artisans and are well organized. Families live together in well maintained and clean compounds. Traditionally one compound is composed of three houses organized in a triangle. The "Goye", the biggest house where the family is living, is always standing in the middle. The "Herar" (guest house) and the "Zeger" (store) are next to it (see fig. 166). Sometimes the guest house and the store are together in one house, so the family has only two houses. In front of the compound in direction to the road is a yard, which is important for activities like weddings or cultural celebrations and also for privacy. Behind the house the backyard and the farm are situated (see fig. 167). Usually the homesteads are built side by side facing the main road to have a good connection to the market and other facilities. But Gurage villages can also be situated on a plateau, arranged around an open public space, which has the advantage of a better atmosphere, lower temperatures and better ventilation. (Last 1981; Worku 2010; Alpha/ Gutu 2010)

31: see movietext scene 29

fig. 166: Arrangement of houses in a Gurage compound

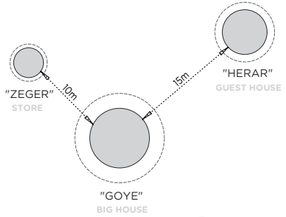
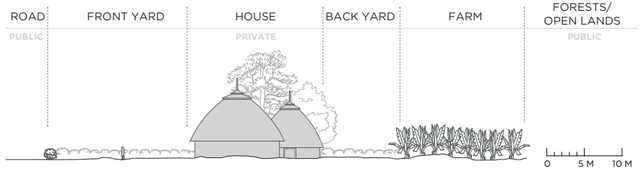
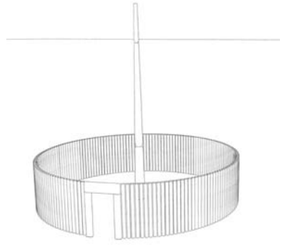


fig. 167: Section through a Gurage compound



Construction: All the materials used for the construction of a traditional Gurage house can be found in the surrounding area. Depending on the specific location and tradition, these materials and the construction method can differ a bit. Erecting the building needs the skills of numerous specialists and families are helping each other. The construction is not done by contractors but by local artisans and labourers mobilized by holding a traditional coffee ceremony.

The most important element of the house is the centre mainstay, called "Echibe", which is supporting roof. It has not only a technical function; it has also a symbolical meaning as it represents the head of the house and will also be inherited to the next generation. After raising the centre mainstay, there is always a big feast where an ox will be slaughtered. Depending on the source of information, the pillar will be erected before or after the construction of the cylindrical wall structure. For this wall, a ditch is made along the circular outer boundary of the house. Wooden studs are put inside and form the structure of the wall. They can either be in a bigger distance to each other with gaps filled with thinner wood or bamboo and tied together, or they are close together and connected horizontally from the outside. To construct the roof, the rafters are fastened on top of the centre mainstay and to the wall and tied together in a sequence of parallel circles. Then an umbrella-like structure ("Wagga"), a set of diagonal beams supporting the roof is fixed on the pillar. In bigger houses there can be a second set of beams. At last the roof will be thatched with grass and the inside of the walls plastered with a mixture of earth and straw. (Gebrewold/ Kassahun 2015; Gebrewold 2016; Shack 1966; Yitbarek 1997)



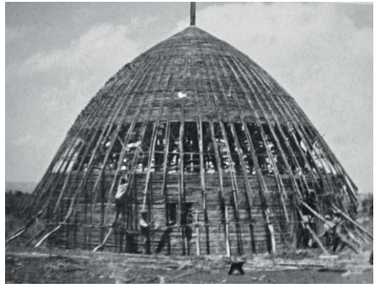


fig. 168: Centre mainstay "Echibe" and wooden wall structure

fig. 169: Wooden structure covered with bamboo

fig. 170: Rafters

fig. 171: Umbrella-like structure "Wagga"

fig. 172: Bamboo is fastened on the inside of the rafters

fig. 173: The roof will be thatched with grass

6.3 About the dwelling unit

SRDU

fig. 174: Logo SRDU

SRDU (Sustainable Rural Dwelling Unit) is a proto-typology of a housing unit in rural areas. It is combining the positive elements of vernacular architecture with a better living standard, sustainable materials and renewable energy like solar energy and bio-gas. The target is to improve rural housing standard. By the time the project got bigger in scale and finally 8 housing units on 4 different places have been built. (EiABC 2011)

Project kick-off: SRDU-project started in 2009 as a research of EiABC on rural housing, coordinated by Dr. Elias Yitbarek. Based on this research they wanted to construct a single unit to test in on a real site. They could win partners in Gurage Zone, so the research was focused on housing in this area. A team if 8 instructors from EiABC, 13 Master students and 33 undergraduate students were gathering data in the area. After analysing the material a design was made and presented to different people in January 2011. The idea became wider and the stakeholders more in number. Arthur-Waser-Foundation secured funding for one year and ETH-Zurich became involved for supervision reason from Switzerland. Construction of SRDU 1 started 2011 in Gubre, near the local university. (Gebrewold 2016)

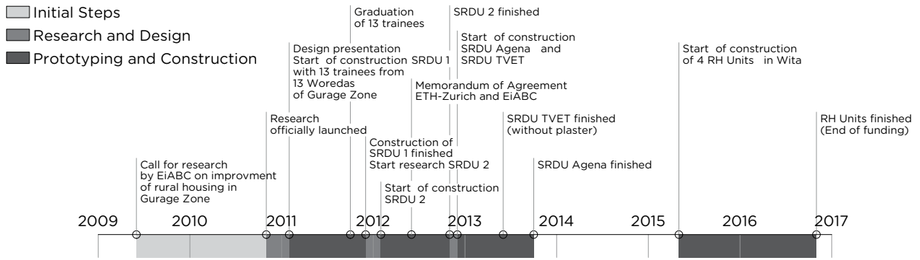
Main principles: SRDU embodies the positive features of modern houses and vernacular architecture of the region. The new housing unit shall be cost effective, easy and fast in construction and responsive to the local context. Other important principles are the use of appropriate material and construction methods, the use of renewable energy and capacity building. (EiABC 2_2012)

Key Partners: The core research team is formed by members of different chair of EiABC and the Horn of Africa Regional Environment Centre (HoAREC), who is responsible on renewable energy.

* Local Partners: Wolkite University, Wolkite Polytechnic College, Gurage Zonal Administration and the Bete-Gurage Cultural Centre (BGCC), which is a voluntary association to promote Gurage culture.
* International Partners: ETH-Zurich North-South Centre and Arthur-Waser-Foundation

Financing: The initial research was financed by seed money from EiABC. Later most of the funding was provided by Arthur-Waser-Foundation. HoAREC covered the expanses on renewable energy research, training and components. (EiABC 2011)

fig. 175: Timeline of SRDU-project



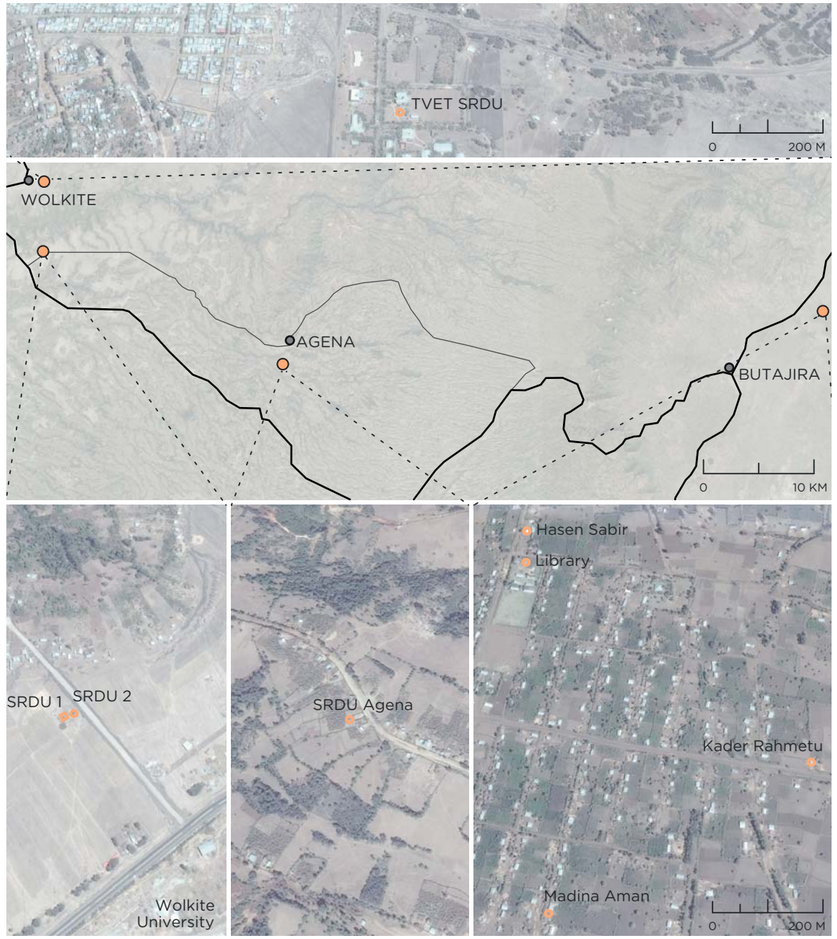
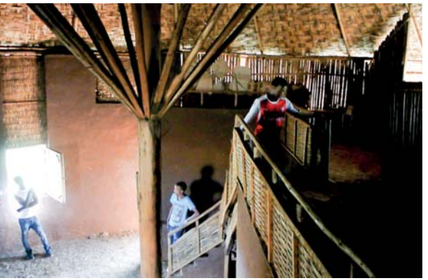


fig. 176: The eight building sites of the dwelling unit M 1:500.000 and 1:10.000

6. SRDU-PROJECT









6.4 The evolution of SRDU

The 8 dwelling units were all built in Gurage-Zone, starting in Gubre in the west and ending near Butajira in the east of the Zone (see fig. 176).

SRDU 1:[32] The first prototype was built in Gubre next to Wolkite University. The plot of land belongs to BGCC and they wanted it to be permanently exhibited to demonstrate Gurage culture. For construction 13 artisans from 13 different areas in Gurage-Zone were invited and trained. As a combination of a modern and a traditional house SRDU 1 has a rectangular form. Like in traditional house there is a flexible open space for living and dining near the entrance. Half of the house has two storeys with a kitchen and a bath room in the ground floor and two bedrooms in the mezzanine floor. Construction was completed in December 2011after about 11 month and inauguration with all stakeholders was conducted. They saw potential in the project. (Gebrewold 2016)

SRDU 2:[33] After the success of the first unit it was decided to scale up the project. Comments from the stakeholders were gathered to improve the design. SRDU 2 and all the following housing units became a more circular layout because people in the region are fixed to that geometry. The room layout nearly stayed the same, apart from an additional stable situated in the back of the house. The 13 artisans that constructed the first unit were enlarged through two TVET (Technical and Vocational Education and Training) graduates. TVET-Centres exist all over the country and they saw potential to scale up the project to different regions. SRDU 2 was erected next to SRDU 1 in about ten month and finished October 2012. (Gebrewold 2016)

SRDU Agena:[34] In November 2012 the construction of another unit started in the village Agena. A local family heard of the project and wanted to live in a SRDU unit. They financed it by themselves and built it with technical assistance of the 13 trainees and the two TVET graduates. The rest of the labourers were mobilized in traditional way by holding a coffee ceremony. The building method and layout of the house was nearly the same like for SRDU 2, but the additional stable is missing. The unit was finished September 2013 after about 16 month. (Gebrewold 2016)

TVET SRDU:[35] To further scale out the project in a wider area it was decided to develop an own curriculum for TVET to educate people in the construction of SRDU. The initial step was to build one housing unit at Wolkite Polytechnic College starting November 2012. Mai 2013 construction stopped without finishing plaster and interior. (Gebrewold 2016)

4 RHR Units in Wita:[36] Though there was a memorandum of agreement signed between ETH-Zurich and EiABC in Mai 2012 to continue the project for 36 month the collaboration ended when the representing coordinator of EiABC Elias Yitbarak left university. Dirk Hebel who was representing funders' side had the obligation to report something to them. With the rest of the funding he continued the project under the name Rural Housing Research (RHR). He got help from a member of the former research, Melakeselam Moges. He acted as contractor in the construction of 4 more units in Kebele Wita starting April 2015. Three of them are houses for families and one has the function of a library of a local school. A few modifications in design and construction have been made for these units. September 2016 construction was finished. (Gebrewold 2016)

32: see movietext scene 30

fig. 177: SRDU 1 outside

fig. 178: SRDU 1 inside

33: see movietext scene 43

fig. 179: SRDU 2 outside

fig. 180: SRDU 2 inside

34: see movietext scene 45

fig. 181: Agena outside

fig. 182: Agena inside

35: see movietext scene 44

fig. 183: TVET SRDU

36: see movietext scenes 50-53

fig. 184: RHR unit Hasen Sabir

fig. 185: RHR unit library

fig. 186: RHR unit library

fig. 187: RHR unit Kader Rahmetu

fig. 188: RHR unit Madina Aman

6.5 The construction of SRDU

As already mentioned there are different versions of SRDU or RHR units. What they have in common is the umbrella-like structure of the roof, which was taken over by the traditional Gurage house. Also the room organization with a ground floor and a mezzanine floor and the construction of the wall with adobe bricks are the same. In the detailed description on design and construction I refer to SRDU 2, which is the role model for all the following versions.

Design: The initial interest of the research team was to design a sustainable building constructed with local available materials. In respect to the rural community and the local tradition they did not want to divert from the original Gurage house but qualify it. The design concept was to isolate the suiting from the house. The building was seen as a vertical envelop around an umbrella. Regarding the spatial layout some adoptions had to be made, for instance the separation of humans and animals and the integration of a toilet and a place to wash. For more privacy a mezzanine floor was installed. (Gebrewold 2016)

Construction: According to the design principle of an umbrella and a vertical envelop a light framework supporting the roof will be constructed first. Then the wall, which is only self-load bearing, will be erected.

* Excavation and foundation 1: First step of construction is to clear of the site and to make excavations for the foundation. The depth depends on the respective load. The trenches will be filled up with stone material up to the ground level.
* The frame structure: The first step after making the excavations is to erect the central pillar. It should be at least two metres below ground level. The bamboo studs of the framework with a diameter of 7 cm are placed in the right position. They will connect the foundation with the wall and improve the lateral stability and earthquake resistance of the building.
* Foundation 2: A trench foundation out of stones concrete with a thickness of 50 cm is made, that fixes the studs in their position. On the inside it will end the same level like the floor; outside it should be at least 25 cm above ground level to protect the earthen wall from water. (EiABC 2011)
* The roof: The studs will be connected with each other to form a wooden ring beam. The rafters made of a double layer of bamboo with will be fixed on top of the central pillar. Then two umbrella-like structures ("Wagga") will be fixed on the central pillar and connected to the rafters (see fig. 191). First the rafters will be covered with woven bamboo-mats (see fig. 189) and form a kind of bamboo-basket, and then five layers of bamboo sheets are fixed on it (see fig. 190). This technique is traditional in the southern rural areas of Ethiopia. The special grass traditionally used as thatching material is not easily available anymore, so it was decided to replace it. Bamboo cover also has the advantage that it is easier to mend, because you can replace single sheets that are broken, while thatched roofs cannot be repaired partially that simple. (Gebrewold 2016)
* The wall: The walls are constructed with adobe blocks. First step is to erect the two vaults that carry the mezzanine floor. Because of the thrust these vaults need to be reinforced with buttresses. It is essential to build these buttresses before starting the vault. A formwork was used to construct the vaults. The next step was to erect the outer walls. The bamboo studs supporting the roof were built-in the masonry. To construct the arches above the doors also a wooden formwork had been used (see fig. 192). (Maini 2012)

Figures on the right page:

fig. 189: Weaving bamboo mats

fig. 190: Fixing bamboo sheets

fig. 191: "Wagga" and Bamboo Basket

fig. 192: Wooden formwork

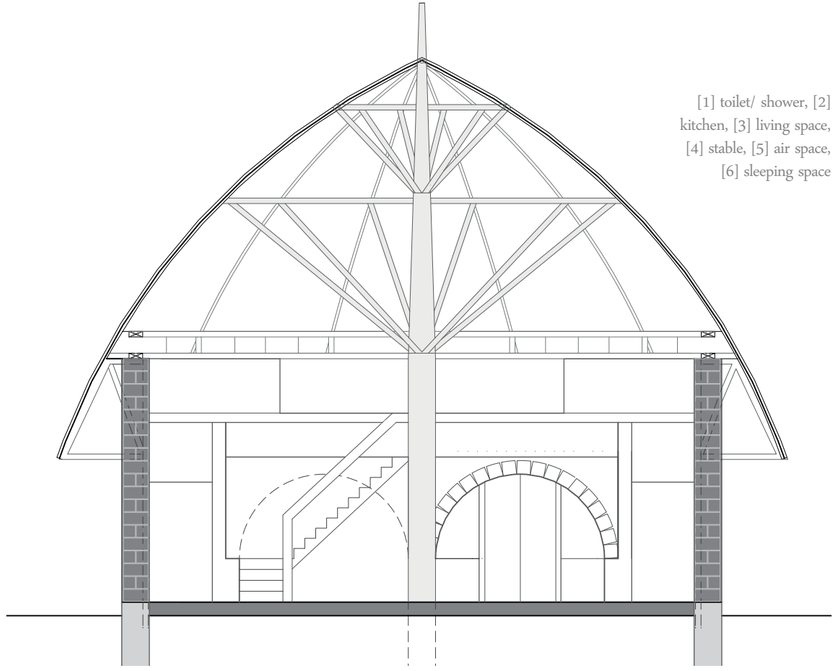


fig. 193: Ground plan of SRDU 1 M 1:500:

[1] toilet/ shower, [2] kitchen, [3] living space, [4] stable, [5] air space, [6] sleeping space

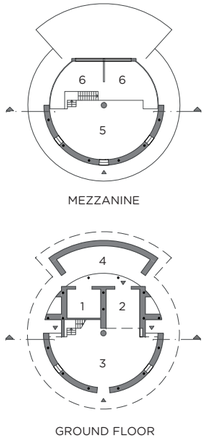


fig. 194: Section of SRDU 1 M 100:

6.6 The implementation of earth

When I visited the SRDU sites in November 2016 all housing units were already finished. Information I got mainly from Berhanu Gebrewold from EiABC and Fita Alayu, who is human resource development officer in Wolkite Polytechnic School. I could not find out details about brick production and the exact composition of the material. In case of TVET SRDU you could see the construction of the wall (see fig. 199), because it has not been plastered. Also the foundation of the vault is clearly visible, because it has never been completed.

The research team decided to implement earth as building material because many people already know how to work with it, as most of the buildings are covered with it. Why they decided for adobe blocks and not another earth construction material I could not find out in my research. One reason may be that the mezzanine floor is supported by a vaulted ceiling and they also needed the bricks for this purpose. The research team was generally interested to improve the applications of utilizing earth in construction. For SRDU it had been taken as floor plaster, where they used a mixture of cement and mud, as plaster for the walls and for the bricks. (Gebrewold/ Kassahun 2015)

The mixture: The housing units have been built on 8 sites, so the soil quality is different. Investigations have to be made separately for each of them to find out the composition and the right mixture for bricks. In case of TVET SRDU in Wolkite there was a very sticky soil called "Awolse". It has been tested at EiABC and they evaluated it as very strong and good as substitute for cement blocks. You only had to mix it with water and add straw as stabilizer; there was no reason to add sand or cement. (Alayu 2016)

The mould: On my research on site I could observe that different sizes of bricks have been installed. The biggest and main block size of 25 x 50 x 25cm and had been used for the outside walls and also for the vaulted ceiling. I could not find a lot information about the different moulds used for making bricks. What I could observe on the pictures is that they used a single formwork for the big blocks. It seems like it was made of metal and that you can open it. Because of the huge size of the adobe block I can imagine it would be too difficult to lift up the form, so maybe you can dismantle it. Because of the heavy weight of 17kg, it was considered to reduce the size of the block, so that the production could also be managed by a family.

The production: I also have not much information about how the production of the bricks was organized. From pictures I could see a temporary wooden framework covered with plastic was constructed for SRDU 1 to protect the bricks from rain and direct sun during the production and the drying process (see fig. 197).

fig. 195: Mixing soil and straw

fig. 196: Making blocks

fig. 197: Drying blocks

The wall: As the walls are only self-load bearing a single bond of one row of headers and one row of stretchers was used (see fig. 200). For the arches and the vault a brick size of 25 x 25 x 25cm was used.

The plaster: The walls of the housing units were plastered inside and outside with two layers of a mud mortar mixed with straw. For the fine plaster of the outside the research team was experimenting with different stabilizers. For SRDU 1 they used traditional mud plaster with straw, and then they made tests with adding straw or cactus juice to make it more waterproof (see fig. 198). (Gebrewold 2016)

fig. 198: Water resistence test

fig. 199: Brickwork TVET SRDU

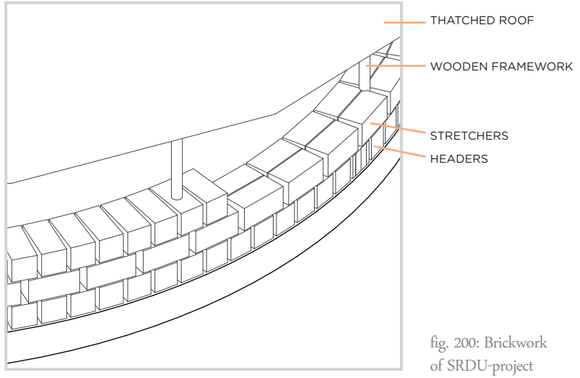


fig. 200: Brickwork of SRDU-project

6.7 The education of the workers

Since the beginning of SRDU project, capacity building and hands-on training on a one-to-one construction were important elements. January 2011 13 artisans were recruited from different Woredas in Gurage Zone and trained by experts in building the components for a SRDU. September 2011 a temporary graduation was organized for them, were they received three different-sized formworks and a construction manual for SRDU in Amharic language (see fig. 202). The objective was to encourage them to continue construction houses with adobe bricks. (EiABC 1_2012)

fig. 201: Graduation of 13 trainees receiving formworks

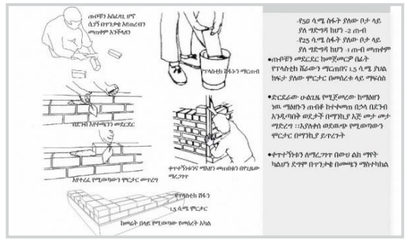


fig. 202: User manual for SRDU

After the construction of SRDU 1, Wolkite Polytechnic School became partner of the project to get it into population. 17 regular TVET students were trained for more than three and a half month in the construction of SRDU. To promote the project, they built one housing unit on campus of Wolkite Polytechnic School. In addition to this a standard training programme was developed and submitted to the ministry of education. It includes 3 modules with 1.5 month theoretical training on the building materials, two month practical training on SRDU components and 3.5 month construction of a whole housing unit. The target is to implement the curriculum all over the country. (Alayu 2016)

6.8 The design in comparison to the local architecture

SRDU project is orienting very much on the local architecture. It is kind of an improved traditional Gurage house. The principle of construction is completely the same: "(...) a composition of umbrella and cylinder". [37] The proportions differ in some ways: In case of the traditional Gurage house, the roof takes in a bigger part in the comparison to SRDU, also umbrella and roof have a steeper angle (Fig. 71). Regarding the surface they decided for other materials. Bamboo replaced the traditional thatching material and adobe bricks the wooden wall construction. Also on the inside many adoptions have been made. Urban services like sanitation space, food preparation space and a plug-in energy source are integrated in SRDU. A mezzanine floor offers more private space. It was an interpretation of a traditional storage place of Gurage houses situated above the stable or central pillar called "Kot". As you don't need dark spaces to create privacy anymore, the room has much more openings to bring light and air inside. (Gebrewold/ Kassahun 2015)

37: Gebrewold/ Kassahun 2015: 205

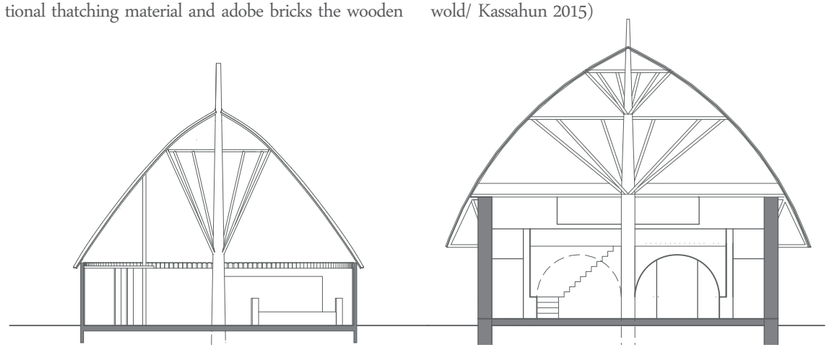


fig. 203: Section of a traditional Gurage house and SRDU M 1:200

6.9 Problems and strategies

Creating a new kind of rural house taking into account local traditions is a very important and ambitious task. It is a well-researched project that developed and grew into bigger scale. But the future of the project is very unsure, since the funding stopped and the project partners went in different directions.

Problems: Different kinds of complications happened during the stages of the project. Many of them could be corrected in the following housing units, some are still prevailing.

* Research: In some aspects the research regarding the traditional house done before construction was not intensive enough. As the first unit was finished it was presented to the stakeholders. They had a big problem with the central pillar. Traditionally it is made from a special tree that needs 30 years to grow to have the right size. It was inherited from generation to generation. The research team didn't know about the symbolical importance and they replaced it four wooden elements of a thinner size. For SRDU 2 they came back to a circular structure and a single central pillar. (Gebrewold 2016)
* Material: Bamboo as building material may not was the right choice. It comes from a place too far away, the distance between raw material and construction site is too big. This causes additional costs. Also people in the area have no idea about harvesting and preparation of bamboo. Competent artisans to train them need to be found. (Alayu 2016)
* Financial problems: There was a big difference between estimated and actual costs. (Alayu 2016)
* Funding of RHR-Units: The last four units were constructed with the rest of the funding from Switzerland. When the money was used up construction stopped. Some things were not completed, like the plaster of some of the units and also the toilets. People cannot complete it by themselves, because they have no skilled person in the village. (Rahmetu 2016)
* Construction: The earthen stairs constructed in the RHR-units are already broken, though they were only a few month old when I visited the sites. The front edges of the steps were damaged. Also the vault has weak points. On several SRDU houses you find cracks on the place where the arches meet. It seems there was no improvement in this case.
* Maintenance: Earth and bamboo are sustainable building materials, but they need to be maintained. Regarding earth it should be easier to manage, as the usage of mud plaster is very common. Nevertheless it is not happening. SRDU 1 is in a bad shape. They painted it in a colour that is not suitable for earthen construction. It is getting off on many places on the outside and the plaster underneath gets washed away. On the inside there are a lot of cracks on the wall. SRDU 2 seems to be in a better condition, it has not been coloured, only plastered. The bigger problem is the roof. In the first three units it is already leaky. It should be easy to change the broken bamboo leaves on the roof. But the material is not available and people don't know how to treat it.

fig. 204: Holes in the bamboo roof of Adena SRDU

fig. 205: Inside the RHR unit of Kader Rahmetu (left page)

Strategies: Most of the strategies had the cause to enable rural society a smooth change to a new home that is following local building traditions, that is sustainable but also offers urban amenities inside.

* Extensive research: Before even starting with the design a wide research on rural housing has been done by housing chair of EiABC.
* Involvement of local institutions: The support of local institutions like the BGCC and Gurage Administration Zone was important to gain trust within the population.
* Hands-on construction: Since the beginning the design was tested and improved. This also helped in winning the local people for the project. First there were some prejudices regarding the construction of SRDU. The materials earth and bamboo don't have a good reputation in society. Especially bamboo is seen as poor men's timber. The strategy to solve this problem was hands-on construction, where also the researchers were involved. So they could see that these people are actually working with these materials though they are not poor. (Gebrewold 2016)
* Involvement of local artisans: Since the beginning 13 local artisans were trained in the construction of SRDU with the target of bringing the technique into the population.
* Continue local traditions: Many local building traditions were adopted because they have proven themselves and to make it easier for people to accept SRDU. For example they took on the custom of slaughtering a sheep after the erection of the central pillar to motivate the workers. (Gebrewold/ Kassahun 2015)
* Involvement of the population: Four of the 8 units were constructed for families to live inside. This was important to see how families use and accept the house. The first was constructed in Agena and finished in September 2013. Unfortunately when I visited the site 2016 they already moved out during rainy season because the roof was leaky.
* Improvement: As all in all 8 units have been constructed, there has been improvement in construction, and also different techniques have been tried out. For TVET SRDU for instance the central pillar and the roof construction were made of bamboo. And in case of the the RHR units, the roof overhang has been enlarged compared to the dwelling units before, so that the wall is better protected from rain.

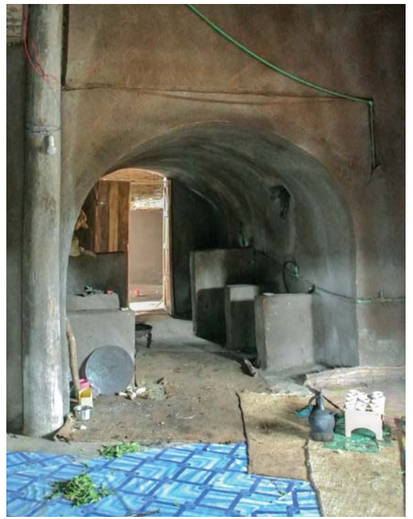
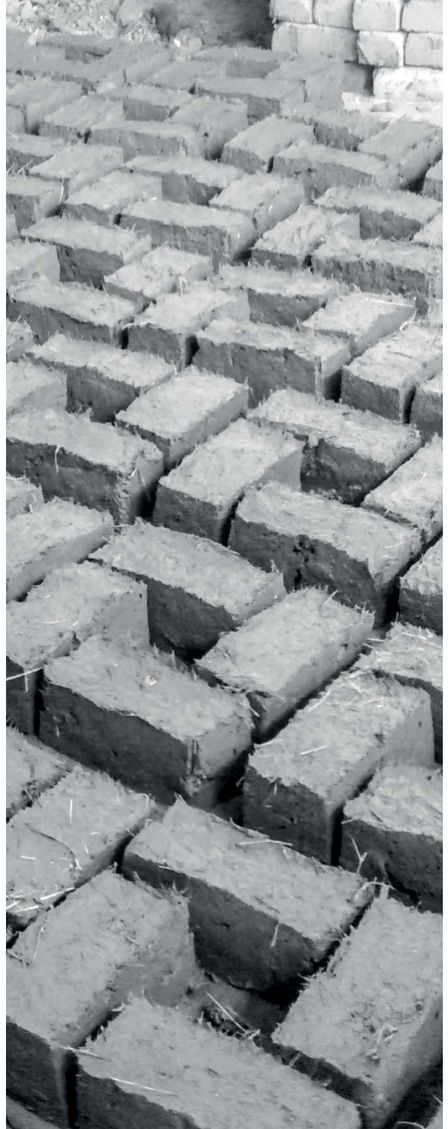
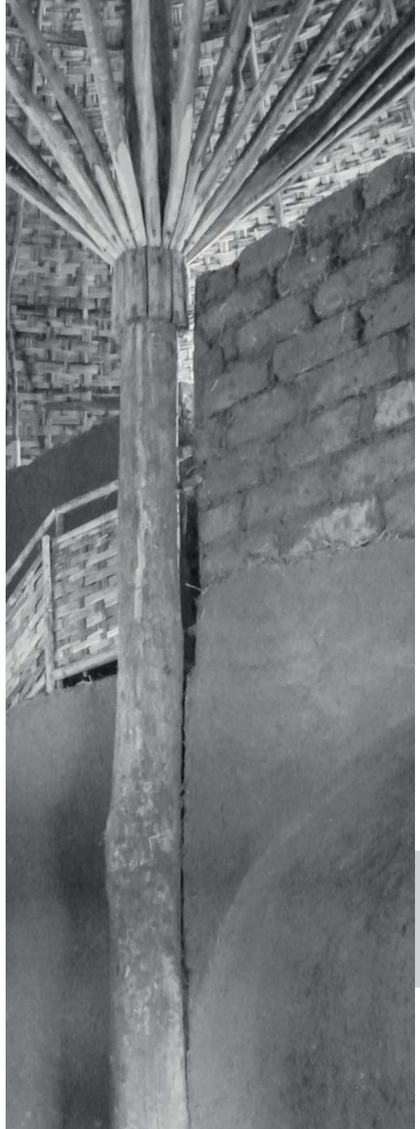


fig. 206: Inside the RHR unit of Hasen Sabir

Despite all the problems I personally hope the research will be continued. The project has the strength that it does not force rural population to give up their traditions in building and yet improves the living standard.





7. COMPARISON

Considering the information in chapters 4 to 6, I will now compare and contrast the three building projects.

Their main similarity is the construction material earth and the sustainability claim, but their purposes are rather different. The Afar Kindergarten project is about the construction of a building complex, whereas the NESTown project is about the development of a whole town and SRDU about the improvement of a rural housing unit. In this chapter I will discuss the differences and similarities of these projects.

fig. 207: Wall of AK-project, fig. 208: Mass production of adobe bricks for NESTown-project, fig. 209: Adobe block wall of SRDU/ RHR-project

7.1 The initial position

The initial problem: All three projects are connected to an initial problem that gave the impetus to think about an architectural solution. The Afarkindergarten-project (AK-project) arose from the need to educate Afar children from the countryside so they have better prospects for the future, as pastoralists' way of life becomes more and more difficult.
The NESTown and SRDUprojects are both related to the urbanization process in Ethiopia and the uncontrolled influx to the existing metropolitan areas, but they have completely different solutions and approaches. NESTown-project developed a kind of mixture between a village and a town, where agriculture is integrated in urban lifestyles and there is a higher density of housing. In contrast to this, SRDU-project seeks to prevent people from moving to towns by improving the living conditions of rural houses to modern standards. The similarity between these two projects is the common goal to improve the standard of living for these populations using new architecture.

The social conditions: The cultural and social background of the people living near the described building sites can be characterized by religion, tradition and different subsistence. The people in Gurage zone and the village of Bura live in a rural area, are orthodox Christians and their main source of income is from agriculture or trade. In contrast, Logia is a town where most of the population are Muslim and work in the service sector or in construction. These different aspects all influenced the design and construction process in some way. In Logia for instance, working hours were not affected by religious holidays so much, although praying five times a day was important to some of the workers.

The environmental conditions: Environmental conditions can have a big influence on the construction technique utilised. Locally available materials and the climate are responsible for the appearance of the buildings. The environmental conditions of the three sites are very different. On one hand there is the desert and Semi-desert around Logia, on the other hand the fertile land in Gurage zone. Nevertheless all three places have very distinctive dry and rainy seasons where a lot of rain comes down in a very short time. Regarding the landscape one would think that in Logia there is nearly no rain at all, but this impression is wrong. In spring 2016 I experienced heavy rainfall in Afar region, but due to irrigation the water disappears very fast again.
Despite these environmental differences, today most of the houses are constructed in the same way. Either they are Chikka constructions, using a lot of wood that is becoming increasingly rare in Ethiopia. Otherwise, they are constructed out of concrete, without considering the local climate and available resources.

Support: The AK-project began as a private initiative of students from the University of Technology in Vienna. Therefore, the people from Austria coming to Afar were all volunteering. A big advantage was the cooperation and support of the local NGO APDA, but the financing was, and is still, a problem. The development money we received from two organizations only paid for the construction material and workers, but not for the students coming to Logia from abroad. The two other projects were both initiations from EiABC and ETH Zürich, so they had the advantage of always having experienced partners like architects and students on site and with ETH Zurich a strong partner from abroad. Furthermore, they both had support from the governmental or different local organizations. However, too many different stakeholders can also lead to conflicts of interests, and maybe then the project cannot be realized as originally imagined. In the case of SRDU these conflicts of interests lead to a separation of ETH Zürich and EiABC and in the case of NESTown-project some of the stakeholders were not that interested in earth construction and insisted on other materials.

7.2 The scale

The scale of the different projects differs a lot. The AK-project includes only one education complex with a few buildings. But one of the goals is to spread the technique of adobe brick production so that this could be an alternative to Chikka houses and provide a chance for Afar people to build up their own business. NESTown -project was large in scale from the beginning. The plan is to construct many towns with the same principle in different areas of Ethiopia. The challenge is still to finish the prototype town in Bura and see if the principle of a rural town can be realized. The SRDU-project was the smallest in scale in the beginning. The idea was only to construct a prototype for a sustainable rural house based on vernacular architecture, but inspired by modern standards of living. After the first unit was finished more and more people became interested in the project. In the end eight units have been constructed and there has already been a curriculum developed to teach the principles of SRDU countrywide.

7.3 Construction and design

Regarding the design, the biggest difference is the form of the buildings. While for the AK-project and NESTown-project a rectangular form and a flat roof was chosen, the SRDU-project is inspired by the traditional round hut with a thatched steep roof. In Gurage Region the traditional house is still very popular therefore it was decided to continue with this form. In Logia there are no round buildings to be found at all, apart from the few Deboitas that you can find in the outskirts of the town that are not suitable for bigger houses like an educational building. Also there is no thatching material available for a steep roof. In Bura all new houses are already constructed in rectangular form, so people seem to prefer them that way today. The flat roof was

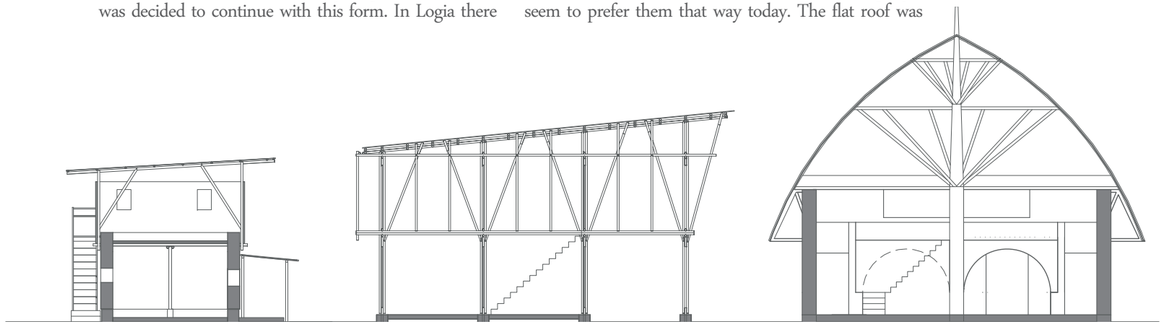


fig. 210: Section of AK-, NESTown- and SRDU-project M 1:200

7. COMPARISON

necessary for rainwater harvesting. All three projects have in common that they have two storeys, which is rather unusual for the areas where they were constructed. One reason for this is the need for a higher building density as the population is growing so rapidly. This is very obvious in Logia where the distance from one end of town to the other becomes more and more and you cannot manage it anymore by foot. The two storeys also have a financial rationale as the most expansive part of the house is the corrugated iron sheets. In the case of the NESTown-project the density is enhanced by the number of eight housing units in one building, so they are similar to a row-house.

What is conspicuous regarding the section is that the SRDU is a house only for one family although it has a huge volume of space compared to the other two houses. If you compare the square meters the difference is not so big. With about 84m² for 14 children the hostel of the AKP has the least space per person, but it has a different purpose than the other two projects, which are family homes. The RWU of NESTown-projects have about 80m² if both floors are occupied, while SRDU-project has a living space of about 87m². This difference is small if you take into consideration the difference in volume which is visible in the section. One reason is the big airspace, which is the result of the mezzanine floor that includes only half of the ground area. Another reason is huge room under the roof, which you also have in traditional Gurage houses. Some of this space you can use for storage purpose, but most of it has no use at all. The thing about the huge volume is the great spatial experience inside the house, but from a sustainability aspect less volume may be better.

As already mentioned, the main element that the three projects have in common is the adobe wall construction. But in its use AK-project differs a lot from the other two projects, where the roof construction is supported by a wooden framework and bricks are only used as filling material. The wall of the ground floor of the hostel is supporting the wooden framework of the upper floor and the roof, so it is much more important to have a strong construction. A special feature in the construction of SRDU-project is the vaulted ceiling on the ground floor, whereas the other two projects have simple beamed ceilings. Also the enhanced use of bamboo as construction and thatching material should be mentioned. The umbrella like construction that was taken over from vernacular architecture is also rather special.

7.4 The implementation of earth

In the aspect of sustainability and availability of the material it was decided for all three projects to use earth as construction material; mainly in the form of adobe bricks and mud plaster. The consistency of the raw material was quite different, but in all cases it had rather a high amount of clay, so it had to be stabilized. NESTown-project and SRDU-project used mainly used straw for this purpose, for AK-project sand was considered the better option.
In comparison to other massive earth construction techniques, adobe bricks have the advantage that you can prefabricate them. As soon as they are dry you can evaluate their quality and strength and you can decide of they are suitable for brickwork. Apart from the vault of SRDU-project, AK-project has the most complicated brickwork of the three projects. As it is a load bearing wall it was decided to use the British bond, which is very stable, but also rather difficult to make. The corners are particularly challenging, as the reinforcement bars also have to be included. The other two projects had only Header-and stretcher courses. The wooden formwork had to be included in the wall. This also made construction not so easy, but in this case it was not so important to be precise, because the roof was supported by a wooden formwork.
NESTown and SRDU-projects have the advantage that the roof was finished before the wall was erected, so rain could never affect the bricks that much. However in Afar region we had to cover the wall every day with plastic when there was a chance of rainfall.
The size of the mud bricks was also different. For AK-project and NESTown-project medium sized bricks with a size of 12 to 26 to 10cm resp. 13 to 28 to 13cm have been used. These were easy to carry for one person. For the outer walls of SRDU-project huge blocks with a size of 25 to 50 to 25cm were chosen, which were really heavy, so you needed strong people for construction.
Mud was also used for other parts of the buildings. For SRDU-project a vaulted ceiling was constructed out of mud bricks and the floor was made of rammed earth. The stairs of some of the units were also completely made of earth, but that was rather a bad idea, as the front edges of the steps are already damaged. In case of AK-project the floor construction in both levels was also covered with earth. Overall, the technique and the material were accepted well by the people, only in the case of NESTown-project there were bigger problems. Some of the stakeholders did not trust the material, especially the outside plaster, as the roof does not protect the wall from diagonal rain. These concerns are partially understandable. It was then decided to use cement plaster on clay bricks, and time will show if this works. The heavy rainfall is in general a disadvantage for earth construction. So, a huge roof overhang and a water resistant foundation are important. Flat earthen roof constructions for instance are not that suitable, as they would have to be repaired very often.

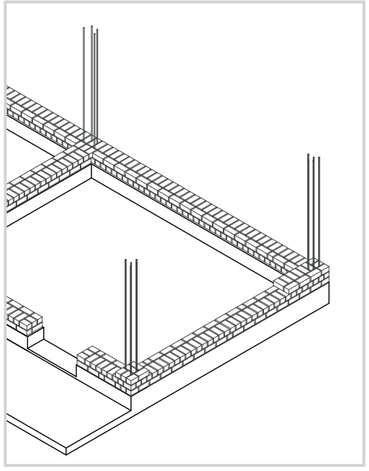


fig. 211: Brickwork of AK-project M 1:100

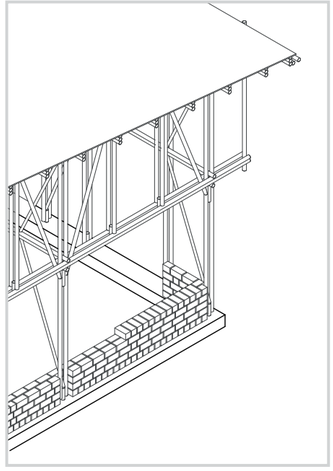


fig. 212: Brickwork of NESTown-project M 1:100

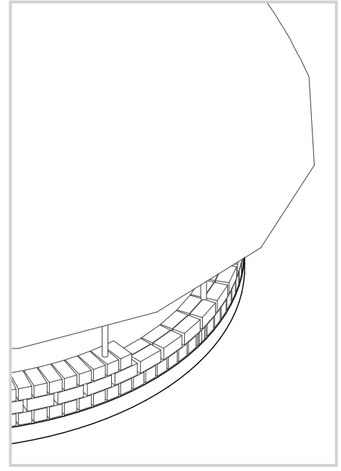


fig. 213: Brickwork of SRDU-project M 1:100

7. COMPARISON

7.5 The education of the workers

Education was an important issue in all of the three projects. For NESTown and SRDU-project there was an extensive education programme with certification in the end. For AK-project it was also planned to do a similar certification, but due to the circumstances this has not possible so far. Of course the people were educated and workshops in theoretical and practical topics were given, but the team changed too often, and some of the workers were really only employed as auxiliary hands. The goal was that some of them may continue constructing houses with adobe bricks; however the knowledge about brick production and masonry work may not be sufficient for that. For NESTown, present and future inhabitants of Bura were educated for approximately one year in constructing their own town. This has the big advantage that there will always be people who know how the buildings need to be maintained or repaired. SRDU-project also had a trainee programme over three and a half months. They cooperated with Wolkite polytechnic school and also developed a standard training programme that they wanted to implement all over the country. But there is a problem in that the trained people do not live inside or near the already constructed units.

fig. 214: Artisan training NESTown-project

fig. 215: Workshop AK-project

fig. 216: Trainees SRDU 1

7.6 Problems and strategies

As I was not involved in the construction and planning process of NESTown-project and SRDU-project, I don't have as much information about the problems and strategies as with AK-project, where I worked for nearly three months. So I have to refer to what I read, on what people told me and on what I observed when I visited the sites.

Problems: Doing construction work in a developing country is very challenging, doing it with earth even more. Many of the problems listed below occurred during the construction process and could be solved and only caused delay. However, some of these problems are still present, even if the building is already finished, like the question of future maintenance.

* Politics: Because of revolts among the biggest two Ethnic groups in Ethiopia, the Oromia and Amhara people, the government declared a state of emergency that was not lifted until August 2017. In Bura, which is actually in the Amhara region, work stood still for two months. The project in Logia was not affected that much, but the restrictions on communication possibilities like the mobile network made daily life more complicated. (hrw.org)
* Stakeholders: The number of stakeholders and donors differs a lot in between the projects. While SRDU and NESTown are official university projects of EiABC and ETH Zurich and got a lot of funding, AK-project was more or less initiated by a single person and only supported by a local NGO and a help from TU Vienna. This had the advantage that decisions could be made more easily and quickly, but the disadvantage that it is very strongly dependent on the commitment of this person, which is a lot of responsibility.
* Climate: As far as I could determine from my research only AK-project had such difficulties regarding the weather and climate. The high temperatures made it hard for us foreigners to work and the rain also troubled us a lot. Maybe the reason is that for the other two projects local architects and students were involved who knew exactly how the weather conditions could be in this country. In both cases the roof construction was erected before the adobe walls.
* Workers: Different problems occurred regarding the people that were educated and engaged to construct the buildings. In Bura there are a lot of religious holidays, so nearly half the month people were not working. This is very disrupting if you rely on good construction progress, which is often the case when you get development money. In addition to that the workers in Bura also had to finance the houses they were constructing in collaboratives. So in harvest season work was also not possible, because the money was needed more. For AK-project it was difficult to find motivated and hardworking people, especially among the Afar. So people were educated in construction but then only stayed for a few days or weeks. The good thing was that Logia is a town with many people searching for work, so we managed to find a good team in the end.
* Acceptance: In all three projects some people were sceptical regarding the construction. Earth is seen as material for poor people and they do not see why it should be useful for innovative architecture. It is also not helpful if people passing by see damages on the not even finished buildings, for instance cracks in the wall like in SRDU or NESTown-project or bricks and walls destroyed from rain in the case of AK-project.
* Termites: I discovered traces of termites in the area of all three building sites. NESTown-project and AK-project were directly affected by them. The first shadow roof of AK-project was infested by the insects and one time we also discovered termites in a newly made brick. At the model houses of NESTown-project I could observe termites making their way into the adobe wall with the wooden framework underneath. They were removed before they could reach their target.
* Maintenance: The question of who takes care of the three construction projects when they are finished is not clarified in my opinion. For AK-project it would be sensible if we could train one person working for APDA that would be responsible for the future maintenance of the buildings, but so far this has not been possible. In the case of NESTown-project the inhabitants themselves are helping construct the buildings they are living in, so they

7. COMPARISON

may also know how to repair them. But as far as I could observe the already constructed model houses are not in a good state and not really maintained, so they are already damaged after existing for about four years. SRDU project also has the problem that people living inside the units do not know how to maintain them.

* Presence of foreigners: AK-project had the goal that construction would be continued after the team from Austria had gone. As we all have duties at home and we don't get any money for working on the building site in Logia it is not possible to stay until the whole complex is finished. The first two times Katharina left the building site for a longer time, we have not managed for construction to be continued for a long time after we have left. This time we were told by Valery Browning that the hostel of Matthias Kraßnitzer had been completed under the lead of APDA after he left Logia in May 2017 and that the first children will move in end of September 2017. But so far I have seen no pictures that would confirm this information. In the case of NESTown-project the prototyping and trainee programme was led by Benjamin Stähli from Switzerland. In 2014 the responsibility was given over to the cooperatives and Ethiopian town coordinators, but they are in close contact with Fasil Giorghis in Addis Ababa and Franz Oswald in Switzerland. When I visited the site I did not have the feeling that this system is working so well, as the progress in construction was very slow and many cooperatives had left the project. I had the feeling Benjamin Stähli was better in motivating the people to work. But now things seem to have improved again, the number of cooperativities increased from 52 to 67 in the last four months and acceptance is better now. SRDU-project has worked very well without the presence of foreigners since the beginning. (Browning 2017; Jembere 2017)

Strategies: Some of the strategies for successful implementation of the projects are already listed as result of the problems mentioned before. But there are some strategies that were important from the beginning.

* Cooperation: All three projects were a cooperation between Ethiopian and foreign institutions. The foreign help was important for knowledge transfer and to acquire money.
* Gaining trust: The three different projects had different strategies to win the people over to it. AKP tested the material to show how strong it is and also got a better bond to the workers by inviting them to coffee and fruits every day. NESTown project also constructed a prototype that was tested in its stability and also ran information campaigns to inform the people and held a vote to decide if they were willing to be part of the project. SRDU project worked closely together with Gurage cultural centre and their wishes and objections were taken into consideration in the design of the building.
* Local materials: The use of materials that people are familiar with was a tool of all three projects to make acceptance of the new kind of construction easier.
* Education: Education is the key if you want a long-term change in the building sector. If you teach people how to construct a house it also gives them self-confidence and new perspectives. So, education was an important strategy in all three projects.
* Construction Manual: For NESTown and SRDU project a construction manual for brick production in Amharic language was created. In the case of SRDU the trainees also received a wooden formwork so they can also make adobe bricks for themselves or other projects, which I personally think is a good idea.

fig. 217: Bricks after rain
AK-project (right page)

8. CONCLUSION

8.1 Summary

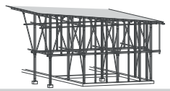
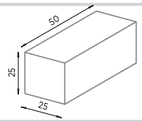
	AK-project	NESTown-project	SRDU-project
Purpose	Education complex	Rural town	Dwelling unit
Location	town	Village (future town)	village
Landscape	Semi-desert	Highlands	Highlands
Weather	Seasonal rainfalls	Seasonal rainfalls	Seasonal rainfalls
Form	Rectangular	Rectangular	round
Roof	Flat/CIS	Flat/CIS	Steep/thatched
Space	~84m2/14 children	~80m2/family	~87m2/family
Floors	2	2	1+Mezzanine
Volume	Small	middle	huge
Roof support	Adobe wall 	Framework 	Framework 
Ceiling	Beamed ceiling	Beamed ceiling	Vaulted ceiling
Bricks			
Outside Plaster	Stabilized soil	cement	Stabilized soil
Education	Workshops	Training programme	curriculum

fig. 218: Table summary

8.2 Suggestions

Based on the experience I gathered during my work on the building site in Logia and the visits of SRDU- und NESTown-project, I will now give some recommendations regarding the implementation of a construction project with adobe bricks in a development context.

* Partners/Funders: If you start a construction project in a foreign country, it is really important to have at least one partner within the country who knows about the conditions and also the local laws. And of course, you should also know how to finance the project. Partners and funders should support and understand the design and construction technique you want to implement. They should be especially aware of the advantages and weaknesses of the construction material earth to avoid any confusion and conflicts later on. It also should be clear beforehand who will manage and maintain the buildings after the construction is finished.
* Climate and building site: Before you start to design, you should already have an impression about the building site and the climatic conditions of the place, e.g. when the rainy seasons are, if there are strong winds and from which direction they come, if the site is prone to flooding and also the soil conditions on your site. First it is important to make sure if the underground is suitable and stable enough for the intended construction. In the case of NESTown-project e.g. a conventional foundation was not possible because of the highly expansive black cotton soil, so a pile foundation was necessary.
* Society: Also the community should be involved in the plans of the construction project, especially if they will be somehow affected by it. For NESTown-project there has been a big information campaign and also a vote to determine if the people are willing to support the project. In Logia people passing by our site were very interested, but as we did not understand their questions and also did not always have to time to get someone to translate, we could not answer them. An information poster in the local language would have been a good idea to enable greater transparency.
* Design: If you design a building with adobe bricks, it would be very good if you already have experience with this material. You should know about the properties and the rules of construction. One of the most important things is the weather protection. If there is any chance of rain, you should really have a good concept of how to protect the earthen parts in order to construct a durable and exemplary building. Weather protection is also important during brick production and during the erection.
* Prototyping: Especially people who are not very experienced in earth construction should consider constructing a prototype of the whole building or parts of the building first.
* Roof before adobe wall: Through my experiences in Logia I definitely came to the conclusion that it is reasonable to separate the substructure supporting the roof from the adobe wall, especially if you are not that experienced in earth construction. Even if there is a long dry season and there will be theoretically enough time to erect the wall before rain starts, there can always be delays in the building process. Additionally the roof construction enables the work to be protected from heat and rain and is also a safe storage for finished bricks.
* Construction schedule: Though there can often be surprises, problems and delays on a building site in a development context and it is difficult to make plans, a construction schedule would be useful. First, you know how long it will take at least to finish the project. Secondly, you can coordinate activities more easily and also can consider the climatic season. Lastly, you and your team have an overview

about the progress on the building site and know exactly what to do next. And if there are delays, you will know how long the delay will be at least.

* Construction supervisor: When you are planning and supervising a building project abroad, it may not be possible to be on site all the time. For this reason, it is very important to have a reliable local construction manager working with you on site, who knows everything about the project and who understands and supports your plans.
* Working hours: It is important to allow enough time for recovery between the working hours. In Logia we had a very tight schedule and only one day off a week. In my personal opinion, this was not enough.
* Distance building site to accommodation: The distance from the building site to the place you live should be not too much. Due to the climatic conditions in Logia we had a long lunch break every day. It would have been good if the distance between the building site and our home would have been less, but in our case we lost about 1 ½ hours every day on our way to work. Also in case of strong rainfall it would have been better to live near the building site to be on place faster to control the weather protection.
* Education: I would recommend separating the theoretical lessons from the construction process. In NESTown and SRDU project there has been a long training programme before construction started. Because of the tight schedule this was not possible in Logia. Also the fluctuation of the workers was rather high in the beginning. So we were educating them during working hours, and often people stayed only for a few days or weeks in our team. I think the education programme should be voluntary and people joining it should get benefits, like a higher payment after a successful completion or a mould as present like in SRDU-project. It would have been a possibility in Logia to have two days off instead of one, and half a day could have been the voluntary education programme.
* Technology transfer: A goal of the three projects was to spread the technology of adobe brick production. Therefore I would recommend to create a construction manual for adobe brick production in the local language, like it had been made for SRDU- and NESTown-project.
* Personal relationship and motivation: When foreigners come to build something in Ethiopia, the locals are often suspicious about our intentions. So it is important to gain their trust. In Logia we learnt that our coffee break in the morning was a good tool to form better relationships with the people. Some of our workers also invited us home to meet their families, which was a great experience. For motivation it is also a good idea to celebrate milestones in the building process. And generally, if the work is fun the people are more motivated.

In my time in Ethiopia it became obvious to me how difficult it is to run a building project in a foreign country using a material that many people regard as unprogressive. It is true that adobe construction can cause many problems if you don't use it appropriately. The greatest weakness is the sensitivity to water. It is also is very labour intensive to produce them and their compressive strength is weaker compared to materials like concrete or burned bricks. So some people may ask if it even makes sense to start a project using adobe bricks as building material. I would definitely say yes, but only if the builder or designer is really experienced and can guarantee the durability of the construction. But all these advantages are worthless if the building is not constructed well and has no use for the people who really need it, and especially if someone is building with the help of development aid money, they should act responsibly.

fig. 219: Gelada baboons in the highlands around Lalibela (right page)

REFERENCES

BIBLIOGRAPHY

ALPHA, Y., GUTU, D., among others (2010). Gurage traditional house. Unpublished brochure of students. Addis Ababa: EiABC Chair of Conservation of Urban & Architectural Heritage

BROWNING, V. (2013). A vision for the Future – The work of the Afar Pastoralist Development Assocaition (APDA). In A. Rieger-Jandl (Ed), Tradition in Transition – Reflections on the Architecture of Ethiopia (pp. 195-201). Vienna: IVA-ICRA

CHERENET, Z.& SEWNET, H., Eds. (2012). Building Ethiopia – Sustainability and Innovation in Architecture and Design Vol. I. Addis Ababa: EiABC

DACHVERBAND LEHM, Ed. (2002). Lehmbau Regeln. Begriffe, Baustoffe, Bauteile. 2. Auflage. Braunschweig/Wiesbaden: Friedr. Vieweg & Sohn Verlagsgesellschaft mbH

DAVIS, L. (2015). Earthen Architecture – Stigma and promise. In H. Sewnet (Ed), Building Ethiopia – Innovations in the Built Environment Vol. II (pp. 134-141). Addis Ababa: EiABC

DEIX, A. (2013). Ethiopia: History and building culture. In A. Rieger-Jandl (Ed), Tradition in Transition – Reflections on the Architecture of Ethiopia (pp. 15-37). Vienna: IVA-ICRA

DER NEUE FISCHER WELTALMANACH – Zahlen, Daten, Fakten (2017). Frankfurt: S. Fischer Verlag GmbH

EiABC, Housing Chair (2011). Interim report SRDU - Vernacurban. Unpublished brochure. AddisAbaba: EiABC

EiABC, Housing Chair (1_2012). Interim report II – Contextualization of vocational training for the building sector in Ethiopia. Addis Ababa: EiABC

EiABC, Housing Chair (2_2012). Panorama of Ethiopian Architecture – Rural Housing-Research-Project SRDU 1 & 2. Unpublished brochure. Addis Ababa: EiABC

EIGNER, A. (2013). Afar Architecture in Transition – from mobile structures towards permanent settlements. Master Thesis. Vienna University of Technology

ENDALE, T. (2010). Gurage Housing. Unpublished brochure of a student. Addis Ababa: EiABC

GEBREYESUS, T. (2015). Urbanization and Urban Planning Practice in Ethiopia – A Historical Perspective. In H. Sewnet. (Ed), Building Ethiopia – Innovations in the Built Environment Vol. II (pp. 68-79). Addis Ababa: EiABC

GEBREWOLD, B., KASSAHUN, M. (2015). SRDU – Hands on Capacity Building. In H. Sewnet (Ed), Building Ethiopia – Innovations in the Built Environment Vol. II (pp. 196-205). Addis Ababa: EiABC

GIORGHIS, F., OSWALD, F., CHERENET, Z., STÄHLI, B. & SCHENKER, P. (2015). Real Life Experiment - Amhara Model Town. In H. Sewnet. (Ed), Building Ethiopia – Innovations in the Buil t Environment Vol. II (pp. 41-61). Addis Ababa: EiABC

GOTTERT, L. (2015). A Traditional Local Building Material – A Proposal to Introduce Earth into Ethiopia's Low Cost Housing Programme. In H. Sewnet (Ed), Building Ethiopia – Innovations in the Built Environment Vol. II (pp. 150-159). Addis Ababa: EiABC

HOOGE, H. (2015). Äthiopien. Germany: Reisebuchverlag Iwanowski GmbH

HOUBEN, G., GUILLAUD, H. (1989). Earth Construction – A comprehensive guide. Marseilles: Editions Parenthèses

LAST, J. (1981). Ethiopians and the houses they live in. Addis Ababa: Ethiopian Tourism Commission

LIENDL, R., LEITHNER, J. (2013). Anthropological Contemplations on Ethiopia. In A. Rieger-Jandl (Ed), Tradition in Transition – Reflections on the Architecture of Ethiopia (pp. 157-194). Vienna: IVA-ICRA

MAYER, I. (2013). Christianity and church architecture in Ehtiopia. In A. Rieger-Jandl (Ed), Tradition in Transition – Reflections on the Architecture of Ethiopia (pp. 157-194). Vienna: IVA-ICRA

MAÏNI, S. (2012). Vault stability calculations and recommendations for SRDU II. Unpublished brochure. India: Auroville Earth Institute

MOGES, M. (2012). Building with earth Appropriately. In Z. Cherenet& H. Sewnet (Eds.), Building Ethiopia – Sustainability and Innovation in Architecture and Design Vol I (pp. 232-237). Addis Ababa: EiABC

NESTown Group, Ed. (2014). Amhara Model Town – Buranest Laboratory Concept and Experiences

OSWALD, F. & GIORGHIS F. (2016). Amhara Model Town. Unpublished brochure. Bern, Addis Ababa

RIEGER-JANDL, A. (2013). Between Nomadism and Sedentarism. In A. Rieger-Jandl (Ed), Tradition in Transition – Reflections on the Architecture of Ethiopia (pp. 215-231). Vienna: IVA-ICRA

RÖHLEN, U., ZIEGERT, C. (2011). Earth Building Practice. Planning – Design – Building. Berlin/Vienna/Zurich: Beuth Verlag GmbH

SCHÖNHER, K. (2015). A house for nomads - Development of earth building technologies for the Afar Region: Implementation of a compound for education and culture. Master Thesis. Vienna University of Technology

SHACK, W. (1966). The Gurage – A people of Ensete Culture. London: Oxford University Press

TADESSE, T., SULTAN, H. (2011). The Hostory of Ethiopian Architecture, Art & Urbanism. Essays by 3rd year students of Architecure 2010/2011. Addis Ababa: EiABC

TECHNISCHE UNIVERSITÄT BERLIN, Ed (1998). Lehmbau in Theorie und Praxis. Unterlagen zum Seminar am 25/26. September 1998. Berlin: Institut für Entwerfen, Konstruktion, Bauwirtschaft und Baurecht

WEBER, B., EINHELL, C., KASSAW, D. (2013). Traditional Architecture in the Afar Region. In A. Rieger-Jandl (Ed), Tradition in Transition – Reflections on the Architecture of Ethiopia (pp. 203-214). Vienna: IVA-ICRA

WORKU, Z. (2010). The Gurage people and their Architecture. Unpublished brochure of a student. Addis Ababa: EiABC

YITBAREK, E. (1997). Gurage. In P. Oliver (Ed.), Encyclopaedia of Vernacular Architecture of the World – Volume 3 Culture and Habitats (pp. 2023-2024). United Kingdom: Cambridge University Press

Websites

earth-auroville.com
Auroville Earth Institute
http://www.earth-auroville.com/adobe_moulding_en.php
15.09.2017

britannica.com
https://www.britannica.com/place/Ethiopia#toc37677
17.19.2017

csa.gov.et
Central Statistical Agency:
http://www.csa.gov.et, 05.03.2017

esa.un.org
United Nations World Urbanization Prospects, the 2014 revision
http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf, 02.03.2017

REFERENCES

hrw.org
https://www.hrw.org/news/2017/08/07/state-emergency-ends-ethiopia Human Rights Watch, 04.09.2017
Human Rights Watch of Ethiopia 2010.
https://www.hrw.org/report/2010/03/24/one-hundred-ways-putting-pressure/violations-freedom-expression-and-association, 18.09.2017

nestown.org
Lecture or Franz Oswald given at Academia Engelberg on February 12th 2012.
http://www.nestown.org/content/academia-engelberg-video 01.03.2017

unhcr.org
The UN refugee Agency, Statistical Database
http://www.unhcr.org/afr/figures-at-aglance.html, 02.03.2017

vimeo.com
Lecture given by Benjamin Stähli at ETH Zurich in the frame of the Lecture Series Seminar EMPOWER! on May 14th 2012.
https://vimeo.com/42607491, 10.02.2017

Conversations

ALAYU, Fita (2016)
26.11.2016 in Wolkite. Human Resource Development Officer in Wolkite Polytechnic School.

BROWNING, Valery (2011)
February 2011 during excursion of University of Technology Vienna to Afar Region. Founder of NGO APDA.

BROWNING, Valery (2017)
05.09.2017 email conversation

EIGNER, Alice (2017)
28.03.2017 in Vienna. Spent more than 6 month in Logia and wrote her Master Thesis about urban development in Afar Region.

GEBREWOLD, Berhanu (2016)
14.05.2016 in Addis Ababa. Lecturer and chair holder of Basic Architectural Design at EiABC.

HAILU, Kafyalew (2016)
24.11.2016 in Bura. Assigned Chief Carpenter of NESTown Group.

JEMBERE, Bizuayehu (2016)
17.05.2016 in Bahir Dar, 18.05.2016 in Bura. 22.11.2016 in Bahir Dar. Former deputy town coordibator of NESTown.

JEMBERE, Bizuayehu (2017)
28.03.2017 email conversation

MERSHA, Hunegnaw (2016) 2
3.11.2016 in Bura. Carpenter who joined the Artesian Training Programme 2012 and is working on the construction of BuraNEST ever since.

RAHMETU, Kader (2016)
27.11.2016 in Wita. Inhabitant of a RHR-Unit.

RIEGER-JANDL, Andrea (2017)
13.09.2017 email conversation

SCHÖNHER, Katharina (2016)
08.05.2016 in Logia. Designer of Afar kindergarten complex.

Lectures

DONATH, Dirk (2016).
Lecture given on SCUPAD Congress in Addis Ababa/EiABC on 13.5.

GIORGHIS, Fasil (2016).
Lecture given on SCUPAD Congress in Addis Ababa/EiABC on May 13th

FIGURES

All figures not mentioned on the list were taken by Denise Kießling in 2015 and 2016.

fig. 2 Katharina Schönher 2016
fig. 3 Matthias Kraßnitzer 2017
fig. 4 NESTown Group 2015
fig. 5 Denise Kießling
fig. 12 Matthias Kraßnitzer 2016
fig. 13 HOUBEN, G., GUILLAUD, H. (1989): 6
fig. 14 earth-auroville.com
fig. 18, fig. 20, fig. 21 HOUBEN, G., GUILLAUD, H. (1989): 22, 49, 62
fig. 23, fig. 24 HOUBEN, G., GUILLAUD, H. (1989): 213, 260
fig. 25 Katharina Schönher 2016
fig. 28, fig. 29 HOUBEN, G., GUILLAUD, H. (1989): 252, 262
fig. 30, fig. 31 HOUBEN, G., GUILLAUD, H. (1989): 265, 267
fig. 32 HOUBEN, G., GUILLAUD, H. (1989): 334
fig. 34, fig. 35, fig. 36, fig. 37, fig. 40, fig. 44 Denise Kießling - Reference: Google Maps 2016
fig. 41 MAYER 2013:45
fig. 45 Denise Kießling
fig. 47 Dirk Donath EiABC 2010
fig. 48 Matthias Kraßnitzer 2017
fig. 49 Denise Kießling - Reference Google Earth 2015
fig. 55 Ulrike Herbig 2011
fig. 56, fig. 57 SCHÖNHER 2015: 24, 28
fig. 58, fig. 59, fig. 60, fig. 62, fig. 63 Ulrike Herbig 2011
fig. 61 SCHÖNHER 2015: 27
fig. 67 Denise Kießling - Reference: Google Earth 2016,
fig. 68 Denise Kießling - Reference: Google Maps 2016
fig. 69, fig. 72, fig. 73 Denise Kießling - Reference: EIGNER 2014, SCHÖNHER 2015, Google Maps 2016
fig. 78 Katharina Schönher
fig. 79 Denise Kießling
fig. 80 Denise Kießling - Reference: EIGNER 2014, SCHÖNHER 2015, Google Maps 2016
fig. 81 SCHÖNHER 2015: 45
fig. 82 Denise Kießling - Reference: SCHÖNHER 2015: 61
fig. 85, fig. 86, fig. 87, fig. 88 Matthias Kraßnitzer 2017
fig. 91, fig. 95, fig. 97 Katharina Schönher 2015, 2016
fig. 98 Denise Kießling - Reference SCHÖNHER 2015: 71
fig. 101 Matthias Kraßnitzer 2017
fig. 107 Denise Kießling
fig. 110, fig. 119 Katharina Schönher 2016, 2017
fig. 120 Denise Kießling - Reference SCHÖNHER 2015: 68-73
fig. 122 https://esa.un.org/unpd/wup/Country-Profiles, 02.03.2017
fig. 123 Denise Kießling - Reference: Google Earth 2016
fig. 127 Denise Kießling - Reference: NESTown Group 2014: 52
fig. 128 NESTown Group
fig. 129 Denise Kießling - Reference: Oswald/ Giorghis 2016: 10
fig. 130 Denise Kießling - Reference: NESTown Group
fig. 140 Denise Kießling - Referenc: NESTown Group 2014: 25
fig. 141 Denise Kießling - Referenc: NESTown Group 2014: 31
fig. 142, fig. 143, fig. 144, fig. 146 NESTown Group 2015
fig. 147, fig. 148, fig. 149, fig. 150 NESTown Group 2015
fig. 151 Denise Kießling - Reference: NESTown Group
fig. 153 Denise Kießling
fig. 158 NESTown Group 2015
fig. 165 Denise Kießling - Reference: Google Earth 2016
fig. 166, fig. 167 Denise Kießling - Reference WORKU 2010
fig. 174 EiABC 2_2012
fig. 175 Denise Kießling - Reference: Gebrewold 2016
fig. 176 Denise Kießling - Reference: Google Earth 2016
fig. 189, fig. 190 EiABC, Housing Chair
fig. 193, fig. 194 EiABC, Housing Chair 2013
fig. 195, fig. 196, fig. 197 EiABC 2_2012
fig. 198 EiABC, Housing Chair
fig. 201, fig. 202 EiABC 1_2012
fig. 203 Denise Kießling
fig. 207 Katharina Schönher 2016
fig. 208 NESTown Group 2015
fig. 210; fig. 211; fig. 212; fig. 213 Denise Kießling
fig. 214 NESTown Group 2015
fig. 215 Matthias Kraßnitzer 2016
fig. 216 EiABC, Housing Chair 2013
fig. 218 Denise Kießling
fig. 220 Matthias Kraßnitzer 2016

APPENDIX

fig. 220: Journey to Afdera with our driver, Mark Ortler, Katharina Schönher, Yusuf, Matthias Kraßnitzer and the author, Denise Kießling

FILM TEXT

Video footage:
Ulrike Herbig
Denise Kießling
Matthias Kraßnitzer
Katharina Schönher

General:	2 min
AK Project:	40 min
NESTown Project:	6 min
SRDU Project:	8 min
Total	**56 min**

In 2016 I came to this place to work with other students from Vienna University of Technology on a construction project of an education complex.

Scene 1: First frame

A new building material for this region was introduced: Adobe bricks.

Ethiopia: An African country mainly associated with poverty and overpopulation...

Title: Adobe in Ethiopia

...but also known for its natural heritage like the Simian Mountain National Park....

Scene 3: During the construction period we lived in a local compound in Logia. In the early morning there was already a lot going on.

...and its cultural heritage like the famous rock hewn churches of Lalibela.

Every day after breakfast we left to go to work.

Secene 2: But Ethiopia also has a different side... The Afar Region is one of the hottest places in the world.

Scene 4: The distance to the building site was more than two kilometres, so we went there by Bajaj, the local means of public transport.

The last 500 metres we had to walk.

Scene 5: One major aim of the project was to introduce the technique of adobe brick production to the local craftsmen.

Though adobe bricks are one of the oldest building materials in the world, they have not been known in this region so far.

Scene 6: The finished air dried bricks were used to build up the wall. Adobe construction is a sustainable building technique that you can use in many regions of the country.

Scene 7: Ethiopia is situated in the east of the African continent and is part of the Horn of Africa.

Within the country there are different climatic zones... like the arid and hot areas in the east of the country... or the cooler and more fertile highlands.

Scene 8: The capital Addis Ababa in the centre of the country is part of the highlands. The old town is characterized by Armenian buildings from the beginning of the 20th century. The influence of Italian architecture is also clearly visible.

Today modernity enters Addis Ababa. In 2015 the first tramway of sub-Saharan Africa opened.

The building industry is strongly influenced by references from Dubai and China. But these modern materials and typologies do not correspond to the local climate and tradition and are also highly import dependant.

Scene 9: This movie is about three sustainable building projects in different regions of Ethiopia. All of them use Adobe bricks in their buildings:

NESTown-project is about the construction of a sustainable Rural Town.

SRDU-project is about the development of a sustainable rural dwelling unit.

And the Afarkindergarten-project is about the construction of a sustainable education complex.

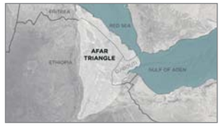
Scene 10: Before the Afarkindergarten -project started in 2015 there was a four year period of research, building survey and documentation. Alice Eigner was also part of it.

Alice Eigner (translated): "In 2011 I took part in an excursion with the University of Technology in Vienna to Ethiopia. The excursion was focusing on the Afar Region. This region is located in the north-eastern part of Ethiopia.

It started in Logia at Valery Browning. We also travelled to the rural areas and completed a small building survey."

Scene 11: Valery Browning is the chairman of APDA, a local non-governmental organization with the mission to improve the living conditions of Afar people. .

Valery Browning: "The people of Afar are all one nationality, they're all one language speaking, and they have the same culture."



The lowland where Afar people are living is also called the Afar triangle and extends over the counties of Ethiopia, Eritrea and Djibouti.

Valery Browning: "The population of the region, it's about 1.4, 1.5 million, according to the statistics. We don't have a great density of population, because we are a semi-desert, and in some parts actually desert.

And so, people live sparsely, they live as pastoralists. There are a few pastoralists left in the world today and most of them have a nomadic side to them"

Scene 12: Alice Eigner (translated): "The arrival was really extraordinary. We took the wrong way and the drivers got nervous. When we arrived it was already dark, so first we had to build up the camp for the night."

Scene 13: Valery Browning: "We have to spend understanding how these people live, okay? In some other parts of the world where you have a city people might live slightly differently."

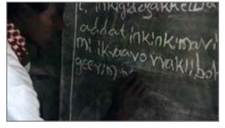
Scene 14: Valery Browning: "The traditional house which looks like a dome is built by the women." Afar people live in compounds that vary in size and are surrounded by a fence to protect animals and people.

The family lives in a mobile house that is covered with mats made of woven palm leaves. Inside the house the simple structure of the construction is visible. The house has to be smoked daily so that the mats become waterproof.

Scene 15: One mobile house can be transported on the back of two camels. Valery Browning: “She’s making the mat of the house. This is it. She’s weaving as she goes and women never stop work.”

Scene 16: Valery Browning: “When we began the organization in 1994 the Afar people were 2% literate...

...and to come up from that low position we modelled a type of development deliberately to suit the culture, the environment... so it’s mobile.



When the community moves, the teacher moves, when the community moves, the health worker moves, and the third person we have is a women extension worker.”

Scene 17: Valery Browning: “Women are the ones who are least developed with the most difficult case, in a very paternalistic society. The woman is serving men.

Collect the water, collect the firewood, have the babies, breastfeed the babies, look after the sick people, this is all job of women, women, women, women, okay?

Men: important jobs: talking, discussing, go to market, take the big animals, the cattle and the camels. And the women: small animals like goats.”

Scene 18: Valery Browning: “Pastoralist way of life is the best in the world.

If I die, and there would be a chance for another life, I would definitely 100 percent say pastoralist, because this is this amazing balance between ecology and land use.”

Scene 19: In 2012 Alice Eigner came back to the Afar Region to do some research for her Master Thesis. Alice Eigner (translated): “My Thesis is about urban structures in the Afar Region. The focus is on Logia.

I chose this town because it has developed the most in the last few years. I wanted to find out the reasons for this growth and how the structure of the town has changed.”

Scene 20: In the south of Logia runs the Awash River, the life line of the Afar region. The secure water supply is one reason people settled down on this place.

Alice Eigner (translated): “But why did Logia grow that much? Maybe the most important reason is the road which passes through the town.

The whole import and export of Ethiopia runs through this road. That means thousands of trucks use the highway and somewhere they need to take a break. Therefore along this road the first buildings were constructed.

A second reason is the neighboring town, Semera. It is a very young town and is now the capital of the Afar Region. The development of this town is very exciting because most of the buildings were office buildings,...

...and there were hardly any residential buildings. That means that many people who work in Semera live in Logia.

The third reason is that a pastoralist lifestyle in Afar Region has become more and more difficult. A pastoralist would never say: “I will give up my nomadic lifestyle and move to a town.” Most times there is a reason.

A reason I often heard was that the livestock had died, often through environmental disasters like droughts, but also through the rainy seasons. When the rain is strong sometimes the river overflows and the livestock get washed away.

A pastoralist without livestock has nothing left and it is very difficult to start over again. So many of them give up their lifestyle and move to urban areas.

Scene 21: Not only in the Afar Region, more and more people are moving to urban areas. This phenomenon affects all of Ethiopia. During the last 25 years the population has doubled from about 48 Million people...

...to about 100 Million and most of these people want to live in a city like Addis Ababa or Bahir Dar, the capital of the Amhara region. Most of the buildings are made of concrete and are not sustainable at all.

Scene 22: NESTown-project is about the construction of a New Sustainable town. It gets realized in the village Bura, next to the road between Bahir Dar and Gondar....

...and near Lake Tana, the biggest lake of Ethiopia.

Scene 23: The new town was designed as a collaboration between the Ethiopian Institute of Architecture and ETH Zurich. It will be constructed together with the community of Bura.

Today most of the 700 inhabitants are living in rectangular wooden houses and some of them are still living in traditional round huts. On the inside, walls are plastered with mud and straw.

The masterplan of the new town composes a town core with radial strip boulevards, four nuclei for particular urban institutions,...

...surrounded by a ring road, arterial roads, four sectors with neighborhood units, called "Close" and communal space in-between.

Scene 24: The following elements are already finished: A part of an arterial road with street side plantation, the town core with a central square and a ficus tree, two model houses and a communal training center.

Two housing units of close one, their stables and the market square are currently under construction.

An important tool to ensure sustainability and income security is integrated town agriculture. This contains theoretical and practical knowledge in topics related to agriculture and livestock management.

Another key issue is rain-water-harvesting to provide enough water during the dry season.

Scene 25: The project in the Afar region had a much smaller scale. Alice Eigner (translated): "In spring 2015 I travelled to Logia again.

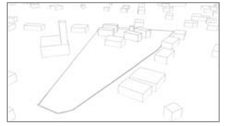
The reason for this was the construction of an education building. The designer is Katharina Schönher.

Katharina Schönher: "Last year we started with this project and I wrote my master thesis about it."The construction site is located in the Northwestern part of Logia, next to a mosque and near the high school..

Valery Browning: "A hostel: Hostels, so that students who come from far away can continue their learning, they don't have to stop at a mobile school level,...

...they can go on to the government school level and we hope go to university and be professional people."

Scene 26: Katharina Schönher: "I was planning a whole education complex that APDA will need for the future to provide education for rural students."



This complex includes a kitchen in an existing building, 4 hostel buildings for 28 girls and 28 boys, a sanitary block, two staff houses, a guard house, a kindergarten for local children and a playground.

When I first arrived in Logia only the foundation of the hostel building existed. It was made of stones and concrete to achieve a better water protection of the earthen wall.

For about two weeks we were constructing the shadow roof in front of the future kitchen.

This place was very good for brick production and also for meetings and workshops, as education about the building material earth was very important to us.

Scene 27: Katharina Schönher: "The Material, the clay we work with, is this one, it's from the big hill."

The soil comes directly from the building site. After removing the first five to ten centimetres of impure soil you can use the material underneath for brick production.

Katharina Schönher: "And clay... it's a mixture... of clay, this is very, very small particles, and silt, it's a little bit bigger particles, and usually there is bigger grains like sand also a little bit inside.

And this is why we have to test, because we have to know how much clay is inside, because the clay is the one that makes it strong, that holds it together."

If you don't get the wet soil off your hands without washing them, it is a sign that there is a lot of clay inside.

For the ball-dropping test you make a dry mixture of soil and water and form a ball with a diameter of about five centimetres. Then you let it fall from a height of about 1 metre fifty.

The different samples are still very compact. This tells us there is a lot of clay inside.

Katharina Schönher: “If there is less clay, it starts to break a little bit, like this one, and if there is very, very little clay, this is nearly like sand, then it brokes totally, okay? On this test, it’s very easy test, but it tells us a lot about the material.“

Another test is the linear shrinkage test. A mixture of soil and water will be pressed into a small formwork. When the material is dried out you can see the amount of shrinkage.

It becomes obvious that the sample shrank about one whole centimetre in length, which is a lot. Cracks are a result of this shrinkage, because when the sample gets smaller there is tension and it breaks.

Scene 28: The reason for the shrinkage is the high amount of clay in the soil material. To reduce shrinkage and avoid cracks in adobe bricks we added sand as a stabilizer.

So, the components we need to produce adobe bricks are soil, sand and water. These components need to be mixed and soaked very well.

The sand, coming from the riverbed and delivered by truck, needs to be sieved first.

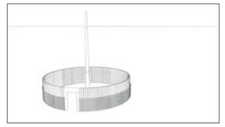
Sand and soil have to be mixed in dry conditions. Then a pile is formed with a hole in the middle that is filled with water. By shovelling the material into the middle, it gets mixed.

When the mixing is finished the mountain needs to be covered with plastic and soaked for two to four days.

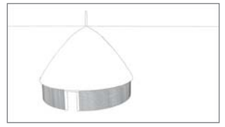
Scene 29: The third project using adobe bricks as a construction material is SRDU-project. It has been realized in the SNNPR-Region in Gurage-Zone, a semi-mountainous area south of Addis Ababa.

Eight houses in four different villages and towns have been constructed through a collaboration of the Ethiopian Institute of Architecture and Construction and ETH Zurich.

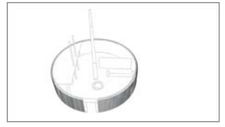
The goal was to improve rural housing conditions to correspond to modern standards. Gurage people are mostly farmers and known for the cultivation of the Ensete plant.



They traditionally live in round huts that have a characteristic construction. A central pillar will be erected first. Wooden studs dug into the earth form the wall. They are connected from outside, for instance with bamboo.



Then the rafters will be fastened at the end of the central pillar and supported by an umbrella-like structure. At last the roof will be thatched with grass. On the inside, the walls will be plastered with mud and straw



The space is hardly separated. The stable is inside the house, there is one private space for higher family members, a storage area and a fireplace in the middle of the room.

Often there is only the door as an opening, so the inside of the house is usually rather dark. Animals sleep inside and the open fireplace can cause health issues. The lack of privacy is also a problem.

Scene 30: Berhanu Gebrewold: “We cannot completely change the house layout, but we have to somehow give order to this space which are not acceptable as a decent house. So, what we did was, we interpreted the house as modern,...

...but the translation of the existing house.” The first two SRDU houses have been constructed in Gubre, near Wolkite University.

Berhanu Gebrewold: “The first unit was constructed as rectangular unit. For us, we thought that rectangular unit is more easily adaptive to modern functions like the wet room...

...and also to efficiently use the space. And somehow, except rectangular, the unit has all the characters of the traditional Gurage house.”

Scene 31: Back in Logia, it was time to explain the construction of the hostel building to our team. Katharina Schönher: ”Okay, any idea what is this? This should be this house we are building there.

You see that this house has two stores. Store above is made with wood, like this construction here and mats, like this, Afar mat or bamboo mat and this is made with? What is this? Jeeey, it’s made with blockets.

The Idea was to find a solution of construction which is very cheap, actually, that the people can build it themselves.”

Scene 32: After the material for the bricks has soaked for several days it has to be mixed again. As we did not have any animals for this purpose, we had to mix it with feet.

This is very important to activate the adhesive forces of the clay minerals and to get good binding forces. Then you need to test the consistency of the mixture. It should be smooth but still compact enough to hold it in your hands.

Katharina Schönher: "Did everyone try? Ibrahim? Ahmed? You have to know this consistence, because this is the right. Enough water, but not too much.

The idea was that the people are able to make this by themselves, because if you have a clay brick production you just need a very small form made out of timber, and that's all you need.

We have to look that everything is wet and yes, we need this one."

To produce bricks it is good to work on a plain surface. You can also spread sand before you place the form so that the mixture does not stick to the ground. Then one person holds the form down and the other one...

...throws a big hand full of soil mixture into it with strength. When the form is full you have to smooth the surface. Then you slowly remove the form. Katharina Schönher: "This is how it works".

Scene 33: A big advantage of adobe construction is, that once the brick is dry you see if it has a good quality or not. Different defects become visible.

One problem is when there are holes in the brick, which makes them less strong. They appear if you don't throw the mixture strongly enough into the form.

Another problem is cracks. You can get them if the bricks dry too fast because of the sun, or because the mixture was wrong.

After one or two days the bricks can be carried outside and another one or two days later they will be stapled. About two weeks after production, they can be used for wall construction.

Scene 34: People in Logia don't know about adobe construction. They usually live in so called "Chikka" houses which are built by contractors from the highland. They have a wooden substructure, with poles put directly into earth.

After the roof is finished the plaster will be prepared. It is made of soil coming from the riverbed. Straw is used as a stabilizer instead of sand. The mixture has to soak for about one week.

The inside of the house will be plastered first. The outer protection can be either made of mud or cement plaster.

Chikka construction has a lot of disadvantages. A high amount of wood is needed, that has to be imported from the highland.

Also the houses are not very durable because they are not stiffened against forces like wind and not protected against termites, which has become a big problem in Logia.

Scene 35: The hostel building is constructed completely differently. Katharina Schönher: "What we do now, next step for the house, will be the bricks. The wall with the bricks, and making the windows and doors.

The system works like this: we always have three blocket, and in the middle we have one to maximum two centimetres hole here." It is important to always cover the joints with the next row of bricks.

If you don't do that, you get weak points in the wall. If there was an earthquake for example, the wall could collapse.

The next row, the bricks are placed rotated and moved half a brick to the side. Katharina Schönher: "Now, you can look: all closed."

For the construction of the wall we always start with the corners. Katharina Schönher: "We make a little bit wet... then you take the earth and you should smash... power!"

When the brick is in the right position, you have to push down strongly until a bit of the mortar comes out on the side. Katharina Schönher: "The pressure has to be to hold the brick and the mortar together, okay?"

A tube filled with water is used to control if the corners are in the same height. Once two opposite corners are placed, a line will be fixed on them to enable straight masonry.

Scene 36: One row of bricks is composed of headers and stretchers. If the edge of the brick is visible on the surface of the wall it is called stretcher, if the end is visible header.

The stretchers will be placed first, to make sure their position is right. Then the headers will be placed.

To make half- and three quarter bricks we cut them with a machine.

The joints need to be filled from above with mortar. Every third row a transverse reinforcement was installed additionally. The hoops were bent by hand.

Scene 37: The wall grew, and it was time to place the lintels. Because of the termite-problem we decided to make them out of reinforced concrete.

Scene 38: When the time for our departure was coming, we had to take care protecting the wall. A temporary roof had to be constructed.

Katharina Schönher: "Now the big hot season is starting and after this, the big rainy season is starting. These are two seasons which are not really the best ones to make a construction project here.

So, during this time I'm away, and after the big rainy season I will come back and we will continue with the house."

Scene 39: On the construction site of NESTown-project, it was easier to protect the bricks from rainfall, because the roof of the rainwater units had been constructed before the wall.

A Rainwater Unit is a row house for eight families living on two floors.

Because of the highly expansive black cotton soil, it is necessary to make a pile foundation. Then the wooden framework and the roof will be erected.

The adobe bricks will be placed between the studs, so they are only self-load bearing. Starting in the corners, one row of headers is followed by three rows of stretchers.

Scene 40: Bizuayehu: "We tried to develop a new way of producing adobe blocks. In terms of size and quality it's been well improved." Finally it was decided to use a brick with sand, silt and straw added as stabilizers to the soil.

The mould has also been improved. Kafyalew Hailu (translated): "We wanted to increase the performance to safe time. So, I developed a new mould together with the town coordinator. With this mould, you can produce four bricks...

....with the format of 13 to 13 to 28 centimetres. With the single mould, you would need four people for the production of four bricks. But with the new mould, you only need two people to produce four bricks."

Scene 41: In Autumn 2016 the construction in Logia continued. The mould has also been improved. Now, three people produced six bricks at once instead of three.

After 17 rows of bricks the ring-beam was constructed. Like the lintels, it was also made of reinforced concrete.

Scene 42: After the ring beam was finished it was important to plaster the wall, so it was protected from rain. We did some experiments to find the right mixture for the available materials.

With three parts of sand and one part of soil there were still cracks. The best result we had was with a mixture of 4 parts sand and one part soil.

On the inside, the wall will be plastered with 2 layers. To enable a good adhesion for the second layer, we made notches into the moist plaster. On the outside walls there will be three layers of plaster.

For the electrical installations, wire mesh was fixed between the wall and the plaster. The ceiling is a wooden construction covered with mats made of palm sticks. They are produced by Afar and traditionally used as slatted frame.

Scene 43: In SRDU-project, another construction for the ceiling was used; a vaulted ceiling, made of adobe bricks.

Berhanu Gebrewold: "In SRDU 2 we gathered comments from all the stakeholders. We have to also correct some of the mistakes that we did.

We thought that at least the front side of the unit to have a kind of circular character and other space, like wet space and kitchen, and also the bar n to be included as an annex to the circular unit."

When I visited SRDU 2, I was accompanied by civil engineering students from Wolkite University. Addisu Wolde (translated): "From an architectural aspect, I think that this building is better designed than traditional houses.

The design of the stairs and the upper floor is particularly good. The fact that the material is easily available and free is a big advantage. The question is, if it is sustainable in terms of durability. "

Scene 44: Fita Alayu: "The TVET-institute or Polytechnic College was selected as one means of getting the project into the population. We trained SRDU-project seventeen students from regular training programme.

After that we wanted to build one project in our campus so that the population can see and comment, like promotion purpose. And finally we got the project built in our campus and it is already ready for use."

As this dwelling unit has not actually been finished, you can see the brickwork very well. Like in NESTown, a wooden framework and the roof have been constructed before the brick wall was erected.

The masonry is very simple, with one row headers followed by one row of stretchers.

Scene 45: In 2013 another dwelling unit had been constructed in the village Agena. It was designed for a family who actually lived in the house.

Fita Alayu: "Generally the project is good but lastly we didn't in calculate to the society, as we intended to do. That has its own reasons.

One of the reasons was financial problem. Second thing is the availability of the materials, the distance between the raw material and the place where we want to implement the project must be clearly studied."

Because the bamboo roof was leaky and the material to repair it was not available, the family already had to move out during rainy season.

Scene 46: In contrast to this, in Logia the house was so far finished it was ready for use. In December 2016, it was possible to have the first coffee break inside the hostel building.

Katharina Schönher: "To find a team... it's also very difficult; a team that you can rely on, that is motivated to come all the time. But, yeah, I guess we found some ways..."

Scene 47: Finally it was time for the construction of the second floor and the roof. A part of the wooden framework had been pre-constructed on the ground.

Imam Abate Ahmed (translated): "This kind of construction is completely new for us. We haven't seen this before, and we would like to learn from it"

Ahmed had a little son, Khalid, who came to work with him. Also Ahmeds' wife, Maserat, became part of our team.

Our workers appreciated very much that we used traditional materials, like the Afar slatted frames in the building. Ali Mohammed (translated): "This house is very nice. When I look at it from above, it looks like Afar."

Ibrahim Mohammed Ali: "I like this work very much because I get more education. When I see this house, very beautiful house and it's fantastic." The aspect of knowledge transfer was also an important issue in the NESTown-project.

Scene 48: Hunegnaw Mersha (translated): "Together with five other people, I have been selected for three month training programme in Bahir Dar." The trainees learned how to build the wooden framework of the rainwater units.

The elements were pre-constructed, which was a big improvement regarding the construction processes. Hunegnaw Mersha (translated): "I also learned how to produce adobe blocks. They are a very good and strong construction material

Even churches have been constructed with them. It is also a cheap material for the rural population. Though the material is strong, you cannot compare it with the strength of cement blocks. The people know that adobe blocks are robust,...

...but nevertheless they do not believe in the material. Though we are constructing modern buildings with adobe blocks here, they only regard buildings made of cement blocks as modern."

In particular, the relationship of mud bricks to water needs to be clarified. Walls got damaged because they were not protected with plaster and bricks were left outside without covering them appropriately.

Scene 49: In Logia we also had to learn our lessons in terms of water. Katharina Schönher: "Water is a big problem, not only for construction, but also for the people. Even for drinking there is often not enough water,...

...and so we were also confronted with this problem. Because if you make something with clay, you really don't need a lot, but one thing you need is water, like with many other construction materials, like with concrete as well.

And in the beginning there was no water pipe, nothing on the side, and we had to get the water from somewhere else. So, we started to carry the water by a water donkey.

There was coming a donkey with two barrels of 200 litres, and we had to fill this into a tank. So, later we could find a better solution, finally we could get a pipe to the site, where water is coming, and this made it a lot easier for us now.

This year we also had many problems with the water, so, there was no water coming for nearly two weeks from the pipe and we had to have delivery by truck"

A tank truck, that normally supplies rural areas affected by a draught, brought us water so we could continue with construction. Katharina Schönher: "After the big draught, finally the big rain was coming."

The unusually strong rain for that season was a blessing for the people, but a curse for our building project. Thunderstorms often came by surprise, and even if we covered everything on time,...

...the wind blew away the plastic on some parts. Within a short time, rivers arose that crossed our site. The damages after the rain were very frustrating for us and cost us a lot of precious time.

Many bricks got destroyed. Here, the sustainability of the material comes into effect. There is no need to throw away the bricks...

...you can just crush them and soak them to make new bricks. The rain also changed the appearance of the town a lot and influenced the daily routines of the inhabitants.

Scene 50: The problem of too much water is less problematic in SRDU-project, where the last four rural dwelling units were built in 2016.

They were constructed by ETH Zurich and a local contractor under the name "Rural Housing Research." All of them have been realized in a village in Wita Kebele. Three of them have been constructed for families...

...and one as a library for the local school. While the library is not completely finished yet, the other units have already been inhabited, and I got the chance to talk to the people living inside the houses..

Scene 51: Hasen Sabir (translated): "When this project started, the local people were not willing to participate at first. But after they saw the finished house, they were very much interested to live in this type of house."

Scene 52: Kader Rahmetu (translated): "For animals like cows, sheep or chicken, a stable was constructed next to the house.

Now we have more private space and sanitary facilities. So, generally this project is not such a bad thing.".

Scene 53: Madina Aman (translated): "The doors and windows were not installed properly. But they promised us that someone will come and correct them. But generally, all of the people living in these houses are happy with them."

Alemu Adeane (translated): "I'm really happy I met you and got to know this project in Wita Kebele. I have never seen houses like this before, and I dream of building such a house for myself one day.

I'm interested that these houses have been constructed with earth. As a result, the financial burden will be lower than usual, even though the house is so large."

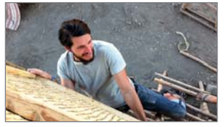
Fita Alayu: "I saw people producing blocks out of their soil traditionally, for their own houses also.

That shows how much it is strong and if we more research on that, maybe the populations mind will change... to use it instead of bricks made of cement and sand."

Scene 54: To implement earthen bricks for construction in the Afar region was also the intention of the building project in Logia. In the beginning of 2017 the hostel building got completed.

The roof was covered with corrugated iron sheets. A large roof overhang is good to protect the adobe wall from rainfall. The mud floor and the plaster were also completed.

In many regions of the world, the application of the last layer of plaster is traditionally done by women. To improve the water resistance of the external wall, oil had been added to the mixture and the surface was polished with a stone.



Then the outer protection of the upper floor was fixed.

Scene 55: In the meantime, a second hostel made of cement bricks was constructed by a local contractor. The bricks have been produced in Logia with a press.

Kafyalew Hailu (translated): "To make cement blocks, first you need machines, second you need to buy cement and sand. These are a lot of expenses.

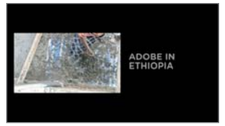
For adobe blocks, all materials you need are available for free, you only need to pay the workers."

Scene 56: In Februrary 2017 the construction of the first hostel was completed and Matthias Kraßnitzer started another hostel next to it. He decided to use rammed earth, instead of adobe bricks as construction technique.

He had to leave Ethiopia in April 2017. By now, the hostel is finished under the direction of the NGO APDA, and the first children will move in September 2017.

We hope that there will be a funding to complete the whole education complex one day. And that there will be other volunteers coming, supporting our workers on the building site.

Alice Eigner: "I think it's brave to start such a project. It's a big effort in terms of time, money and energy consumption. But if someone has the possibility to do it, then he absolutely should."



CREDITS

CREDITS

THANK YOU!

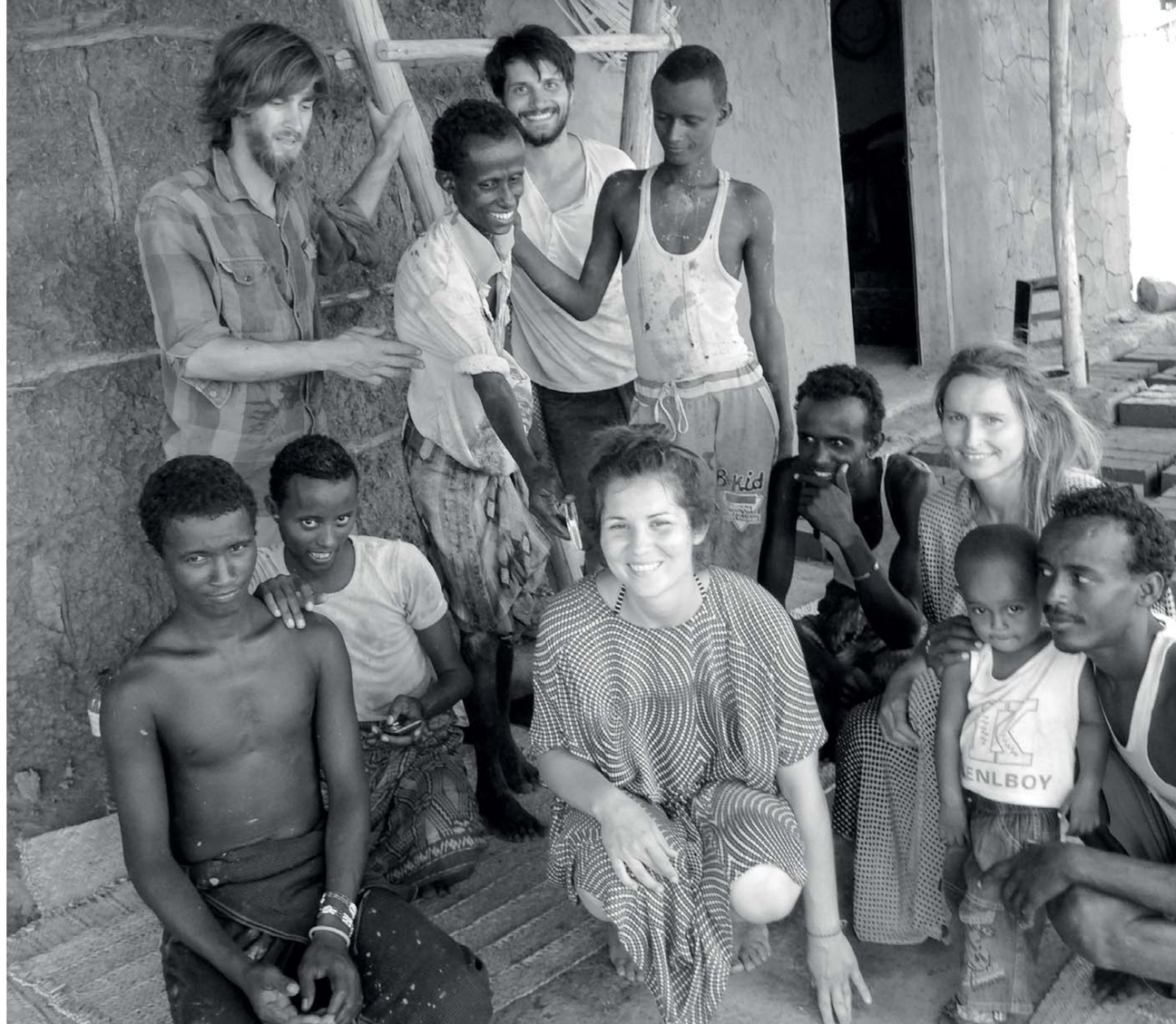


fig. 221: Team in April 2016

ACKNOWLEDGEMENTS

I want to thank all the people that helped me to realize this master thesis. On the tree sites there have been lots of people who supported me a lot.

First I would like to express my great appreciation to my supervisors Andrea Rieger-Jandl and Ulrike Herbig for their valuable advice, their constructive suggestions and their support. Thank you both for all the time you have spent correcting my work!

I want to thank Katharina Schönher for the exiting and instructive time I could spend with her in Logia. Without her commitment, the whole project in Afar Region wouldn't have been possible. I also want to thank Mark Ortler, Matthias Kraßnitzer and the whole team on the building site for their support.

Valery Browning and her family have been especially hospitable. They invited us to live with them in their compound and provided us with food. Also members of APDA like Yusuf, who took us with him to the field so we could get an impression of the Afar on the countryside, have been a big help. A very big thank to all of them!

My research about NESTown project wouldn't have been possible without Bizuayehu Jembere. He showed me around on the construction site and provided me a lot of important information about the project and I'd like to express my gratitude for that. I also want to thank Fasil Giorghis and Franz Oswald for their support and advice and Max, who invited me to live in his compound in Bahir Dar for a few days.

I also would like to express great appreciation to Berhanu Gebrewold, who supported me a lot on my research about SRDU-project and organized the contact to Oliyad, an architect in Wolkite, who accompanied me to some of the sites and translated interviews for me. Oliyad also helped me to meet Eshetu, who was involved in the construction of SRDU and made a journey to the last four sites near Butajira with me. I would like to thank both of them a lot.

A special thank goes to all the interview partners in Ethiopia, Dirk Donath and to Alice Eigner. Her interview became an important in the movie, and she gave me important information about the life in Ethiopia before my first trip.

Big thanks also to Doris, Manuela, Andreas, Stephan and Gina who supported me with their valuable advice, and Jürgen Jelinek, Christian Fuchs and especially Stefanie Thesak for their technical support. To Dawit, who helped me with the translation of the Amharic interviews and Louise, who lectured some parts of this thesis, I also want to express great gratitude!

Finally I want to thank all my friends and family who encouraged me during all the time I worked on this thesis.