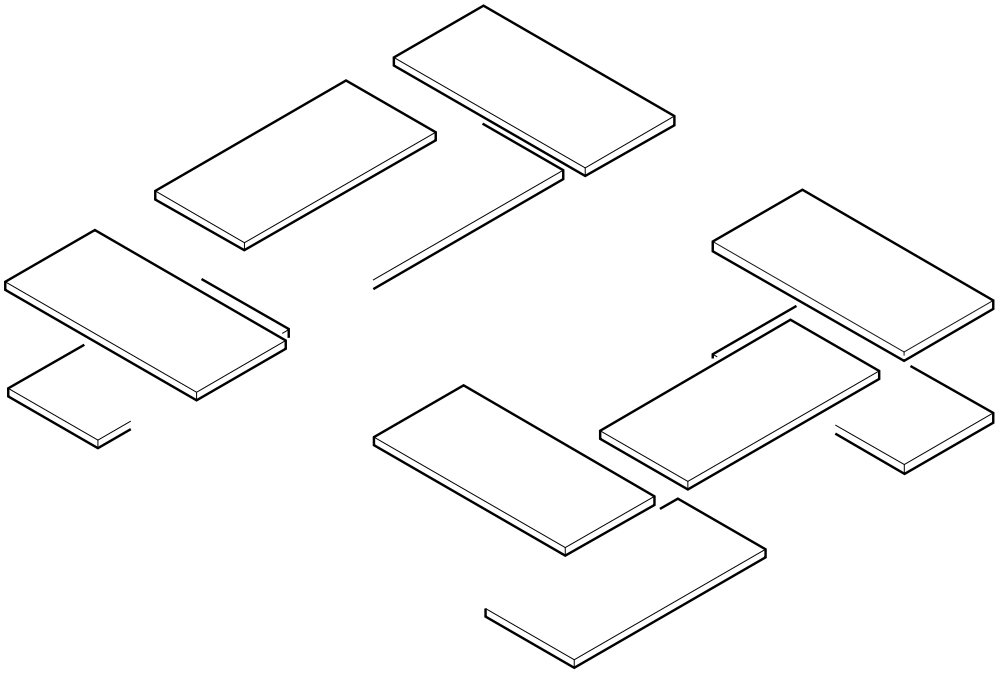


RARA HEZA

Sleep in good conditions

TECHNISCHE
UNIVERSITÄT
WIEN
Vienna University of Technology

DIPLOMARBEIT

Rara Heza

sleep in good conditions

ausgeführt zum Zwecke der Erlangung des akademischen Grades
eines Diplom-Ingenieurs

unter der Leitung von

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

E251 - Institut für Kunstgeschichte, Bauforschung und Denkmalpflege

eingereicht an der Technischen Universität Wien
Fakultät für Architektur und Raumplanung

von

Nico Hillen
01624287

Wien, am 13.09.2019

Kurzfassung

Rara Heza beschreibt die Idee der Realisierung einer Schlafstätte im ländlichen Raum des ostafrikanischen Landes Ruanda. Als Teil einer weiterführenden Schule ist diese für junge Frauen zwischen 16 und 21 Jahren konzipiert, welche ihnen als Rückzugsort im Schulalltag dient. Die Planung und Umsetzung erfolgt in mehreren Abschnitten unter der Leitung von *Ingenieure ohne Grenzen Austria* sowie dem Verein *Junge Menschen für Afrika*.

In dieser Arbeit ist der Planungsprozess des Projekts dokumentiert. Auf Grundlage eines Analyseteils werden lokale Bautraditionen und Baumaterialien auf ihre Anwendbarkeit geprüft sowie begleitend zur Planung beispielhaft untersucht, welchen Einfluss die Partizipation der späteren NutzerInnen während der Planung auf das Bauvorhaben haben kann. Gerade der interkulturelle Aspekt und der hierdurch beförderte Wissensaustausch, welcher durch bestimmte architektonische Vorstellungen seitens der PlanerInnen und auch NutzerInnen dominiert wird, steht hierbei im Fokus.

Abstract

Rara Heza promotes the idea of a place to sleep in the rural parts of Rwanda, a country in Eastern Africa. This place (the proposal) will form part of a secondary school campus and is envisioned as a retreat for young women, aged between 16 and 21. Planned and designed in different stages the project is managed by the association *Ingenieure ohne Grenzen Austria* as well as *Junge Menschen für Afrika*.

This thesis is the documentation of the planning and design process of the project. It aims to analyse traditional construction methods and materials in this area of Rwanda and assesses the applicability of these methods for this proposal. Moreover the possible participation of future users during the planning and design stage and its impact on the project will be explored. A particular focus of the study therefore is the cross-cultural approach to design and through this the exchange of knowledge, which is subjected to the perceptions of architects, planners and end users.

CONTENT

Terms written in *Italic type* are explained in the glossary at the end of this thesis.

figure 01 - the english-class of *IPK*, Kirinda

Preface

The background of the project

This Thesis, as mentioned before, is the documentation of the planning and design process of dormitory buildings at a boarding school in Kirinda, Rwanda. It is driven by the idea to improve the situation of people by architecture. Nevertheless it illustrates just the first part of the implemenation of the project considering the following construction phases at the site.

Rara Heza is an expression in Kinyarwandan language being synonymous with "sleep in good conditions"[1], which articulates the motivation to create a building that accommodates students as good as possible by considering a comfortable climate, sustainable building materials and natural light.

This project was initiated by the association of *JMFA* (Junge Menschen für Afrika) maintaining a partnership with the boarding school of *IPK* (Institute Presbytérien de Kirinda) in western Rwanda. *JMFA* is working with the students and teachers at *IPK* since its founding 2006 and therefore established a basis for trust throughout the last years. This probably was and still is an essential factor to realize a project alike.

Apart from *JMFA*, there is *IOG* (Ingenieure ohne Grenzen Austria), an assocation which manages and realizes worldwide (development-) projects if they match its principles. In the case of *Rara Heza* there was a need for planners and designers and therefore *IOG* joined the team.

1 proposal of the project name by Charles Gahutu, Headmaster of *IPK*

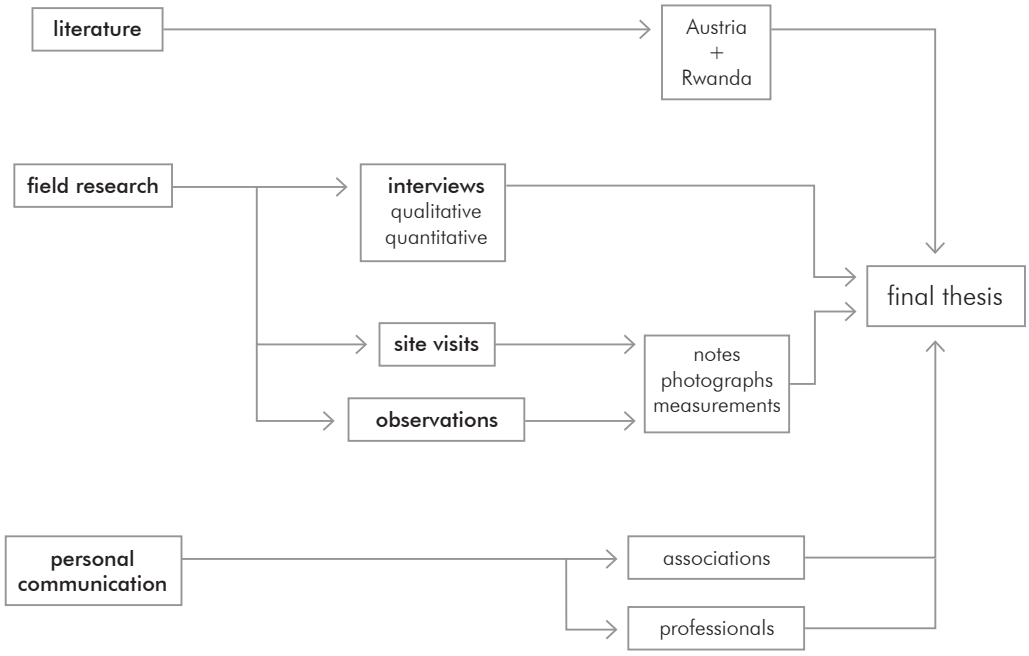


figure 02 - methodology

Methodology

Materials and methods

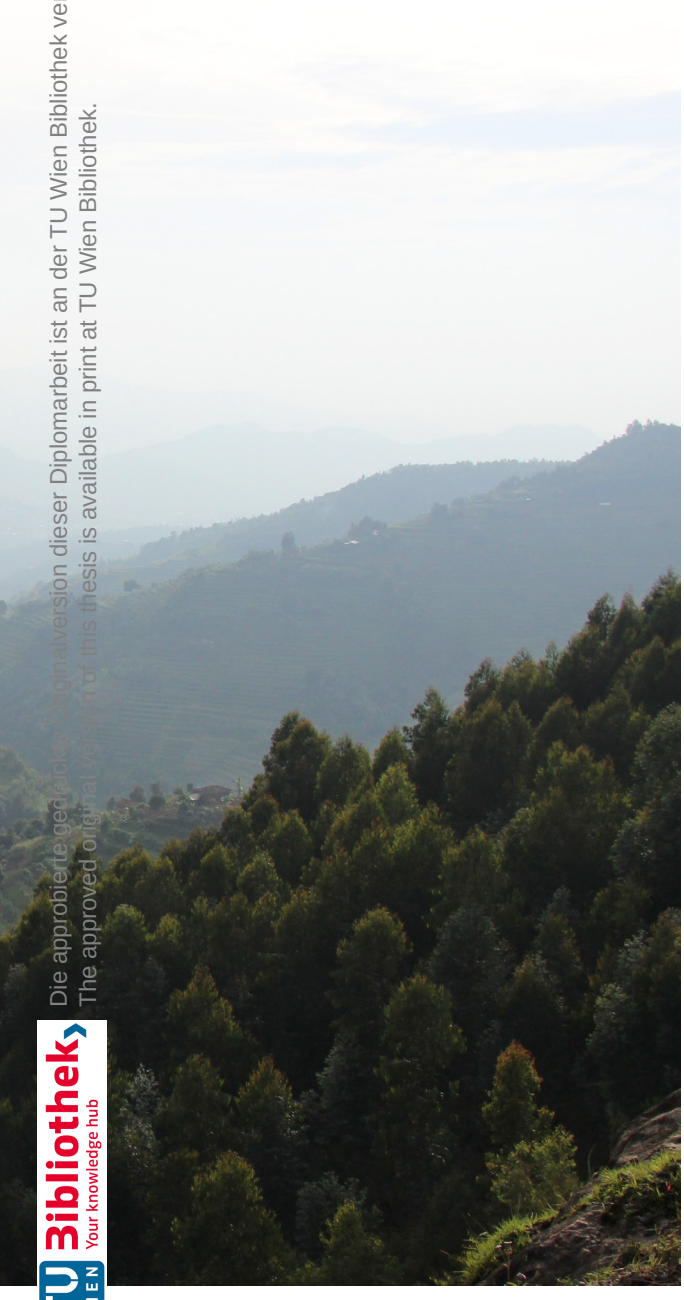
Literature At the start of the planning stage of Rara Heza, research through literature was done in Austria to approach the topic. On the one hand, there was a focus on Rwandan traditional architecture, to gain basic knowledge about the circumstances and the environment in which Rwandans built. Secondly, recent building projects in the Rwandan context and of neighbouring countries were studied, as a reference for the following design. Since it became obvious quite quickly that there is not much information about Rwanda and specifically Rwandan Architecture at hand, the idea of a field research on site arose.

Field research As part of the *KUWI-program* at the *International Office* of Technical University of Vienna, a field trip to Rwanda was done in February and March 2019. During this time, information about Rwanda in general and Kirinda, the village where the dormitories are proposed to be constructed, was collected. Altogether, besides other mentioned sources, the material of the field research forms the basis of this thesis.
In preparation for **interviews**, which were proposed to be held in Rwanda, an interview sheet[1] was prepared some time ahead. According to the situation while being in Rwanda, some questions were adjusted or added later. Firstly, several qualitative interviews were held in Kirinda, including interviews with teachers, students, the headmaster and a representative of the church, based on the mentioned interview sheet[2,3].
The aim with these questions was, to gain knowledge about the people's way of living, and their building tradition amongst other things. In addition, quantitative interviews which were held with the students at the school of *IPK* based on a standardised questionnaire, led to specific answers regarding the design of the dormitories.[4] In general, through these interviews, the intention was to involve local people in the planning process, by asking specifically about their wishes and needs regarding the future dormitories.
Besides, the research was focused on **site visits** and **observations** which were done while visiting Kirinda, Apart from studying reference projects across Rwanda, existing buildings on the school campus of *IPK* and in the village of Kirinda were examined. Through specific measurements and documentation, information about the division of space, the dimension and structure of several buildings, their typologies and the use of material were collected.

Personal communication For further information about specific fields of activity and for feedback regarding the progress of the work of this thesis, meetings were arranged in Austria and Rwanda, including a visit of the School of Architecture and a coordination office for planning matters in Kigali.[5]

1 see RIEGER-JANDL 2018

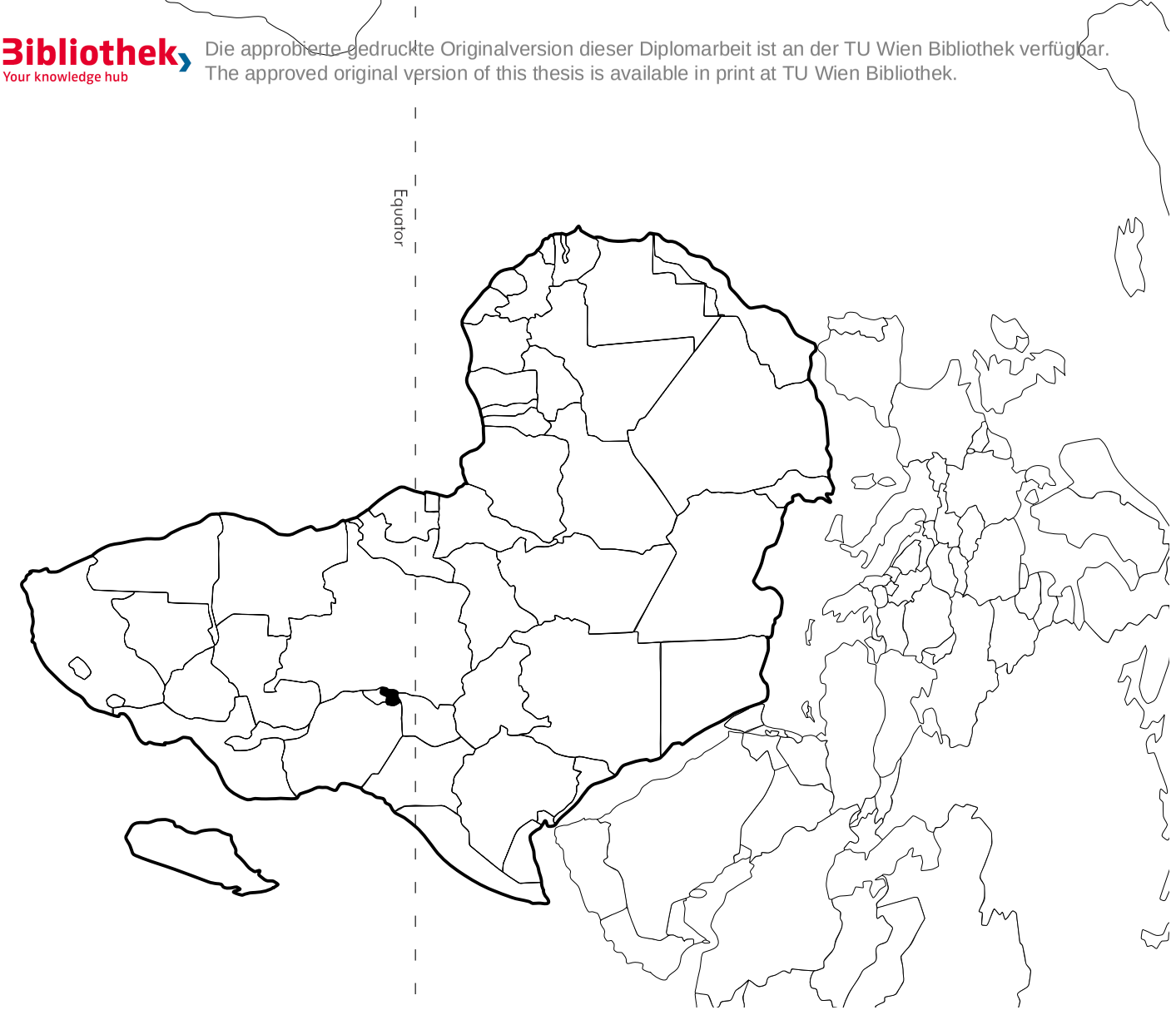
2 see References: interview partners
3 see Annex: qualitative interviews, for a summary of anwers
4 see Chapter 2: participation
5 see 2



CHAPTER 1
Rwanda

figure 03 - western province

figure 04 - location of Rwanda in Africa



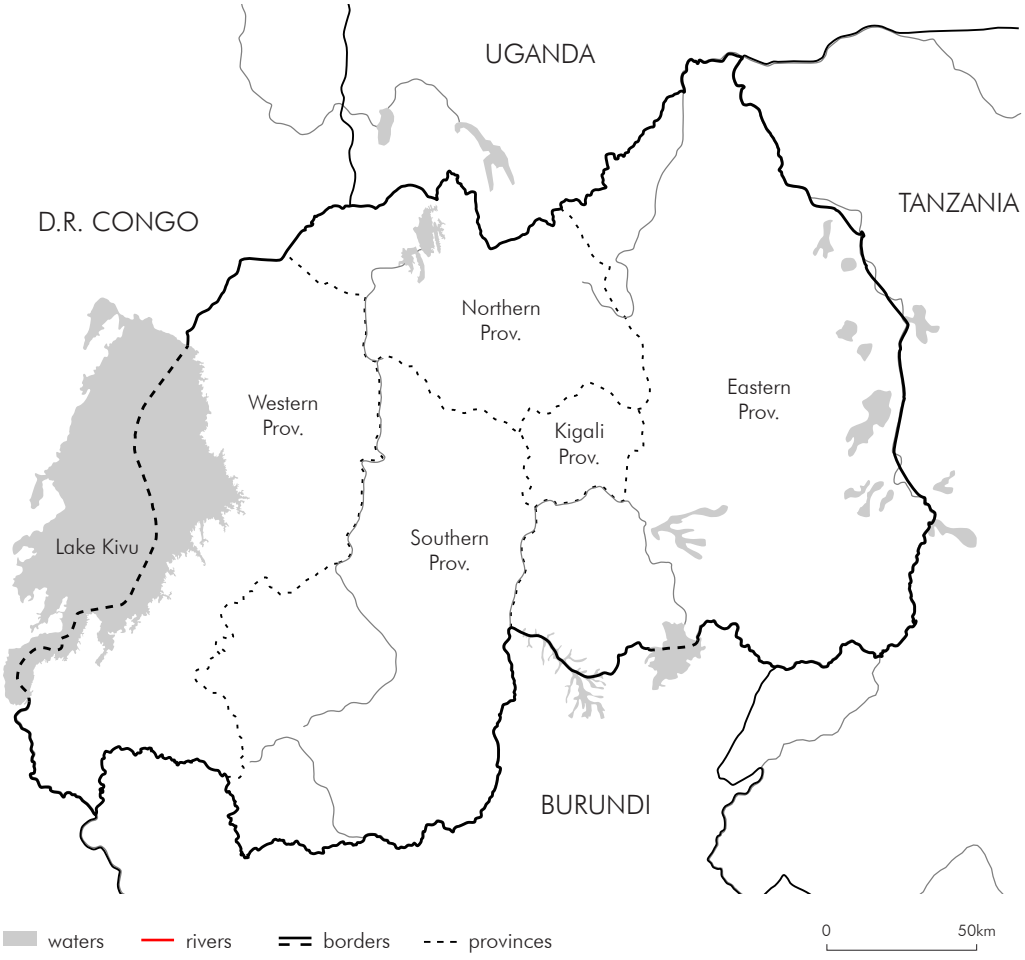


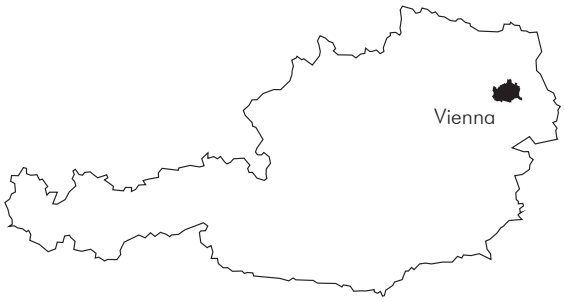
figure 05 - map of Rwanda

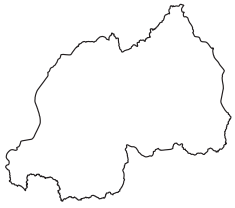
Introduction

General information about Rwanda

Geography The Republic of Rwanda is a country in the region of East Africa which belongs to the greater area of subsaharan-african countries. It is located around 100km south of the equator and therefore it is part of the southern hemisphere. Neighbouring countries (clockwise starting in the east) are Tanzania, Burundi, Democratic Republic of the Congo and Uganda. Rwanda has no access to any sea.[1] Compared to other african countries, it covers a relatively small area of 26.338 km^2. In addition, the population reached 12.187.400 in July 2018 which signifies a ratio of 462,73 inhabitants per km^2. In 2012, 83% of Rwandans were living in rural and 17% in urban areas.[2,3]
To give one an idea of the size and population of Rwanda, the charts (figure 07/08, p. 19) show some of the numbers in comparison to Austria. The population density for example, is more than 4.5 times higher. In addition, the estimated population nearly doubles by 2050 reaching 23.048.005, whereas the Austrian population increases by just 4%. This puts enormous pressure on the development of future dwelling projects as the aim of the rwandan government should be to accommodate all those people.
The official languages of Rwanda are Kinyarwanda (being the native language for the majority of Rwandans), Swahili/Kiswahili, French and English. Whereas Kinyarwanda is a language mainly based in Rwanda with a little amount of speakers close to the borders in Democratic Republic of the Congo and Uganda, Swahili/Kiswahili is spoken in greater parts of Eastern Africa including Kenya, Tanzania and Uganda. English language was introduced as the official language for education in 2008 (before: French). Thus, during the field trip to Rwanda in February 2019, the communication in english with people up to 30 years of age in general was straightforward. Especially during the following research and planning process, this was a great advantage.[4,5]

1 see figure 05 on the left; see figure 04, page 15
2 CIA.GOV web page visited 26/6/19
3 STATISTICS.GOV.RW 2015 p.58 web page visited 1/7/19
4 CIA.GOV, web page visited 30/6/19
5 POPULATION.UN.ORG, web page visited 29/6/19





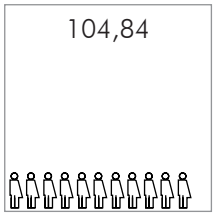
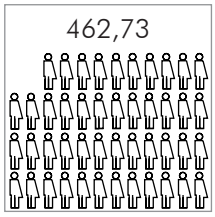
Austria		Rwanda
83.871 km²	AREA	26.338 km²
8.793.370	INHABITANTS as of July, 2018	12.187.400
	POPULATION DENSITY Inhabitants per km² (Frame equals 1km²)	
44,2	MEDIAN AGE	19,2
9.130.699 (+4% since 2018)	ESTIMATED POPULATION IN 2050	23.048.005 (+89% since 2018)

figure 06 - view across Kigali (left)
figure 07 - Austria/Vienna and Rwanda at the same scale (top right)
figure 08 - basic facts (bottom right)

Overall, Rwanda is characterized by an undulating landscape. 1.598 m is the mean elevation of the terrain, although the highest point of Volcano Karisimbi is at a height of 4.519 m. It is shaped by a great amount of rivers, of which some are considered as the source of the White Nile which later becomes the Nile river. Therefore a typical question which comes up while planning buildings is how to deal with the (in parts) steep slopes in an architectural way, as well as to think of adequate drainage systems and erosion to prevent the building-plot from any damage by descending rainwater.[6,7]

Architecture The field trip took off in Kigali, the capital of Rwanda. While exploring the city, the high population density was not obvious in an architectural way.[8] Consisting of mostly one or two-storey buildings, the urban landscape of the city reminds one of a medium-size town (in European standards) rather than a capital city reaching two million inhabitants. There were some areas dominated by higher buildings reaching up to 10 storeys, but this was the minority.
On the other hand, one could observe that the (main) streets were usually crowded during the day with pedestrians and street vendors on one site and a lot of traffic on the other site. According to the low building relief, the city of Kigali takes up a lot of space. Its area which is equivalent to the province of Kigali covers 730km^2 with a population of 1.132,686. This equals a population density of 1552 inhabitants per km^2 in comparison to Vienna, the capital of Austria, with a density of 4574 inhabitants per km^2.[9,10,11]
The time spent in the capital was followed by a period of exploring while traveling through some parts of the country and experiencing Rwanda's diverse landscape. In general, the observations which were made while visiting rural areas of Rwanda were similar to the impressions gained in Kigali. The majority of buildings consisted of just one floor. Therefore the (usually tiny) structures spread out, scattered across the terrain, while not creating much of a narrow urban space.[12]

Climate Rwanda's climate is classified as tropical, with a vegetation of deciduous forest. The average mean elevation of 1.598m generates a basis for an unusual mild climate for being located very close to the Equator. As shown in figure 11 (p. 23), the average annual temperatures in Rwanda are ranging between 15 and 22°C, increasing from east to west with some exceptions in the Southwest, the Northwest and Lake Kivu in the West. This course is based on the existence of a mountain range in the western parts. In general, these highlands have a great impact on the temperatures, as well as the annual rainfall in Rwanda.[13]
Similar to the course of the temperature is the annual

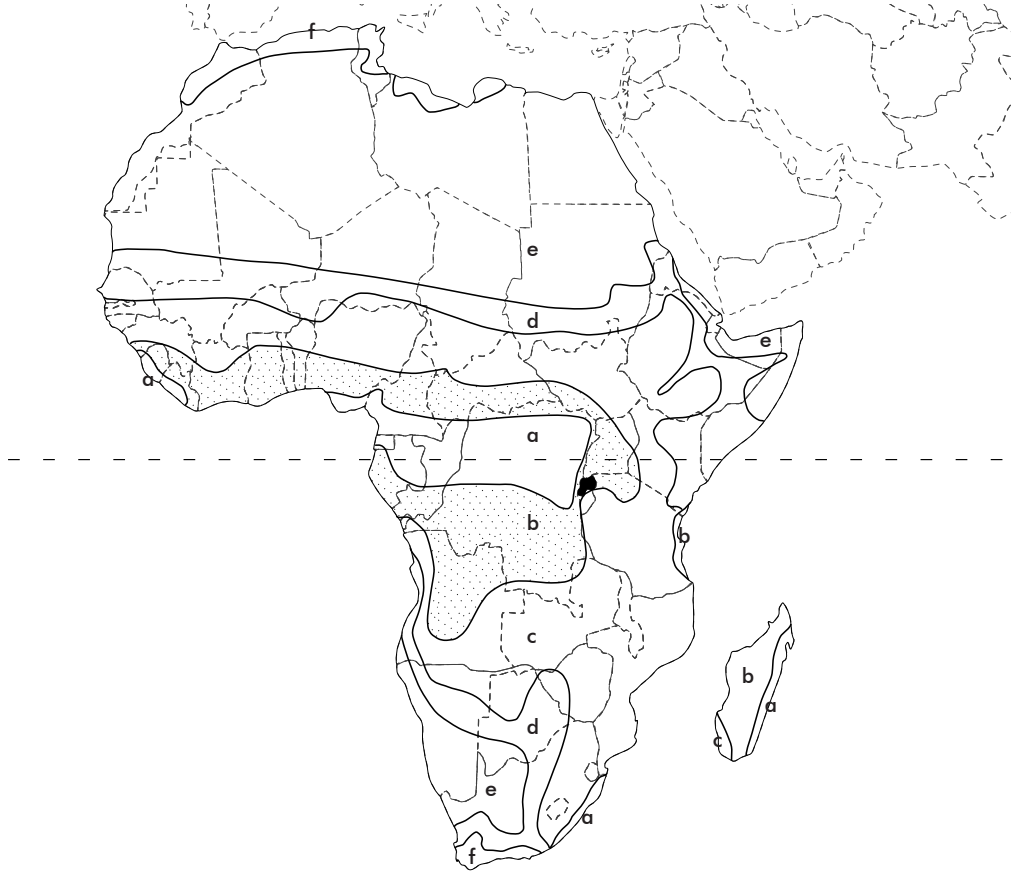
6 CIA.GOV web page visited 26/6/19
7 see figure 03, page 13
8 see figure 06, p. 18

9 STATISTICS.GOV.RW 2015 p.16, web page visited 1/7/19
10 WIEN.GV.AT, web page visited 1/7/19
11 STATISTIK.GV.AT, web page visited 1/7/2019
12 see Vernacular architecture in Rwanda, p. 25
13 METEORWANDA.GOV.RW, web page visited 2/7/19

figure 09 - textiles at the market in Kimironko

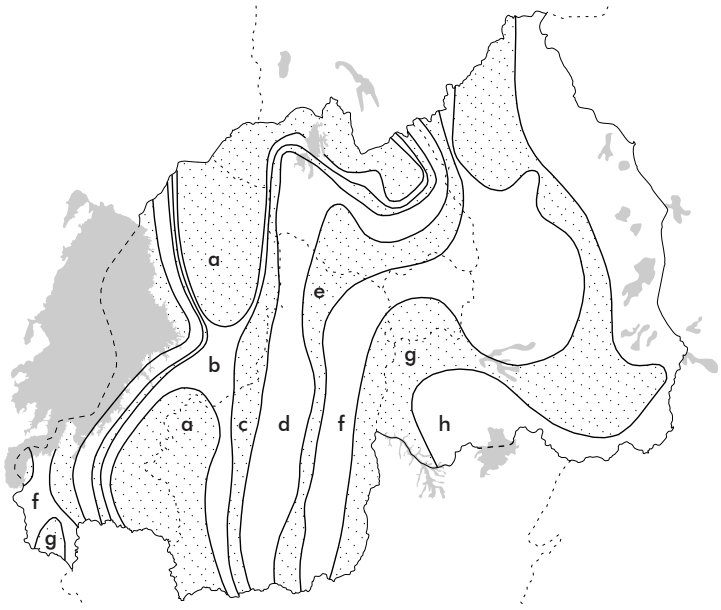
average precipitation, with a maximum of more than 1500mm/year in the highland areas in the west and a minimum of less than 700mm/year in the easter lowlands. In comparison, Vienna, Austria has an annual average temperature of 11,5°C. In addition Vienna's annual precipitation reaches 547,9mm. Therefore both, the average temperature as well as the precipitation figures in Rwanda are significantly higher.[14]

14 ZAMG.AC.AT, web page visited 2/7/19



a non-deciduous forest
b deciduous forest
c savannah
d semi-desert (Sahel)
e desert
f Mediterranean

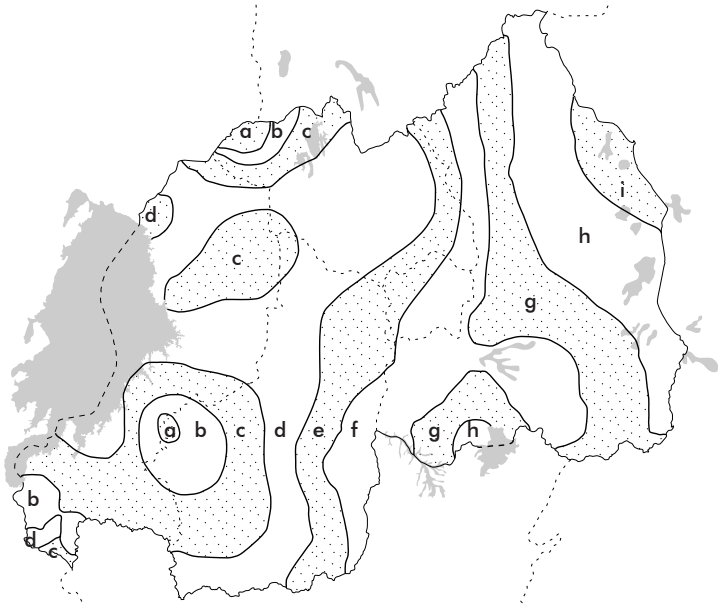
figure 10 - climate zones in Africa



Annual average temperatures (°C)

a	15
b	16
c	17
d	18
e	19
f	20
g	21
h	22

figure 11 - annual average temperatures in Rwanda



Annual average precipitation (mm)

a	>1500
b	1400
c	1300
d	1200
e	1100
f	1000
g	900
h	800
i	<700

figure 12 - annual precipitation in Rwanda

figure 13 - rural settlements

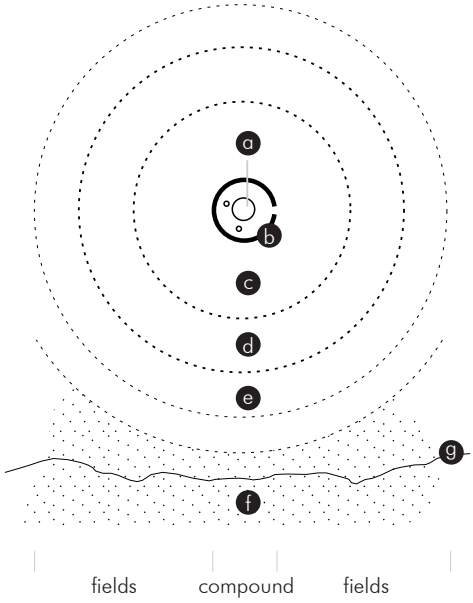
Vernacular architecture in Rwanda

Building structures, materials & typologies

"The pre-modern African city is not simply a functional piling up of materials and space, but a place with an evident, conscious stratification, in which the city is simultaneously [...] a memory of the past, and an imagined representation of the society."[1]

If referring to Rwandan Architecture there is probably no clear limitation of a Rwandan (vernacular) architecture based on the countries borders. Therefore, the outcome of the following pages can be applied within some parts of the whole region of Eastern Africa, if not further.

Spatial environment As mentioned in the preceding chapter, while traveling through Rwanda, one may still observe the traditional rural context nowadays, which is characterized by buildings scattered across the landscape.[2] This has its roots in Rwandan history and culture.
Figure 14 illustrates the circular arrangement of the spatial environment of a (extended) family. In the centre of it, there is a compound which provides shelter for all family members to sleep and eat. A compound is surrounded by Urutoke and Imirima (permanent fields) on which vegetables such as beans and corn, as well as bananas are planted and harvested twice a year. These permanent fields are followed by Indare (temporary fields) being located further away from the central compound. Indare are used to plant and harvest less



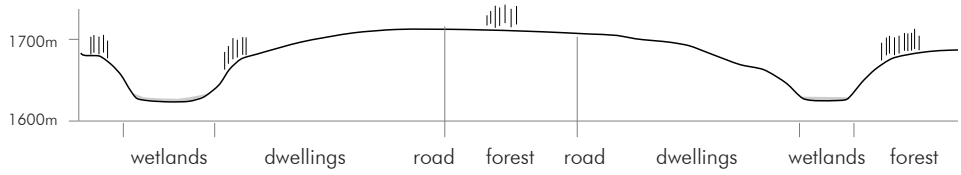
a	compound
b	fence
c	Urutoke (permanent fields)
d	Imirima (permanent fields)
e	Indare (temporary fields)
f	cultivated wetlands
g	river

figure 14 - spatial environment

1 FOLKERS 2010, p. 35
2 see figure 13

graphic A - plan

Cultivated wetlands
Forest
Roads
= 1 Compound
local supply/retail



graphic B - section AA

0 500m

figure 15 - rural context, plan and section (graphic A+B)

essential crops, e.g. coffee beans. Since Indare are not cultivated every season, they are referred to as temporary fields. A fence separates the compound area (dwelling) and the fields (cultivated area), e.g. securing the dwelling area from entering animals. The described sphere of the traditional spatial environment, is usually located close to a river. The wetlands of the river (swamp) are occasionally cultivated, according to the water level of the river. Covering all essential parts of living, this scheme of settlements is self-sufficient for its inhabitants.[3,4]

Rural context In a greater scale, the spatial environment appears as following. Since the average settlement of one (extended) family includes several surrounding fields, usually a certain distance to any neighbour is kept. These family compounds and surrounding fields, on average consisting of one hectare (10.000m^2) of land, create a pattern in which settlements are scattered across the terrain. As displayed in the terrain section on the left, the locations of the compounds correspond to the relief of the landscape. While the lower wetlands are generally uninhabited, according to the variable if not unpredictable water level of the river, the majority of compounds are set up on the crest of a hill. Being less steep, this part of a hill is less likely to be destroyed by erosion[5] and therefore more suitable for planting and harvesting. Thus the traditional settlement pattern might be different to what Europeans would nowadays imagine as rural settlements.[6,7]

Development With the beginning of colonization around 150 years ago, the Rwandan spatial environment changed significantly. Introducing systems of belief and an education system, the colonial powers set up the necessary infrastructure such as churches and schools, which affected the existing spatial environment. As illustrated in the rural context plan on the left, one might discover the local supply and retail buildings close to the edge of the plan. Following churches and schools, those buildings reveal the change of a spatial environment based on self-sufficiency to inhabitants which are dependent on local infrastructure. Therefore future dwellings are rather set up considering existing roads, churches, schools and supply stores in contrast to the traditional settlements before.[8]

Compound The basis of a settlement and at the centre of the cultural environment is a compound. A compound may consist of different parts in circular arrangement, of which the Urugo is the major and Igikari the minor one.[9] Both the Urugo as well as the Igikari are subdivided into smaller building parts according to the purpose of use. There are Inzu (dwellings) to

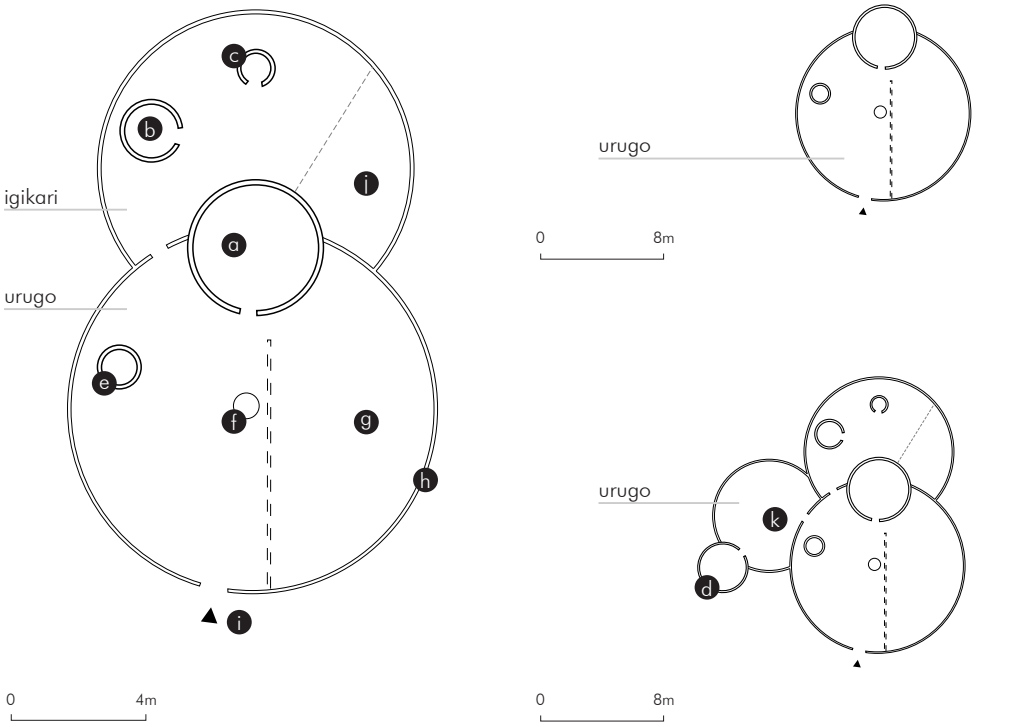
3 TUYIZERE 1998, p.14ff.
4 see figure 14
5 see CLIMATE, Chapter 1

6 TUYIZERE 1998, p.13f.
7 see figure 15
8 BART 1993, p.8
9 see figure 16, p.29

sleep for each family member including a little shrine to commemorate the ancestors. The spaciousT Inzu is the parents dwelling, followed by the children's. Apart from sleeping purposes there is the Ibigega (granary) to store grain from the fields as well as a fireplace for cooking, an animal barn to keep animals safe inside the compound and eventually a tiny garden. In general, the size of the compound is directly linked to the social level of its owner. Hence a higher position in the society usually determines a greater compound, e.g. including a separate Urugo for a second wife. Overall, every compound is enclosed by a fence while the Irembo (main entrance) and the entrance of the Inzu of the parents are located on the same axis.[10,11]

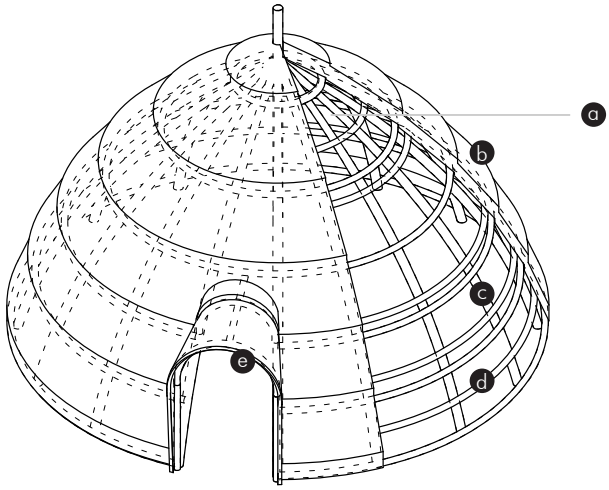
Typologies The following pages illustrate the development of Rwandan dwelling units throughout the last century. Traditional Inzu are constructed by using just two materials, wood and grass[12]. Before erecting the dwelling, the plot is cleared from any grass and a circular area is marked. Secondly, Umuganda (vertical wooden poles) are set up in a regular interval, bent and attached to another vertical pole in the centre of the marked circle. After, Urubariro (crosspieces), usually flexible stalks from plants, are tied up to the vertical poles by ropes, e.g. made of banana stalk or bark. This basic construction is then covered by bundles of grass[13] and finished by an interior ceiling (also made from flexible stalks). In addition some Inzu which are well cared of receive a floor, made from fine grass to achieve a higher comfort for the inhabitants.[14,15]
The next development step of Rwandan dwellings is referred to as Inzu 2.0 in this section. Basically it is characterized by a similar arrangement as the traditional Inzu. Nevertheless, differences in construction indicate a change in building techniques, according to the local climate and conditions. A circular area is marked and a foundation from rocks is build up. Umuganda are set up on this foundation and are reinforced by Urubariro, both made from wood. In addition diagonal wooden poles, also reinforced by Urubariro, are joining the central vertical pole with the outer poles. Analogous to the traditional dwelling, a cover of grass bundles creates a roof on top of the diagonal wooden poles. To finish the dwelling, the structure of the horizontal and vertical wooden poles is covered by a layer of locally available mud and a wooden door. The additional layer of mud creates a more comfortable interior climate since the mud keeps the inside temperature low during the day and pleasantly warm during the night in comparison to the outside temperature.[16,17]
The third typology presented in this section is the rectangular house. Contrary to the first two typologies, the traditional Inzu and the Inzu 2.0, it reveals some crucial differences. Firstly the rectangular house, as its

10 KANIMBA MISAGO, VAN PEE 2008, p. 90-96
11 TUYIZERE 1998, p.15f.
12 see figure 19, p.32
13 see figure 20, p.32
14 MBADUKO 1996, p.20
15 see figure 17, p.30
16 see figure 18, p.31
17 MBADUKO 1996, p.21



a parents
b children
c Uturaro (ancestors)
d second wife
e Ibigega (granary)
f fireplace
g animal barn
h fence
i Irembo (main entrance)
j garden
k additional courtyard

figure 16 - distribution + variations of compounds



a Igisenge (ceiling)
b cover
c Umuganda
(vertical Poles)
d Urubariro (crosspiece)
e canopy (entrance)
f floor cover

Traditional Inzu

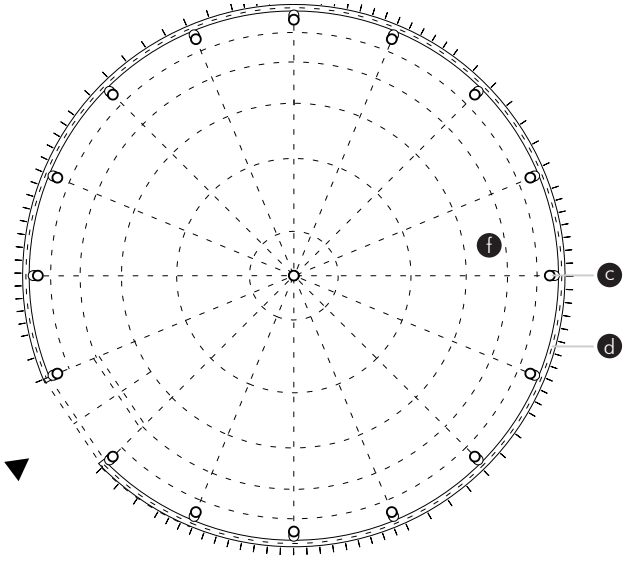
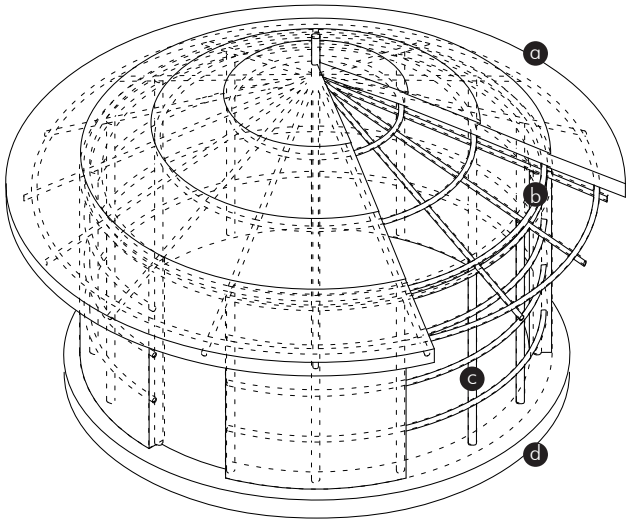


figure 17 - traditional Inzu, isometry and floor plan



Inzu 2.0

a cover
b Urubariro (crosspiece)
c Umuganda
(vertical Poles)
d foundation
e clay/mudwall

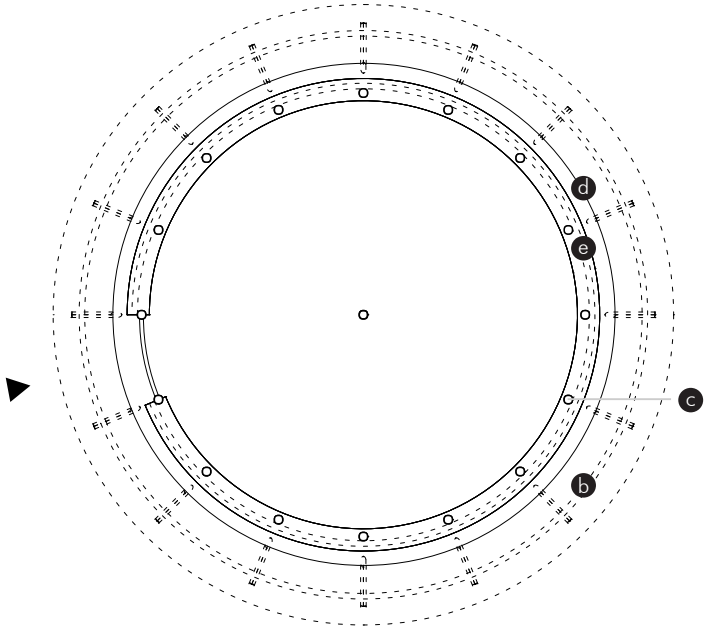


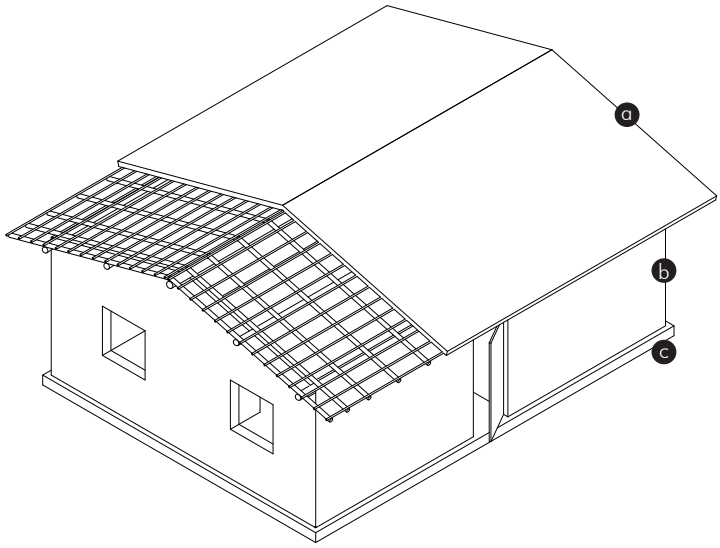
figure 18 - Inzu 2.0, isometry and floor plan

figure 19 - traditional Inzu

figure 20 - collecting bundles of grass

figure 21 - Inzu 2.0

figure 22 - rectangular house



Rectangular house

a cover
b bearing wall
c foundation
d crossbeam
e rafter
f purlin

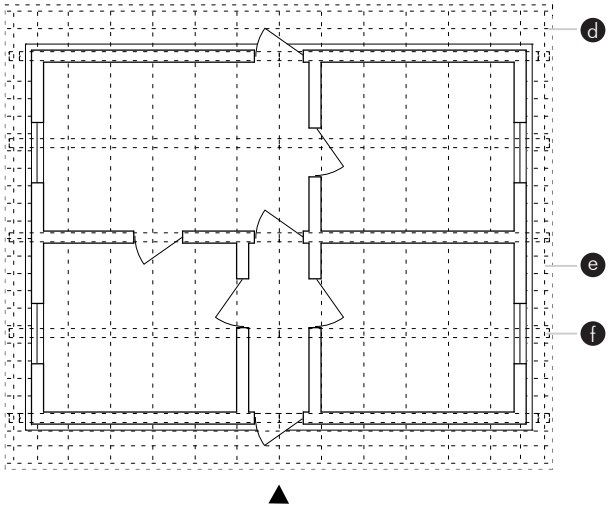
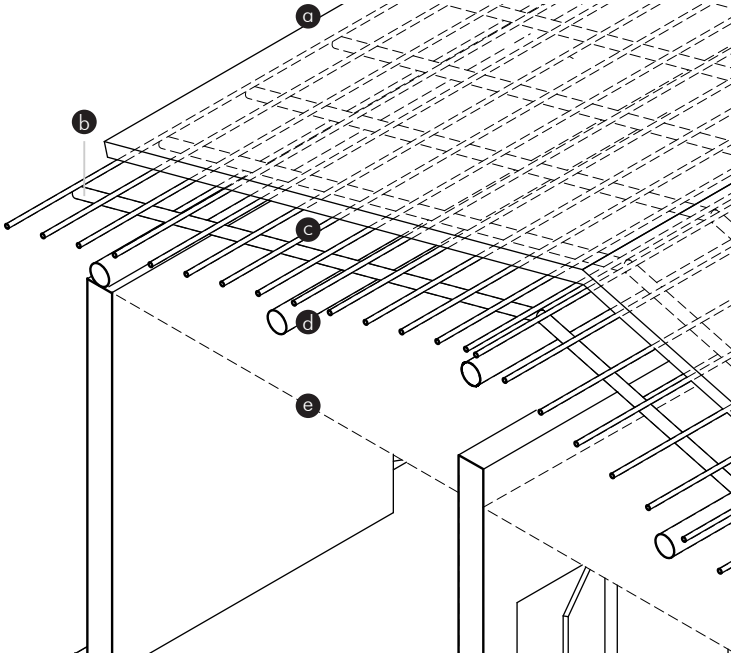


figure 23 - rectangular house, isometry and floor plan



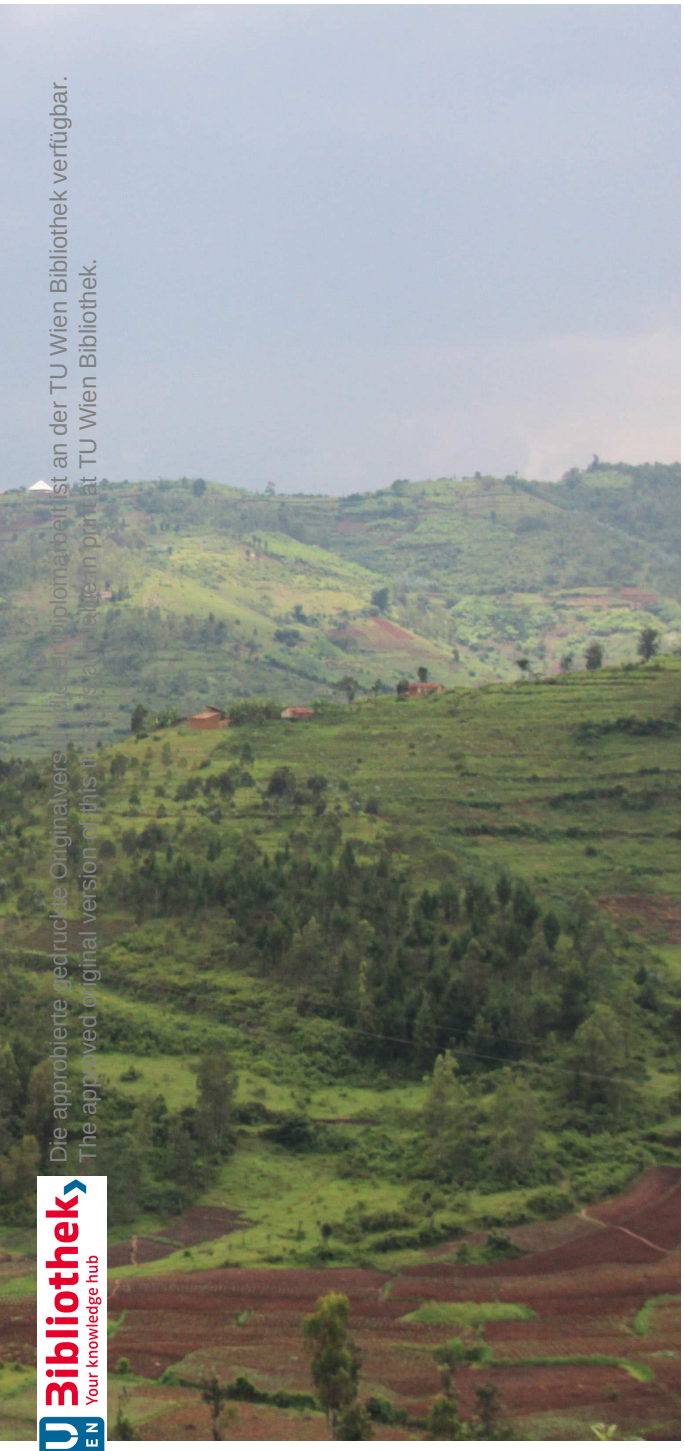
a cover
b rafter
c crossbeam
d purlin
e suspended ceiling (optional)

figure 24 - rectangular house, isometry detail

name indicates, is based on a rectangular instead of a circular arrangement. A foundation from rocks and bearing walls made from mud bricks are set up. These bricks require formwork to create equal sizes which are then laid on top of each other. Since its usage becomes more and more common, mud bricks are replaced by burned bricks nowadays. In addition the bearing walls are replaced by a grid of columns and cross-beams from reinforced concrete. Therefore the structure maintains more stable when it comes to earthquakes. Interior walls and openings (doors and windows) are added. The windows usually consist of wooden or steel frames and glass. To cover the house, a network of wooden rafters, purlins and cross-beams serve as the base for a roof. Depending on the availability and price of the materials, either tiles made from burned clay or metal sheets are used to create a cover. As a finish, suspended ceilings are added occasionally.[18,19]

18 MBADUKO 1996, p.22
19 see figure 23/24, p.33f.

figure 25 - dwellings in Kirinda



CHAPTER 2
Rara Heza

figure 26 - view of Nyabarongo river

figure 27 - view across upper Kirinda

Context

A village in the western highlands

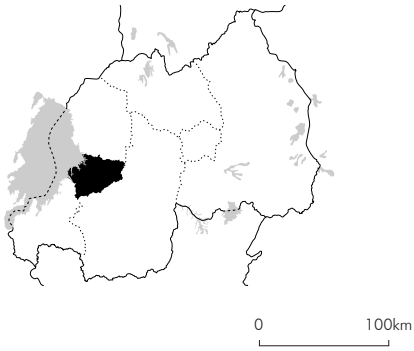


figure 28 - location of Karongi district in Rwanda

Geography The project Rara Heza is located at the boarding school of IPK (Institute Presbytérien de Kirinda) in the village of Kirinda, around 70km in linear distance, west of Kigali.[1] As described in chapter 1, Rwanda is divided into four provinces. In addition there are further administrative subdivisions into districts, sectors and cells. The allocation of Kirinda is in the western province, in the Karongi district. This district, on one side, is dominated by Lake Kivu as a large water body and the natural border to the DR Congo in the west. On the other side there are the western highlands, which are crossing the district more or less straight from south to north. Bordering in the south is the national park of Nyungwe Forest. To the east the rivers of Mbirurume and Mwogo are joining and therefore marking the beginning of the river Nyabarongo which creates a natural border to the neighbouring districts.[2,3]

Roads While examining the infrastructural context of Karongi district, it is striking that up to this day there is just one existing paved road in the north, connecting Lake Kivu and its bordering cities and villages with Kigali.[4] The remaining roads, referred to as unpaved, are usually dirt roads, with some of them in poor conditions. In particular there is one unpaved road crossing Murambi sector from north-east to south-west, which connects Kirinda to the western as well as to the eastern neighbouring districts. This is the only way to reach the village from the outside and therefore it is crucial for any exchange to have an intact road. In general, the existence of mostly unpaved roads signifies longer traveling hours from one place to another although the distances are basically short as illustrated in the following example. To visit *IPK* during the field trip to Rwanda, a bus was taken to travel from Kigali to Kirinda. The route the bus took is calculated with a distance of around 100km and a traveling time of approximately three hours[5] which corresponds with the proposed time by the bus driver. The bus left Kigali around 2:30pm in the afternoon and arrived around 9pm in Kirinda. Although there was one technical break down which was repaired and the service continued afterwards, the bus was particularly delayed due to its reduced speed according to the road conditions. Hence the bus ride of just 100km ended up taking six and a half hours and therefore the journey took more than double of the amount of time as the assumed three hours. Moreover the non-existence of paved roads is not just a matter of people getting from one place to another. Since there is no alternative infrastructural network (e.g. train network) the economy in this region especially relies on the road network, to transport goods such as building materials, pharmaceuticals and food.[6]

1 see figure 29, p.40
2 STATISTICS.GOV.RW 2015 p.24, web page visited 1/7/19
3 MAPS.GOOGLE.COM, web page visited 9/7/19
4 see figure 30, p.40
5 MAPS.GOOGLE.COM, web page visited 15/7/19
6 STATISTICS.GOV.RW 2015 p.24, web page visited 1/7/19

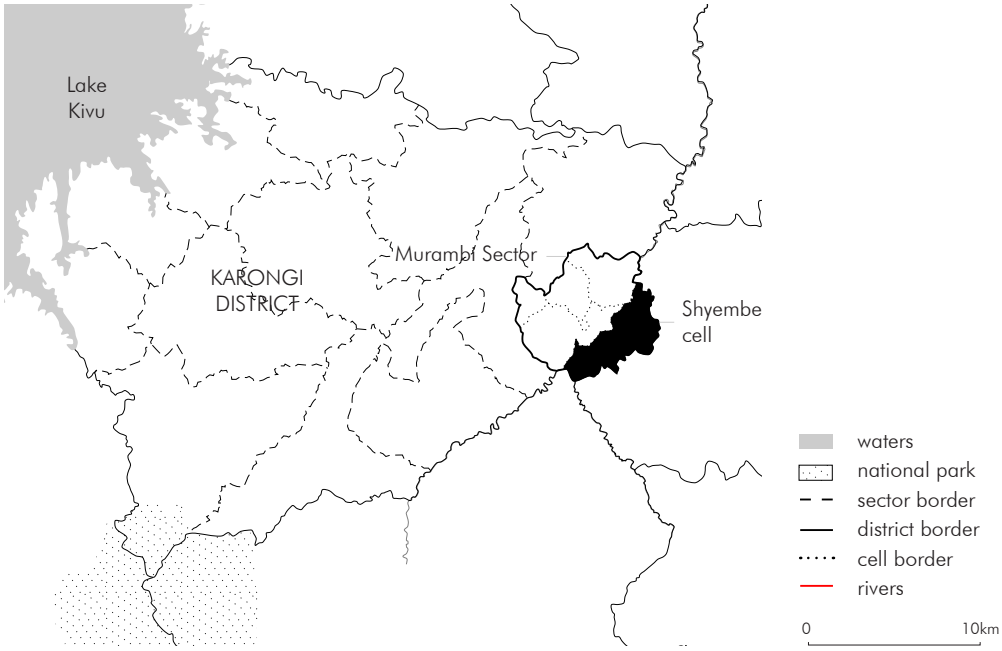


figure 29 - administrative boundaries

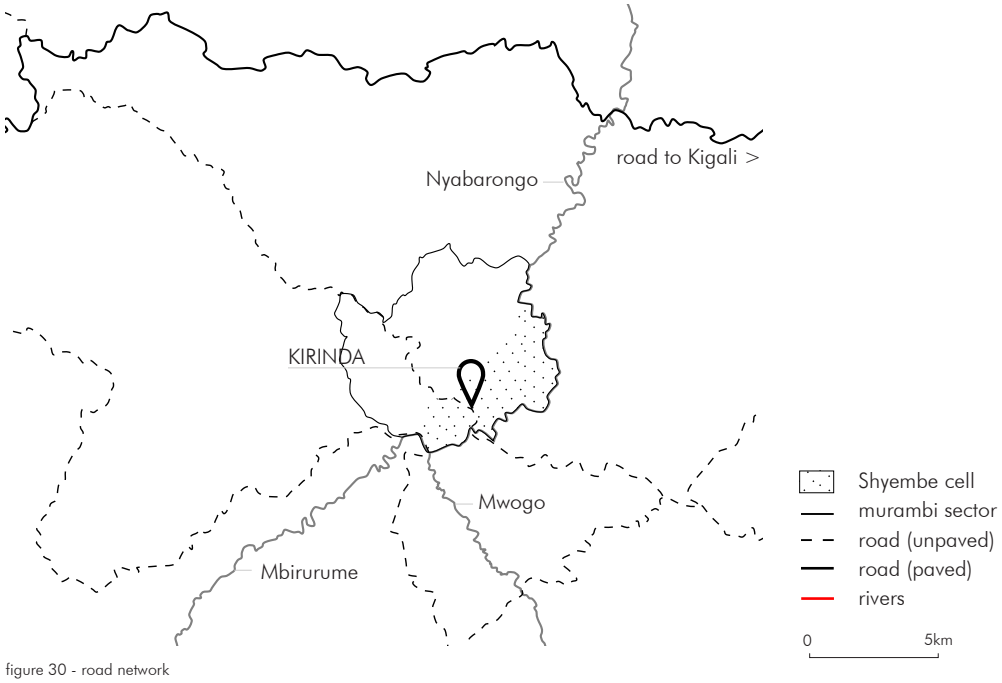


figure 30 - road network

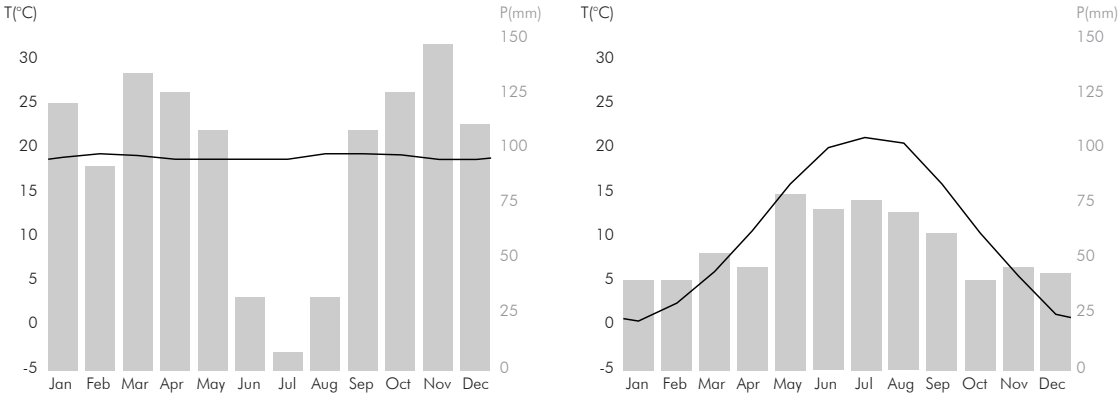


figure 31 - climate diagram Shyembe and Vienna

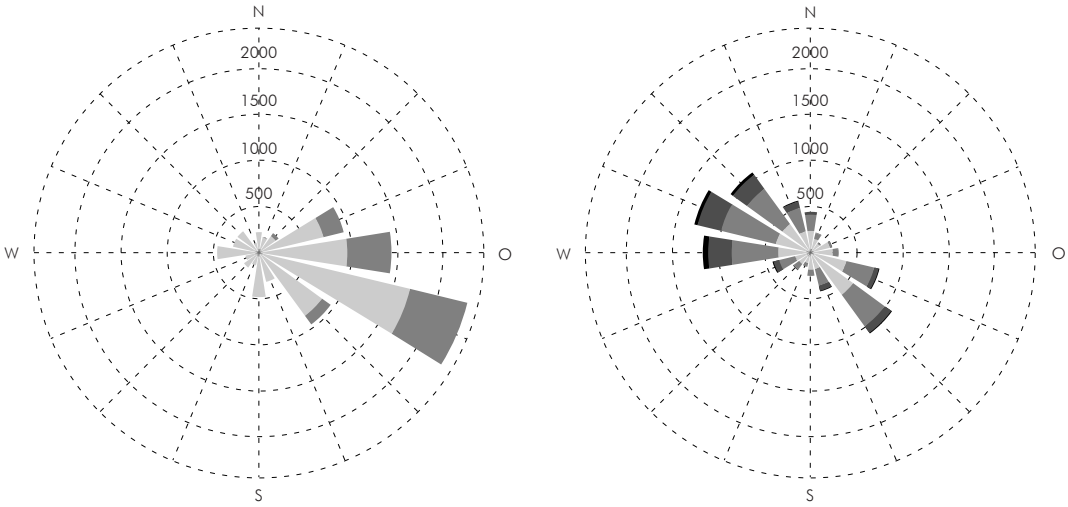


figure 32 - wind rose Shyembe and Vienna

Climate As one may observe in the climate diagrams in figure 31 (p.41), Kirindas climate is characterized by an extended dry season between June and August and a shorter dry season in February according to the monthly average precipitation. The remaining months may be considered as rainy season since its precipitation is significantly higher, reaching the maximum in March and November. The average temperature in Kirinda does not vary much throughout the whole year. Its mean temperature is around 20°C. In comparison to Vienna, one may easily notice Kirindas location close to the equator, since Vienna's monthly average temperatures differ a lot with a mean temperature of 10.8°C. In addition Viennas yearly precipitation adds up to 675.4mm in comparison to Kirindas', reaching nearly the double of 1203.9mm. Additionally as shown in figure 32, the wind speed in Kirinda in general is very low compared to Vienna. It reaches a maximum of 28km/h for around 2400h/year, while in Vienna there are winds with a speed up to 61 km/h during a maximum of 1300h/year. On the other hand the winds in Kirinda are mostly originated in the east and south-east whereas Vienna experiences both, strong winds from the north-west and south-east.

Rural context The village of Kirinda possibly developed similar to the idea of a cultural environment of a Rwandan family.[7] Therefore dwellings of the villages would have its roots in the scattered arrangement of compounds, corresponding to the relief of the landscape. In the case of Kirinda, the Nyabarongo river and its temporary flooded wetlands would have been essential factors determining the location of compounds. Thus the people inhabiting the area around Kirinda before the arrival of colonial powers, probably settled on the crest of the surrounding hills (roughly around 1600 to 1700m above sea level) to be safe from any floodings. Moreover the location on top of the hills enabled the people to set up plots which are more suitable for planting and harvesting as they are less likely to be destroyed by erosion.[8,9]
The described pattern of scattered dwellings one may still observe in today's village layout. As illustrated in figure 34 (p.44) a considerable amount of dwellings, although all with a rectangular shape, seem to have no connection to the existing road network and therefore might be based on the traditional way of compound settlements. Nonetheless the drawing also reveals the change of building arrangements through time. Setting up a church-building on the crest of a hill, an early 20th century building, the presbyterian church began to settle in Kirinda. Various buildings followed until today, including a kindergarten, a primary school and an infirmary. With the introduction of *IPK* in 1981 at the same place of the former infirmary building, a secondary school was added to the ensemble. *IPK* then started to expand until today with several new buildings. Consequently some great amount of land still remains

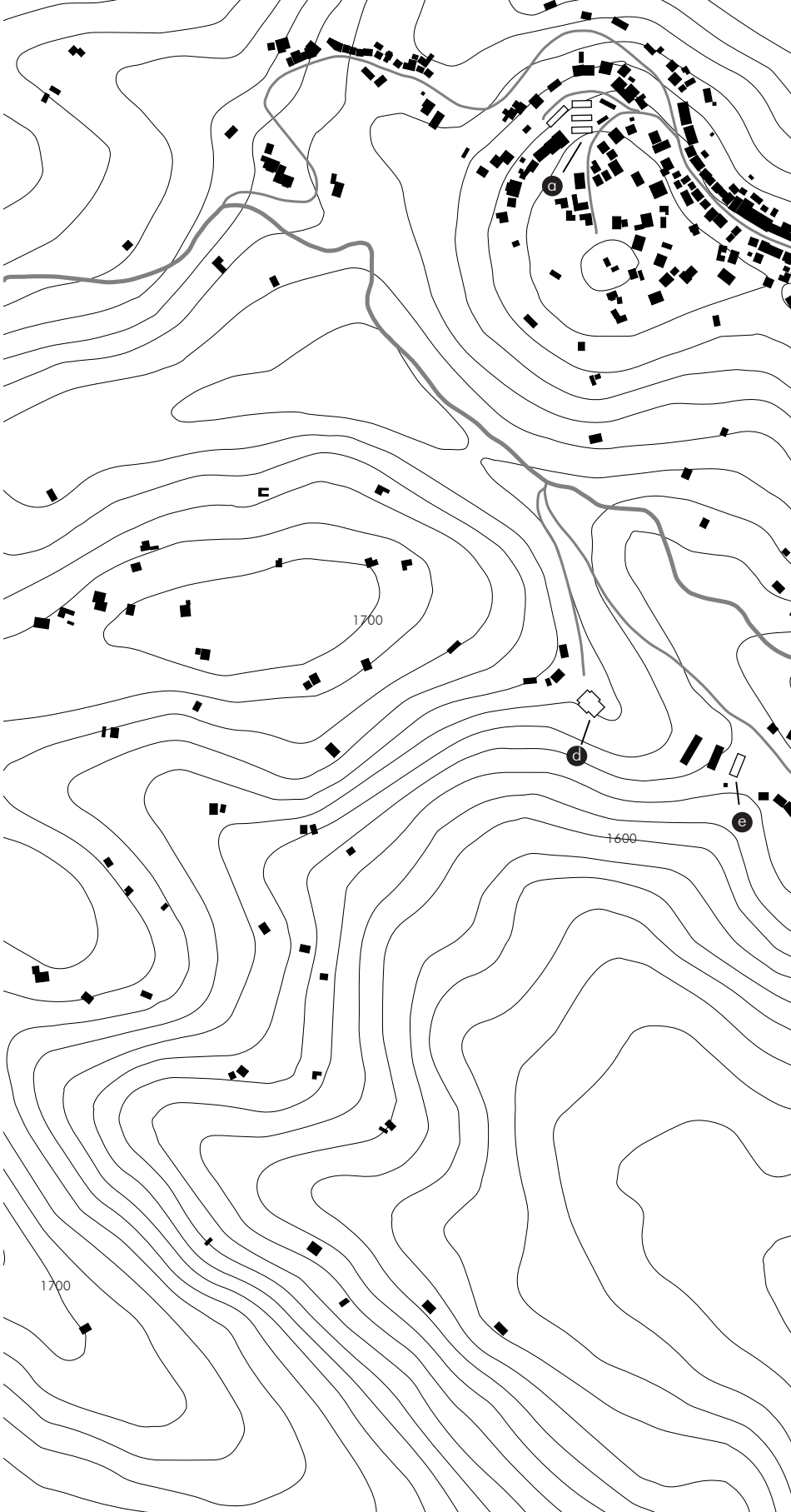
7 see chapter 1 - Vernacular Architecture in Rwanda

8 TUYIZERE 1998, p.13f.
9 see figure 33, p.44

the property of the presbyterian church.[10]
Analog to this development, the Rwandan government prepared the ground for future buildings along defined paths by providing infrastructure, such as (unpaved) roads, a district hospital, a trade center (market), a sector office, schools and a kindergarten. Accordingly people started to erect dwellings along those defined paths which now appear as the major paths in the village.[11]
As one may discover in today's plan of Kirinda (figure 34), these parties influencing the shape of the village, the church on the one hand and the Rwandan government on the other, might be the reason for two separate accumulations of buildings corresponding to the terrain. One of them being in the south between the church building and *IPK* and the other one being further north around the hospital, with the major street dividing them.

figure 33 - dirt road

10 KARANGWA, personal communication on 21/2/19
11 STATISTICS.GOV.RW 2015 p.24, web page visited 1/7/19



waters
buildings
major street (unpaved)
minor streets (unpaved)
1600 elevation in meter

a market
b hospital
c reference project (kirinda dorms)
d church
e kindergarden
f clay pit
g campus of *IPK*
h Nyabarongo river

N

0 200m

figure 34 - plan of Kirinda

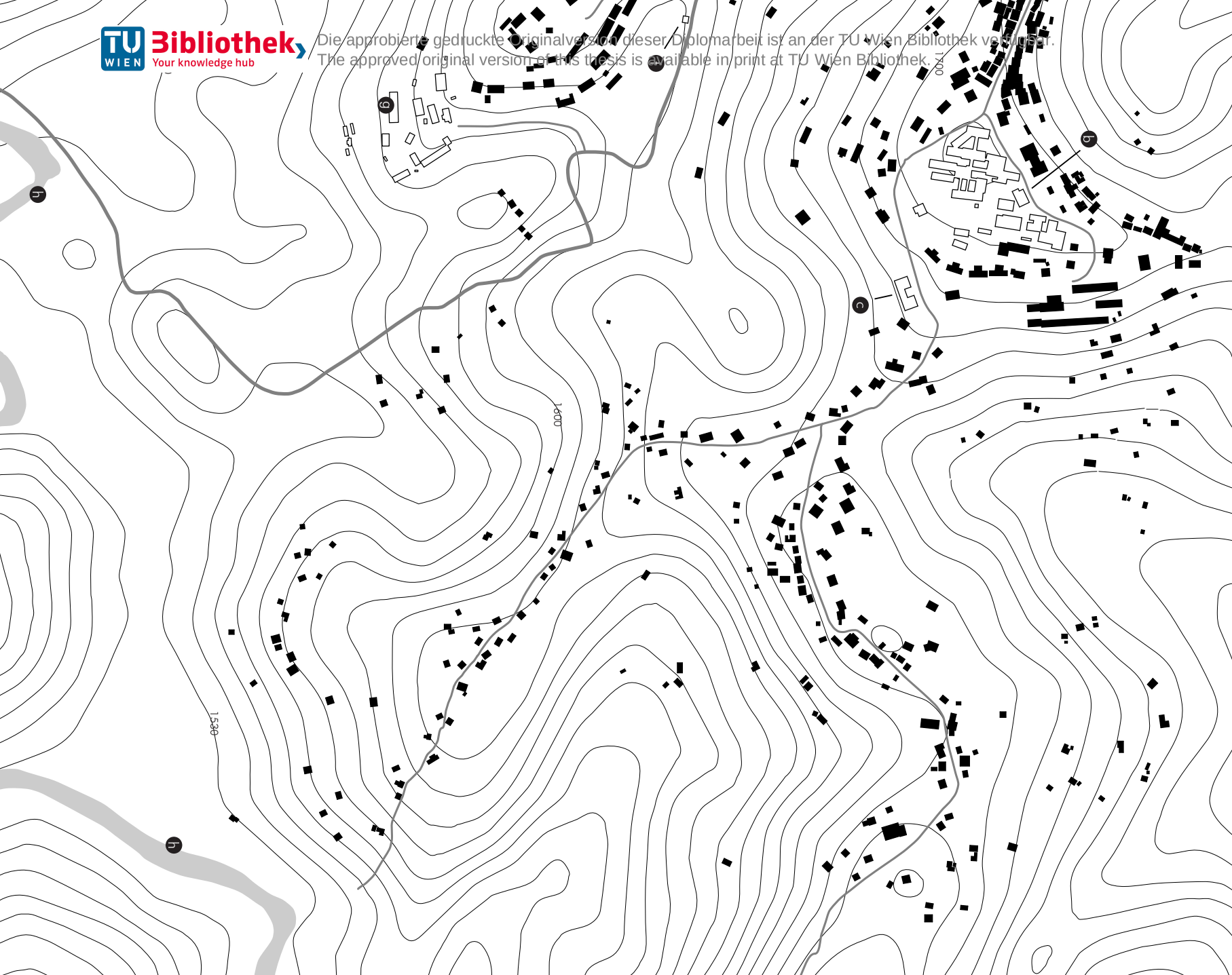


figure 35 - entrance door of *IPK*

Institute Presbytérien de Kirinda

A school managed by the presbyterian church

The place The Institute Presbytérien de Kirinda (*IPK*) is a boarding school for both female and male students. It was founded by the Presbyterian church of Rwanda in 1981. In the rwandan educational system it is classified as a higher secondary school, teaching three different disciplines which are the following.

1. Accountancy Department
This discipline was introduced in 1981 and there are around 130 students studying in the academic year of 2019.

2. Computer Science Department
Computer science is taught to 119 students at the moment and was introduced in 2014.

3. Construction Department
There are 70 students studying construction. This department was founded in 2017.[1]

This concludes that there are 319 male and female students in total. As a boarding school, *IPK* offers some students a place to stay during each term of teaching. One part of the students is living in dormitories on the school campus, separated into female and male dormitories. Another part of the students either stays with their families (if these are living close enough) or they are residing with guest families in Kirinda.[2]

Education in Rwanda Based on the 2018 Education Statistics issued by the rwandan Ministry of Education the rwandan educational system is subdivided as shown in figure 36 (p.48). The average child in Rwanda stays within its family until the age of four followed by time spent in the nursery (age 4-6). With around seven years, primary school (primary sector) starts and ends with the change to the lower secondary school (lower secondary sector) at the age of 13. After, there is the higher secondary sector (age 16-18) followed by the tertiary sector (e.g. university). According to this, *IPK* is classified as a higher secondary school in the higher secondary education sector.[3]

Daily Life Starting in mid-January, the academic year at *IPK* is divided into three terms.[4] At the end of each term there are exams, followed by holidays. There are short (two weeks-holidays) in April and August and longer holidays from the end of November until mid-January when the academic year starts off again. During the holidays the students usually go home to their parents place to spend some time with their families. The holiday breaks are the only time during the year when the dormitories are not used by the students. Thus, the rest of the year the students are staying within the school campus.[5]
The daily routine of the students, as observed during the field trip in Rwanda, is illustrated in figure 38

1 GAHUTU, personal communication on 18/2/19
2 see 1
3 MINEDUC.GOV.RW, web page visited 27/3/19
4 see figure 37, p.48
5 see 1

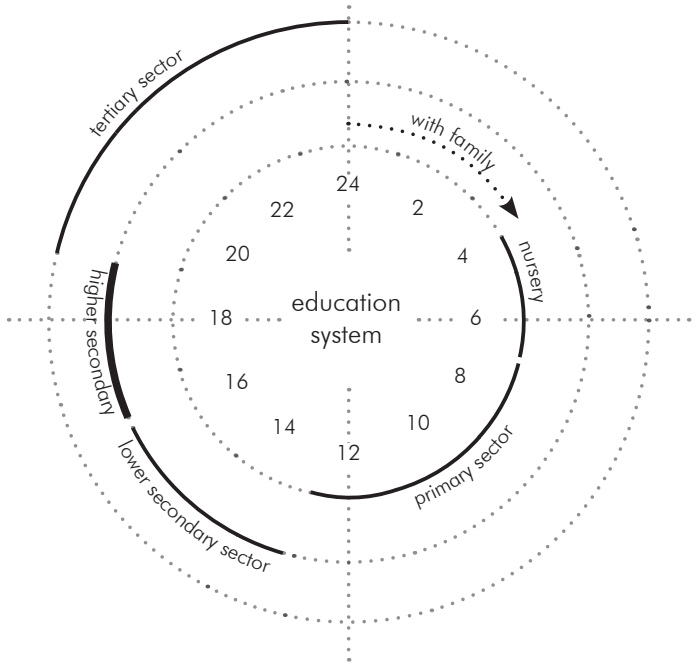


figure 36 - educational system in Rwanda

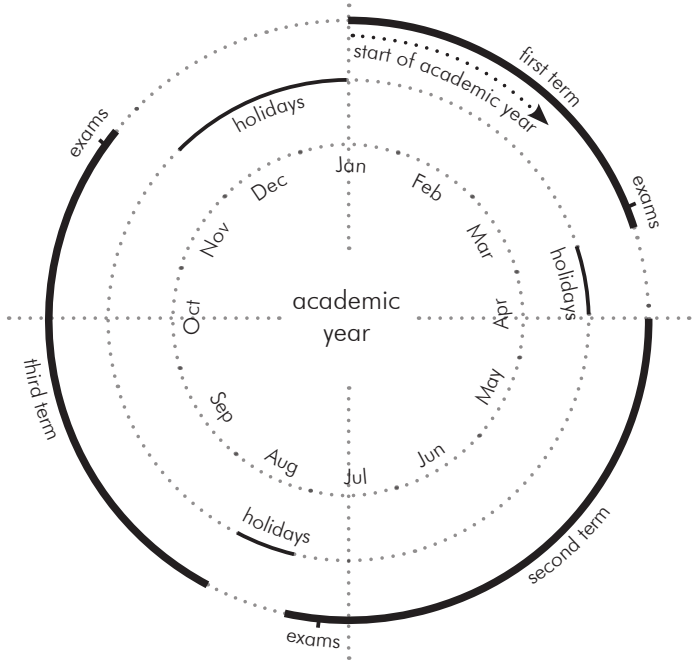


figure 37 - academic year at *IPK*

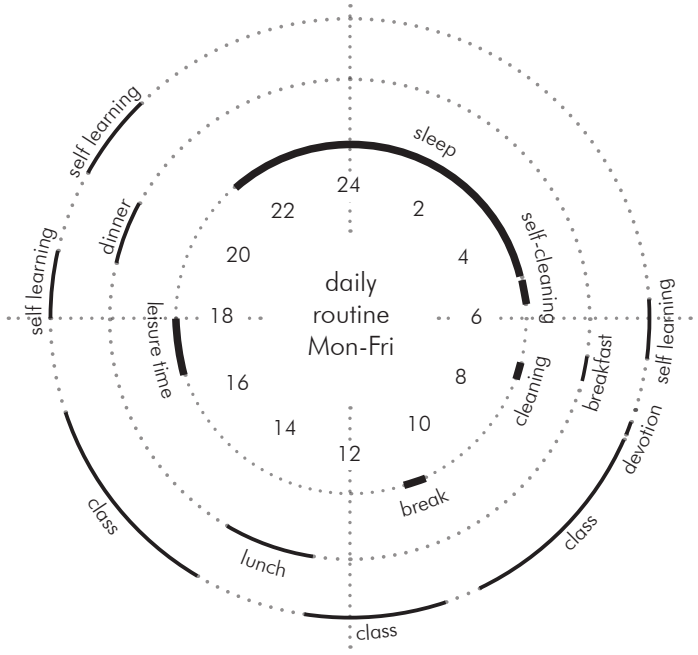


figure 38 - daily routine

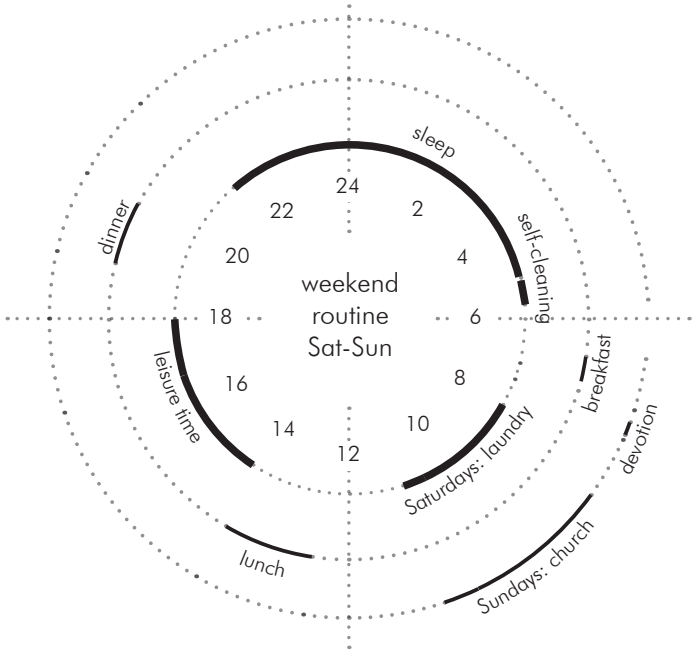


figure 39 - weekend routine

figure 40 - sports ground close to *IPK*

(p.49). For students which are sleeping at the dormitories within the school campus it starts by being roused around 5 am. At that time they get ready for the day. In general the daily schedule is dominated by the time spent in classrooms (instructional time). This time is extended by a so called self learning time, in which the students can prepare themselves for the classes, do homework or study for upcoming exams. Self learning happens mainly in the classrooms which therefore are opened by teachers early in the morning. Because of the lack of alternatives the students are advised to do this in the classrooms. The self learning occurs three times during the day, but it does not mean that all the students always spend time studying. As well as during leisure time and other breaks the students pursue activities at or close to the campus of *IPK*. This for example includes playing at the sports ground close to the school campus. There are also the so called *clubs* besides regular teaching classes, which for example improve the english skills of the students. They are managed by teachers of *IPK*. The self learning and instructional time are interrupted by the breakfast, lunch and dinner breaks which take place in the canteen at the school campus.

In comparison to the daily routine, there is not as much scheduled during the weekend. The time destinated for breakfast, lunch and dinner is usually the same. Apart from doing the laundry each Saturday morning and going to church every Sunday morning, the students mainly have an extended leisure time during the day. To highlight the time students spend in their dormitories, the activities happening within the dormitories are marked with bold strokes in figures 38 and 39 (p.49). In general, the dormitories are used throughout the year for the majority of time. In the daily life (monday to friday) the students mostly use the dormitories as a place to sleep and to have some breaks from the classes. However, as there is an extended leisure time each weekend, students have the opportunity to spend more time in their dormitories - whether it is for doing some homework or just hanging out with some roommates.

Privacy As it will be described in the following section, of the existing structures[6], in which some of the buildings at *IPK* are analysed, there are separate dormitory

6 see Chapter 2: existing structures at *IPK*, p.57

buildings for female and male students. Although one may imagine that it is similarly handled in boarding schools across Europe, this separation seems to be very important in Rwandan tradition, even up to today. As outlined in a personal interview by Ildephonse[7], a construction class teacher at *IPK*, woman and in particular girls in Rwandan boarding schools are supposed to be provided by sufficient private space. This privacy neither signifies being completely on their own nor that each of the women inhabitat their own room. Instead privacy just implements a separation between male and female while the woman might even stay all together in one room. This definition of privacy as of being alone with other women instead of each person being on its own is important to mention since there might be a lot of students staying together in one room. Moreover, as described in the first chapter, people are used to share a room with other family members as they grow up under common living conditions.[8] At *IPK*, privacy is accomplished not only by two separate buildings but also by using the slope as a natural barrier. Hence the students are already divided while being on their way to their dormitory buildings.[9]

Bathroom facilities Toilets at *IPK* are divided by gender. Thus there are separate toilet buildings dedicated to female as well as to male students. In general, the water closets (WC's) at *IPK* work in the following two ways. One part of the WC's are water flushing, which use the water from the public network in Kirinda and are considered more comfortable and clean, since they emit less smell. Overall, water flushing WC's could just be observed in the administration building. The problem with these WC's is the unreliable supply of water in Kirinda. During the time of the field trip at *IPK,* at least 1/3 of the days there was no water available. Hence the WC's did not work as they are supposed to and were left abandoned. The second type are composting WC's. These WC's do not use any water. Instead, all of the faeces are collected and stay within a pit located underneath the WC. In case of *IPK* the composting WC's are used for a certain amount of time until they are closed for a while. With this closure the faeces have time to dry out and can be used as fertilizer afterwards. A disadvantage of the system practiced at *IPK* is the availability of just half of the amount of WC's in each period (usually 6 months).[10] Sinks are either attached to a toilet building or added separately on the school campus. They are made of bricks and/or concrete and have a water connection. Therefore students at *IPK*, apart from cleaning themselves, use the sink for laundry purposes by filling up some buckets with water and cleaning their clothes by hand. In the same way most of the showers are handled. Since there is not always a water connection right at the same spot of the showers, buckets are filled up and emptied after, on top of each person in the shower cabin.

7 MBARUSHIMAN, personal communication on 21/2/19
8 see Chapter 1: contemporary Rwandan architecture
9 see figure 41, p.52

10 GAHUTU, personal communication on 20/2/19

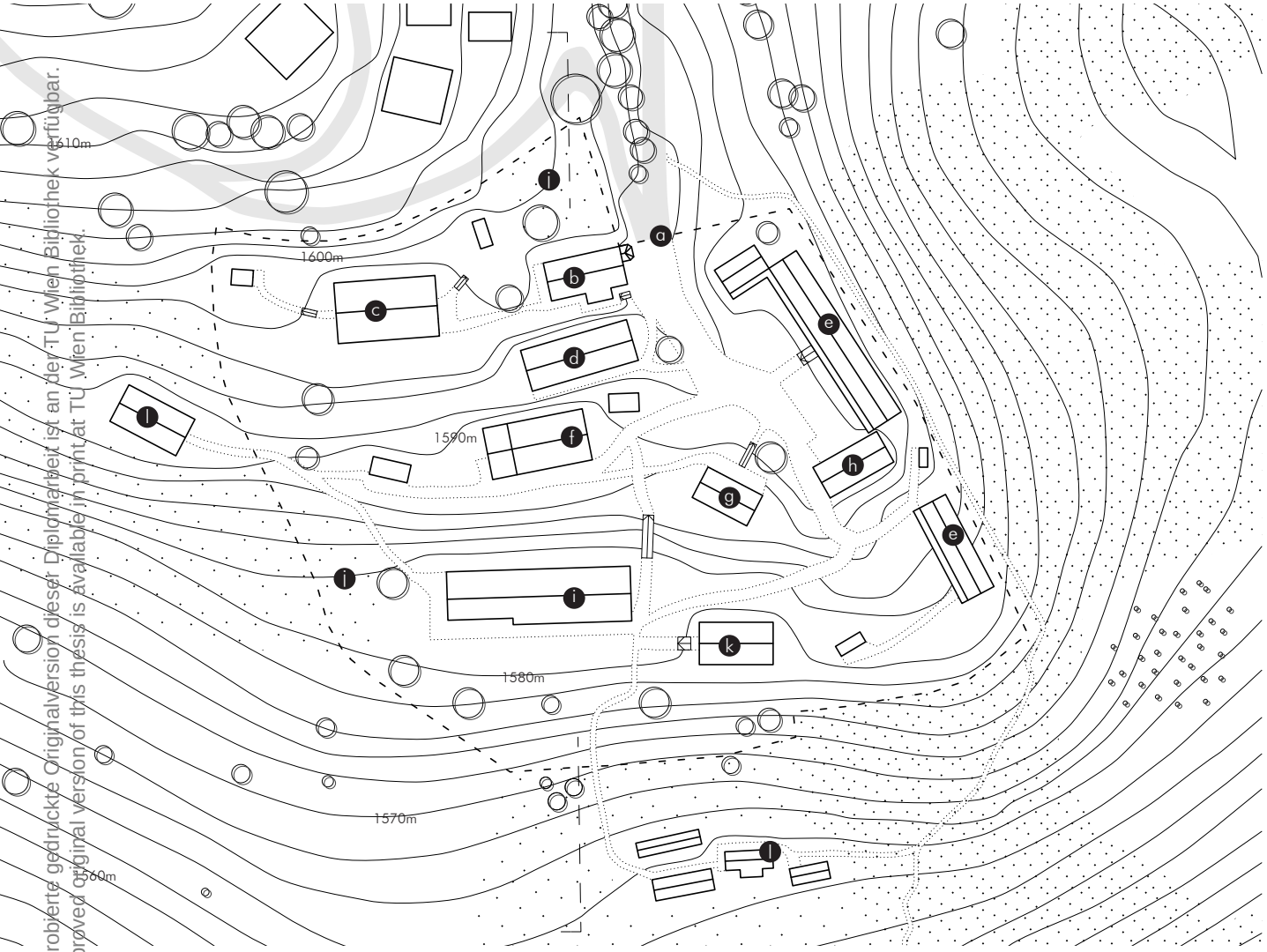


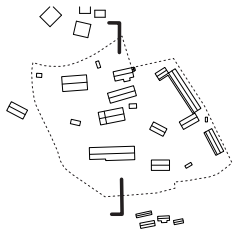
figure 41 - site plan *IPK*

Location As displayed in the plan of Kirinda[11] at the beginning of this chapter, *IPK* is located in the south of the village. There is an unpaved street connecting the main entrance of the school with the main street and therefore an access by car is possible. The campus of *IPK* is surrounded by a fence which maintains the privacy of the students. This fence is cut by the main entrance close to the matron building, which usually is the only way students and teachers enter the campus. Two other entrances, one to the south and one to the west, are serving the farms which are situated outside of the fenced area. Mostly unpaved paths are connecting the buildings of the school campus according to the topography. As mentioned before, the first building, which was erected on the school campus, is the matron building to the north. Close to the matron, the administration building accommodates the teachers during their preparation times and breaks from class. As well, the headmaster of *IPK* has his office in this building. The students on the other hand reside in their own dormitories, which are the girls and the boys dormitory. These two buildings are separated by a height difference of approximately eight meters, with the girls dormitory being located at the higher point of the slope. Both dormitories have adjoining toilet buildings, separated from each dormitory. To the east of the campus there are several buildings including classrooms for daily teaching and a meeting hall which enables the people at *IPK* to hold masses as well as group meetings. Meals during breakfast, lunch and dinner are served in the canteen building which includes a kitchen. There are two locations of a garden in which students are able to plant and harvest fruits and vegetables. In addition a library provides necessary literature and a workshop building performs as a shaded training ground for the construction classes since the space protects the students from strong midday sunlight and heavy rainfall. There are occasional trees inside the fenced area, of which some were planted during the last years. Moreover outside the fenced are to the east and south there is an accumulation of trees which may be considered as a forest. Some of those trees were cut down according to the need of firewood, as derived through an interview with Francine Musabeyezu, which is managing all matters of agriculture at *IPK*. Therefore new trees, situated in the southeast of the campus were planted recently to afforest some parts of the area.[12,13,14]

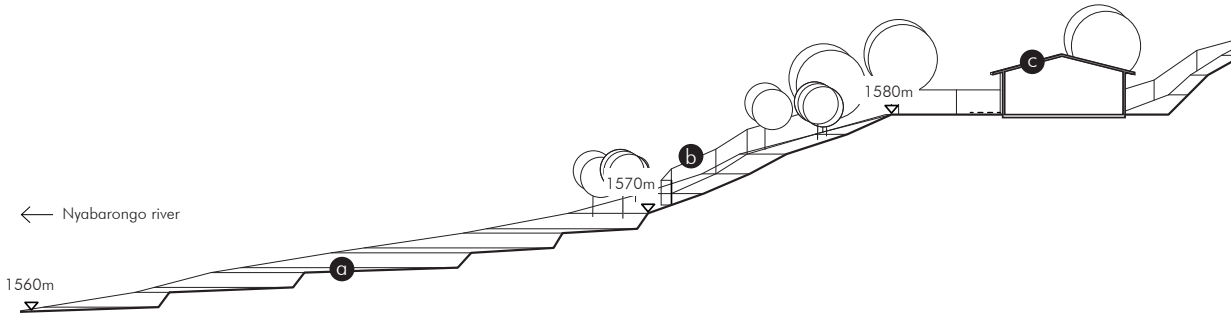
Topography In general IPK is set up on the slope of a hill between 1560 and 1600 MASL. For the erection of each building on the campus, the slope was excavated according to the relief of the section. The street sits at the highest point of the area while the fields are at its lowest. The reason for the appearance of the fields is the protection from any damage caused by erosion (surface water), which seems to be reduced by terrac-

11 see figure 34, p.44

12 see figure 41
13 see 10
14 MUSABEYEZU, personal communication on 20/2/19



location of section

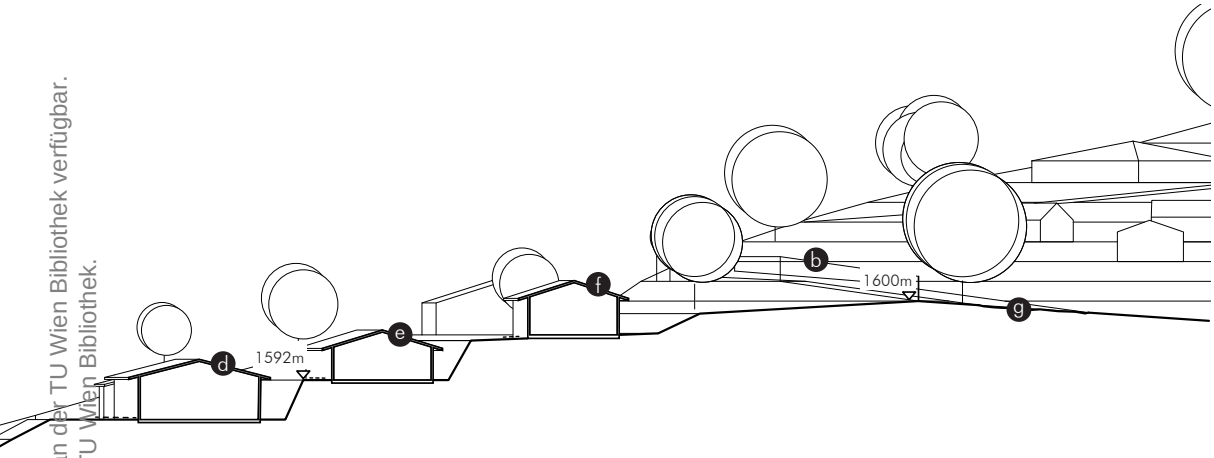


ing the land. Being located in the upper part of the slope, a panoramic view is offered from many angles of the school campus. In particular one may notice the Nyabarongo River which is situated to the south in the valley below *IPK* at an elevation of 1520m. Further up the hill, neighbouring to the north, there are several residential buildings.[15]

The task According to Charles Gahutu, headmaster of IPK since the year 2000, there will be more students applying for a place at *IPK* in the near future.[16]
An important fact proving this is, that the rwandan government tries to increase the literacy rate of students. In the 2018 Education Statistics, issued by the rwandan Ministry of Education it says that "The government of Rwanda [...] strives to improve access and quality education, specifically [...] the quality and youth literacy rate from 86.5% [...] [2018] to 93.2% [...] [2024] for 15-24-year-old students, [...]".[17] In addition, one reason as Charles Gahutu mentioned, is the closure of several private schools throughout the country which seems to put more pressure on the schools being left. As an example the number of TVET (Technical and Vocational Education and Training) schools in Rwanda decreased from 402 (2017) to 360 (2018). A further reason is the growing population as mentioned in the first chapter. Providing higher secondary education as a TVET school for students between 16-19 years of age, *IPK* therefore will be a key component as an institute for education which is needed to increase the literacy rate throughout the next years.[18,19]
With the facts of the desired growth of the literacy rate, the decreasing amount of schools, as well as the growing Rwandan population in mind, there is a need of space on the school campus of *IPK*, to accommo-

15 see figure 42, p.55
16 see 1

17 MINEDUC.GOV.RW, p.17, web page visited 28/3/19
18 MINEDUC.GOV.RW, p.16, web page visited 28/3/19
19 see 1



0 10m

a fields
b fence
c canteen
d boys dormitory
e administration
f matron
g street

figure 42 - section *IPK*

date future students. As it will be mentioned in the analysis of the existing buildings (see next section), the current boys' dormitory is a former meeting and event space. According to the interview held with Charles Gahutu, there is the intention of accommodating the male students at another place than the recent boys dormitory, if possible. Hence the idea of creating new space, specifically to accommodate students, came up during the recent years.[20]

20 see 1

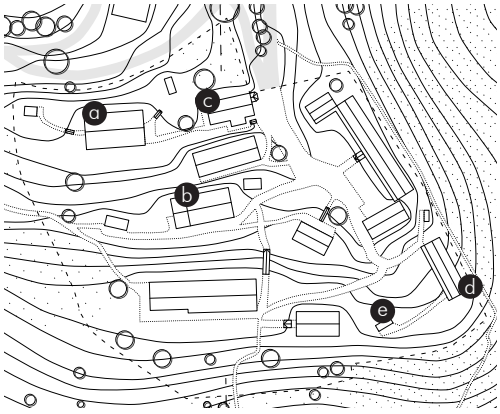
figure 43+44 - analysing existing building structures

Building Surveys

Existing structures at *IPK*

Local characteristics With a first proposal of the future dormitories in mind, the next step was the inspection of some parts of the school campus of *IPK* to gain some knowledge about the way people are building in this area. In particular it was planned to analyse the structure and the use of materials of some buildings to be able to design a building in this environment.
IPK consists of an ensemble of various buildings which were erected during the last decades. Their typologies are somehow similar, yet different in the way of how they were being constructed. Arriving at the school campus, the most remarkable fact to see was how the local technicians were dealing with the terrain, especially the slopes which in some parts are reaching around 20°.[1] As the team of *IOG's* first design of the future dormitories was based just on photos and a rough estimate of the slope, the focus while working on the design in Vienna was to think about the arrangement of the different areas according to the hill. The issues of vertically flowing water were not considered in much detail at that point. It became obvious that it will be crucial for a sustainable (long lasting) design, to consider the location on a steep hillside and therefore to think about appropriate solutions regarding a drainage system to prevent any erosion of land through flowing (rain)water.
In addition, such a variety of construction methods of the existing buildings was not expected. By choosing some of them for a deeper analysis in this thesis, the aim is, to cover the majority of construction techniques found at *IPK* as illustrated on the following pages.

Figure 45 presents an overview of the analysed buildings and their location on the campus of *IPK*. Not every building which was inspected, was completely accessible, due to privacy reasons. Therefore, some room arrangements could not be considered completely and are left out in the following drawings and explanations.



a girls dormitory
b boys dormitory
c matron
d construction class
e toilet building

figure 45 - analysed buildings

1 see Chapter 3: The site

figure 46 - girls dormitory building

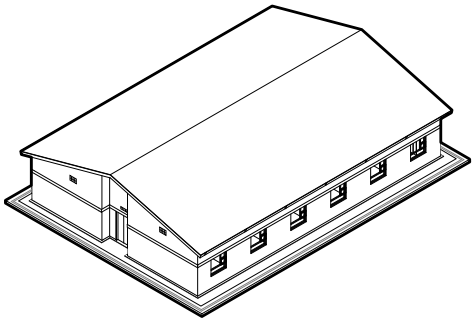


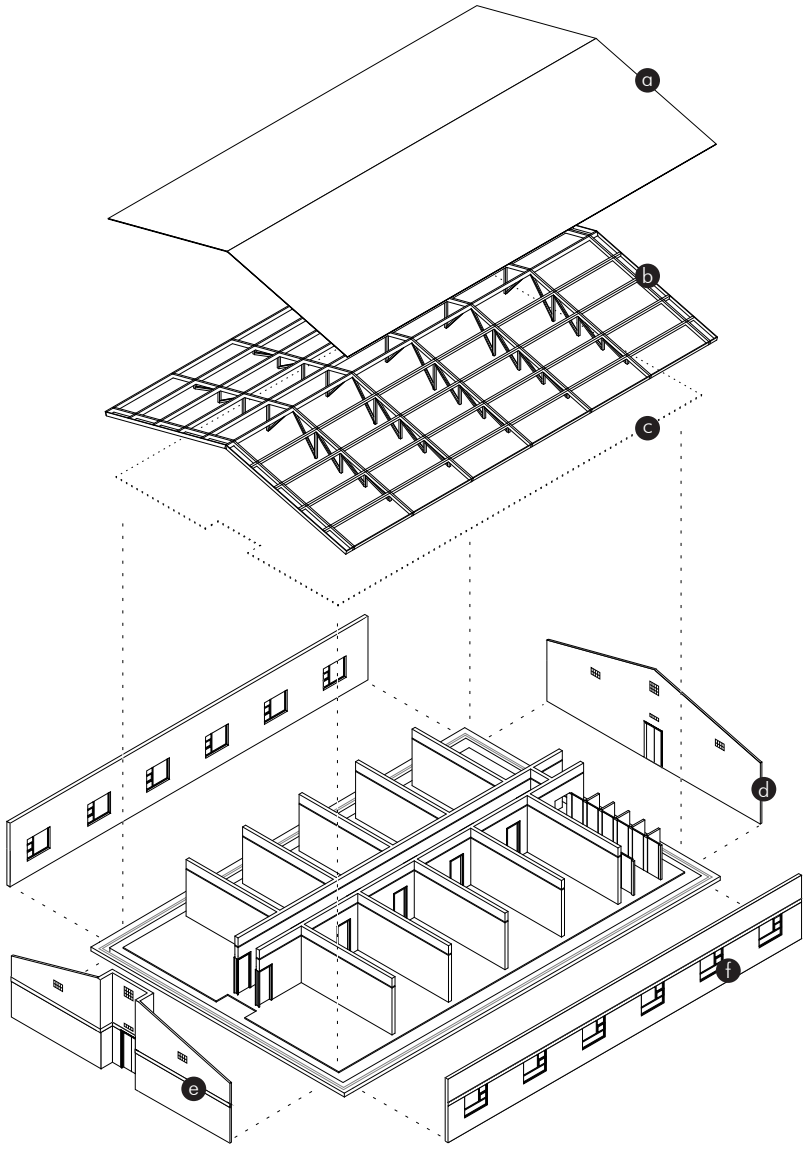
figure 47 - axonometry

Girls' dormitory building

Division of space The building presented in this section is the place to accomodate all female students of *IPK*, unless they are staying with families in Kirinda or having their families living nearby (as described in Chapter 2: *IPK*). It is set up on a rectangular plot, around 24x14m and around 5.5m at its highest point. The plot is east-west orientied and stretching along the contour lines of the terrain. This implies less excavation before erecting the building. The space is divided equally into 12 rooms with 10 rooms being used as dormitories, one room equipped with showers and one room used as a storage space. The 10 dormitories are arranged symmetrically along a central corridor covering an area of 22.2m^2 each. One steel-frame window of 1500x1200mm per room facing to the outside provides daylight in every room including the showers. In addition every dormitory is furnished with 12 wooden- and steel-framed bunk beds measuring 2000x900mm and 15 lockers to store the students personal belongings of 700x560mm each, although some beds as well as lockers are not intact and cannot be used. Contrary to the rest of the rooms, the showers cannot be accessed from the corridor. Instead students enter this part from the outside, at the western side of the building.

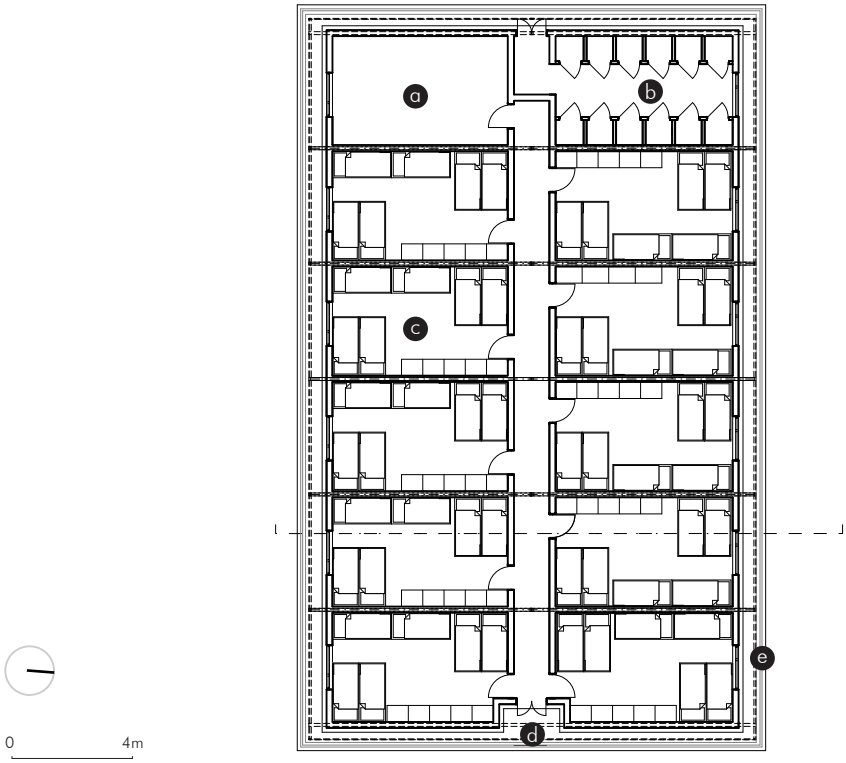
Structure & Materials The construction of the girls' dormitory building is based on bearing walls consisting of burned bricks. On the back side of the building, which is facing the slope, a layer of cement up to the height of 500mm is preventing the brick wall from damage caused by heavy rainfall. The outer walls are reinforced by a 200mm strong circular cross-beam made from stone which is set directly above the doors and windows at a height of 2100mm. On top of the bearing walls, a structure of wooden beams forms the base for the wooden purlins and rafters, both as well supported by the outer bearing walls at each of their ends. The roof finishes with a cover of metal sheets, which are connected to the rafters. At the interior one may discover a suspended ceiling. One reason for this separate ceiling is to reduce the noise of the metal roof created by heavy downpours as well as birds walking on the roof. Another reason is to increase the atmospheric comfort, since without any additional layer one would look at the bare ceiling further up, as well as there would not be any barrier separating the dorms. Besides these structural components, there are ventilation openings to enable an airflow along the upper part of the building. Moreover drainage pipes surround the whole building to collect the water flowing down according to the terrain. Unfortunately there is no retaining wall at the slope at the back of the building, protecting it from any soil, which is washed away.[1]

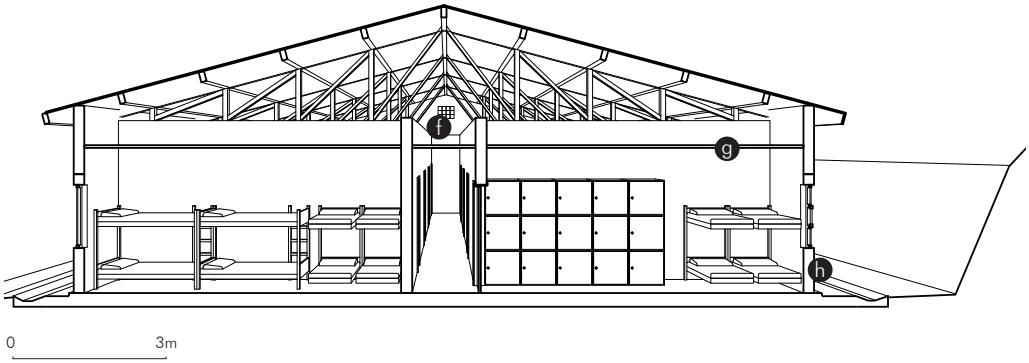
1 TWAGIRA, personal communication on 24/2/19



a	metal roof	c	suspended ceiling	e	cross beams (stone)
b	wooden beams	d	brick walls	f	steel windows

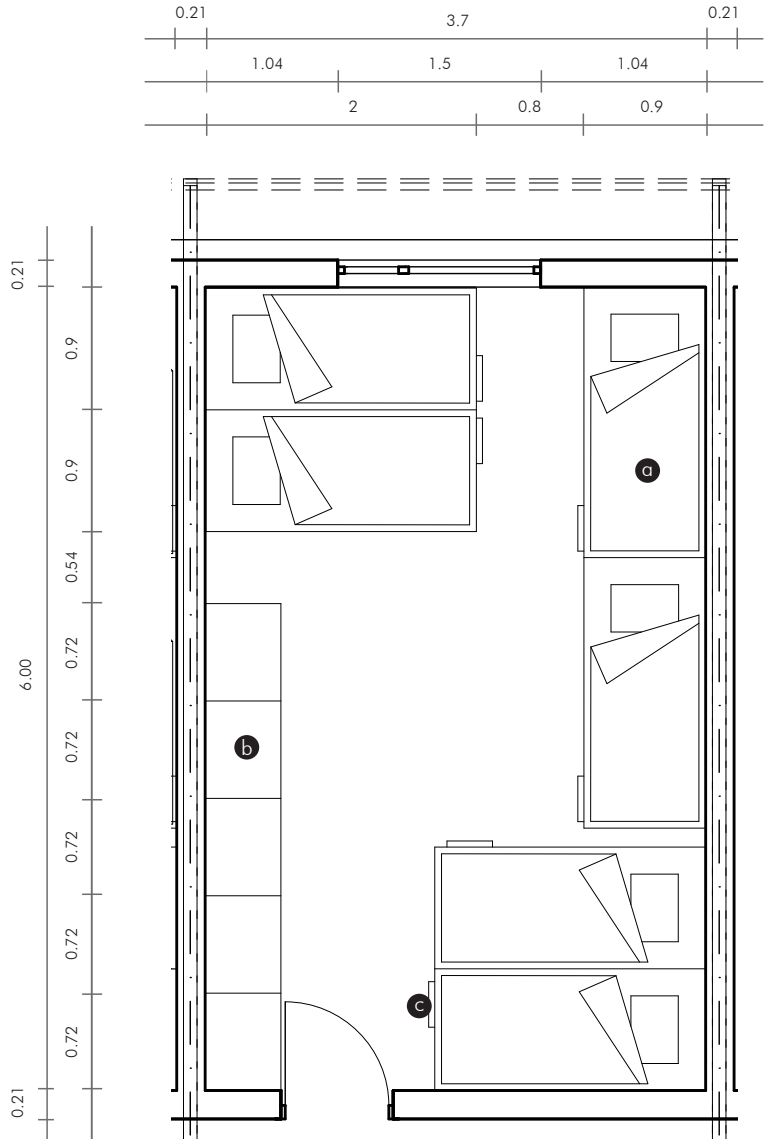
figure 48 - exploded axonometry





a	storage	c	dorm	e	drainage	g	suspended ceiling
b	showers	d	main entrance	f	ventilation opening	h	coating (rainprotection)

figure 49+50 - ground floor + cross section



a bunk bed b locker c ladder

figure 51 - average dorm

figure 52 - dormitory interior

figure 53 - boys dormitory building

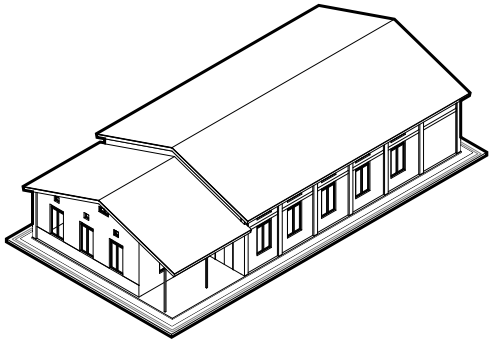


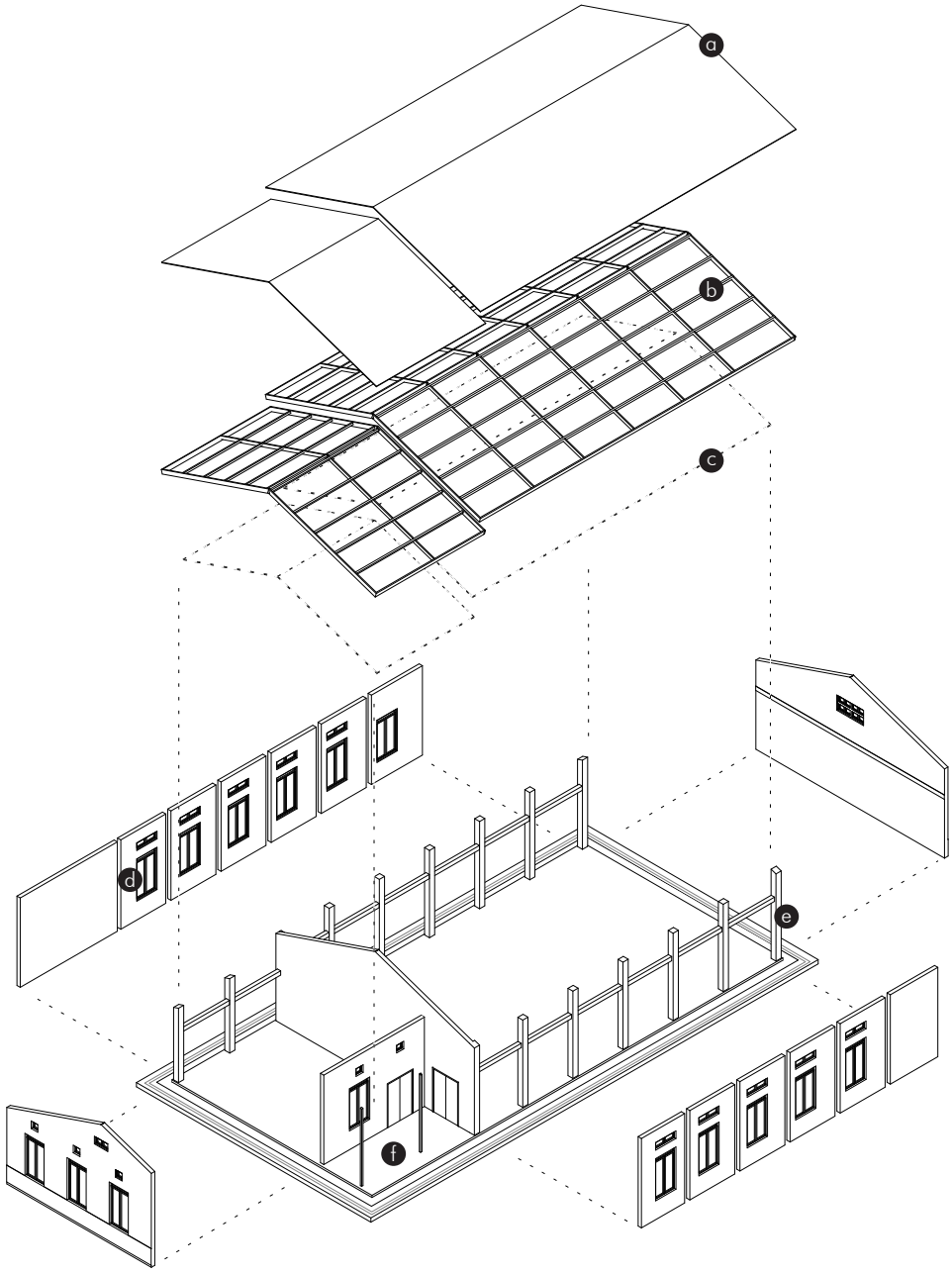
figure 54 - axonometry

Boys' dormitory building

Division of space Equal to the dormitory of the female students, the boys' dormitory accommodates all male students of *IPK* except the students, which are staying outside the school campus. It is as well east-west oriented, with its longer front facing the hill. The plot measures 24x12m with a height of 6.1m, while one part of the building is stepping back by 3m, to create a covered area for the entrance. Contrary to the girls' dormitory building, one may observe that there is no division into separate sleeping rooms in this building. In general there are just two rooms, with the greater one being a former meeting and event space and serving as dormitory space nowadays. Therefore all male students sleep in just one room.[1] The second room is accessed by a door facing the covered outside area. Steel-frame Windows to both long sides measure 1170x2000mm, with an additional ventilation opening on top. As well, there are ventilation openings on the shorter outer walls, in the east and west. The dormitory space is furnished with a great amount of wooden- and steel-framed bunk beds measuring 2000x900mm, without any separation nor any lockers. Hence the students keep their belongings inside the bags they brought with them, for a whole term of teaching (usually three months).

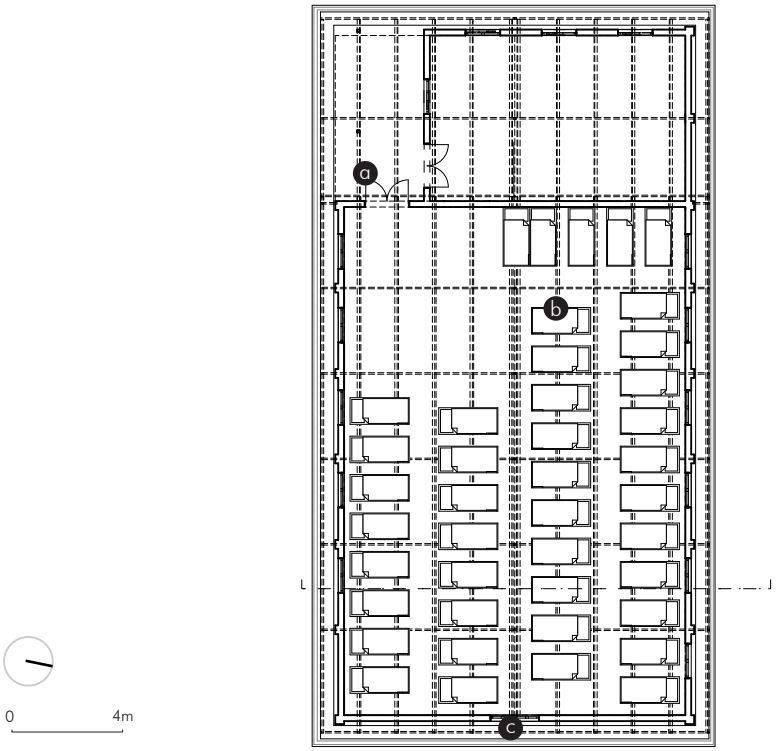
Structure & Materials The boys' dormitory building is based on a grid of brick columns (each 300x300mm). These columns are connected horizontally by a cross beam made of stone on the long sides of the building and set the foundation for steel rafters, which are seated on top. Together with steel purlins, which are connected to the rafters, as well as being supported by the outer brick walls, they form the base for a metal roof. Between the brick columns, 200mm strong brick walls including the windows, fill up the remaining space. Similar to the girls dormitory building, a suspended ceiling increases the comfort of the buildings users, drainage pipes conduct the flowing water around the building and there is no retaining wall at the slope at the back of the building, protecting it from any soil, which is washed away.

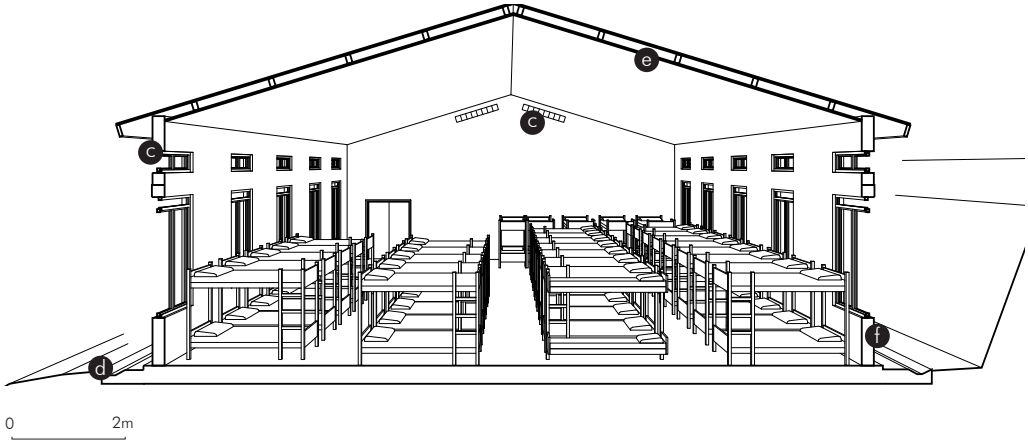
1 GAHUTU, personal communication on 18/2/19



a	metal roof	c	suspended ceiling	e	brick columns + crossbeam
b	steel beams	d	steel windows	f	covered area

figure 55 - exploded axonometry





a	main entrance	c	ventilation opening	e	suspended ceiling
b	bunk beds	d	drainage	f	coating (protection)

figure 56+57 - ground floor + cross section

figure 58 - matron building

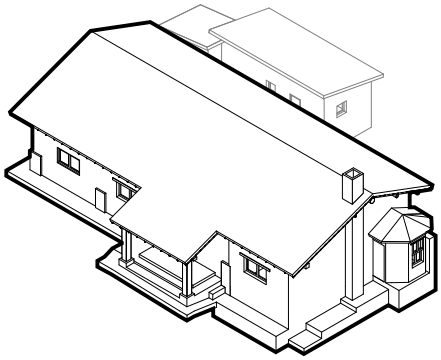


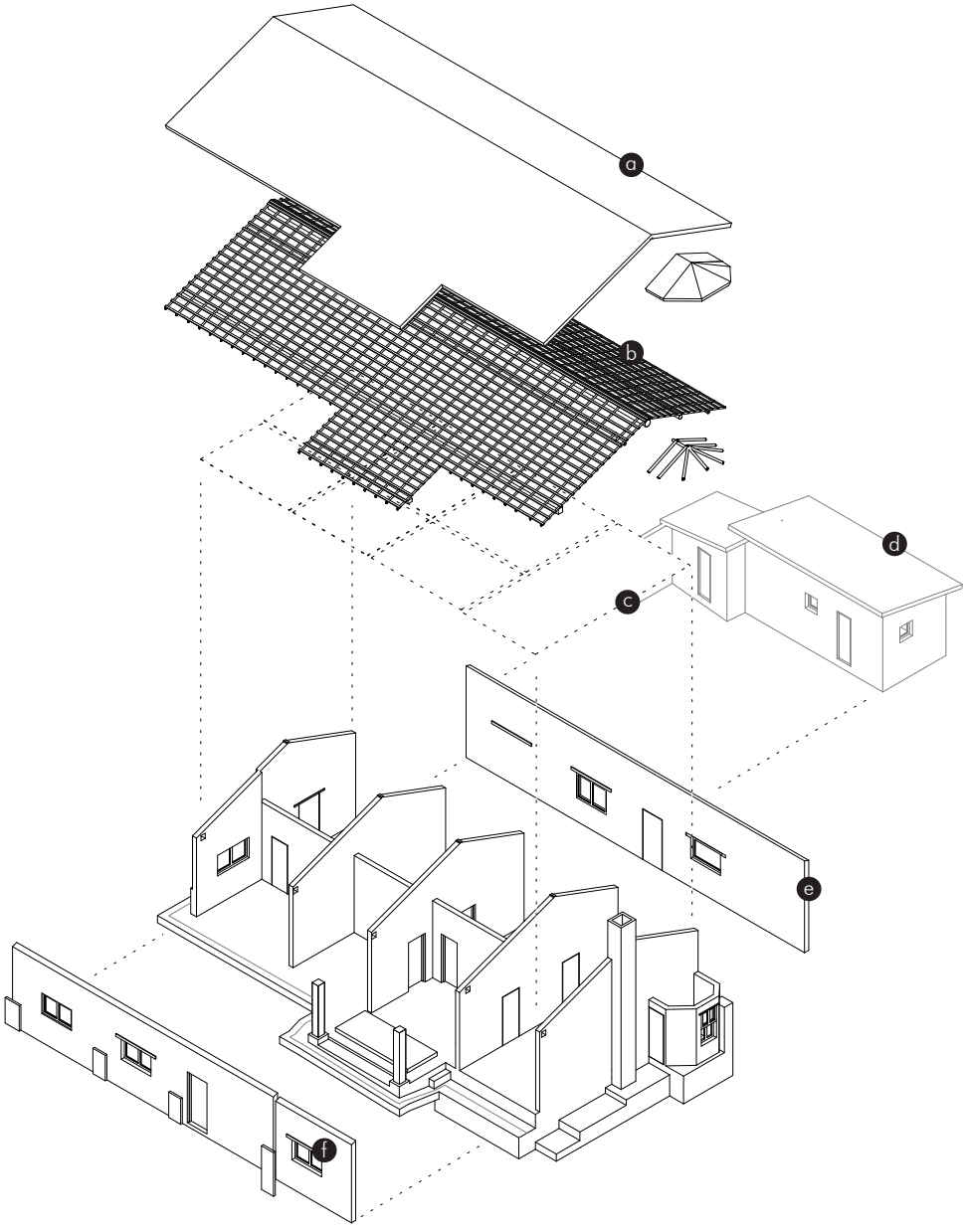
figure 59 - axonometry

Matron building

Division of space For the people at *IPK*, a matron signifies a person which is taking care of the students requests and concerns while being a mediator between the teachers and the headmaster on one side, and the students on the other. This role might be best translated to a tutors position at a university, being the mediator between professors and students. Accordingly, the main part of the building is dedicated to the person working as the matron, including a bedroom, a kitchen and a bathroom. In addition, there are two rooms which function as infirmary space to accommodate students and teachers, which are temporary feeling sick and need to rest. Similar to the dormitory buildings presented before, the matron building is set up on a rectangular plot, also east-west oriented, following the contour lines of the terrain. The main building measures around 17.5x7.7m, with a height of 5.5m. As a relic of the former use, there is a space for a guard or housekeeper, situated right next to the main entrance of *IPK*. In addition there are two minor buildings on the backside which create a courtyard carved into the hill. Two columns mark the main entrance to the building while creating a sheltered area. In comparison to the dormitory buildings, ventilation openings are missing, making a reference to the time the matron building was erected.

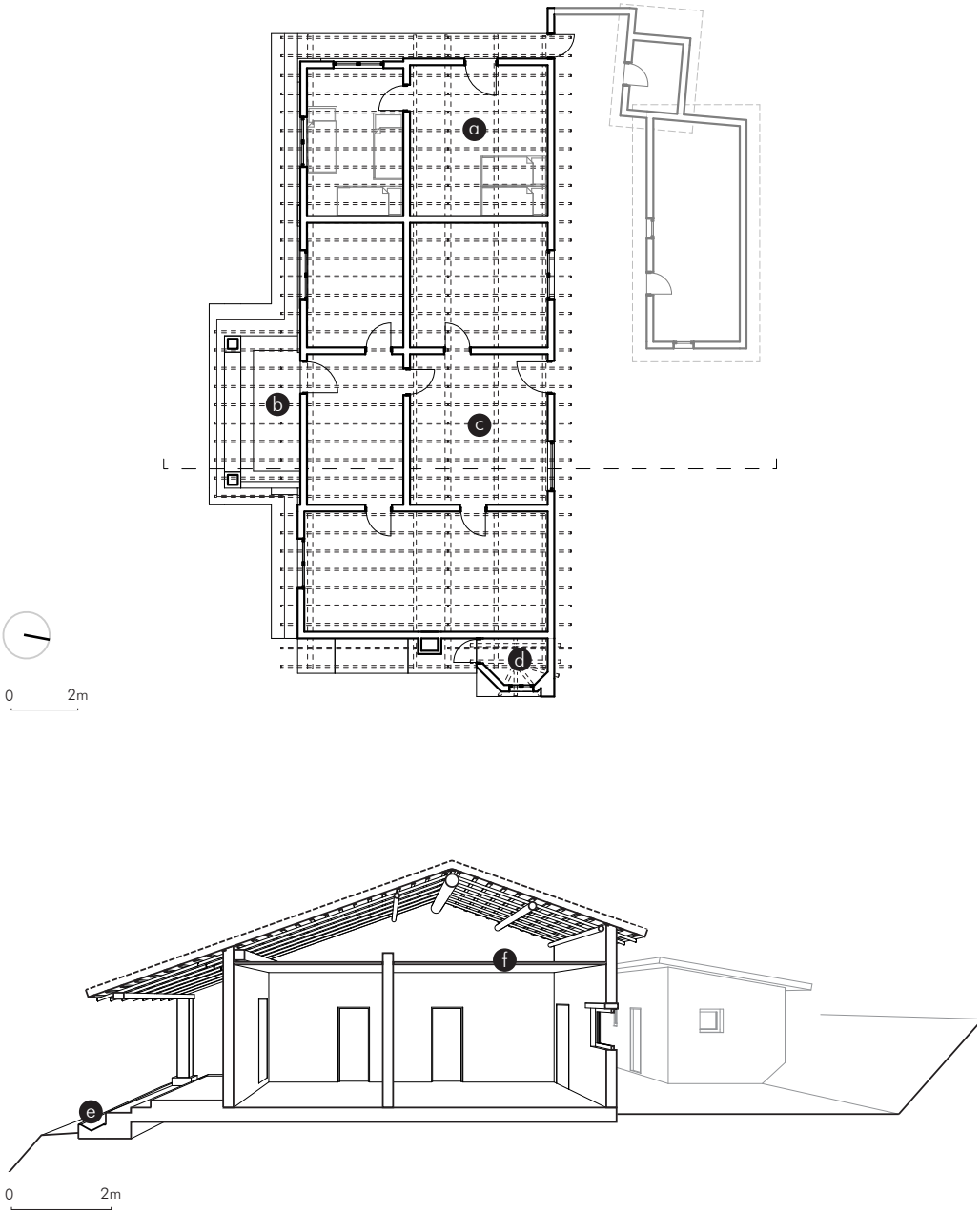
Structure & Materials Since it is the oldest existing building on the campus of *IPK*[1] the matron building reveals some of the building techniques and materials used some decades ago. The basic structure is formed by bearing walls made from burned bricks with a width of 200mm. In addition there are two columns (300x300mm) also made from bricks. These brick walls and columns support the following roof structure. Five wooden purlins together with a large amount of rafters and even smaller crossbeams create the base for the burned tiles as the cover of the roof. Remarkable with this construction is the use of mostly locally cut trees for the beams and locally formed and burned tiles, as one may still observe in today's roof construction. A wooden beam covers each of the wooden-frame windows, which measure 1500x800mm. As well as with the two dormitory buildings, a suspended ceiling exists in the matron building, although it is disputable whether this ceiling was added some years after the buildings construction. There are also drainage pipes located on one side of the building.

1 GAHUTU, personal communication on 18/2/19



a	burned tiles	c	suspended ceiling	e	brick walls
b	wooden beams	d	annex	f	wooden windows

figure 60 - exploded axonometry



a	infirmary	c	living area of matron	e	drainage
b	covered area	d	former guard/housekeeper	f	suspended ceiling

figure 61+62 - ground floor + cross section

figure 63 - construction class building

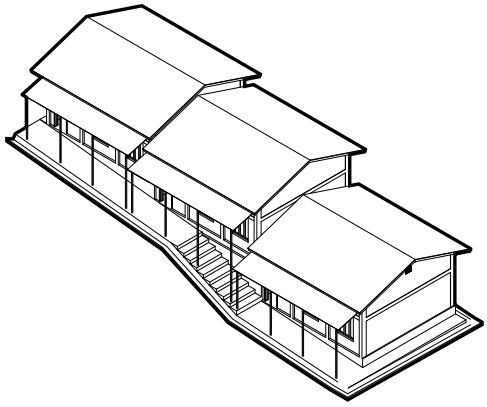


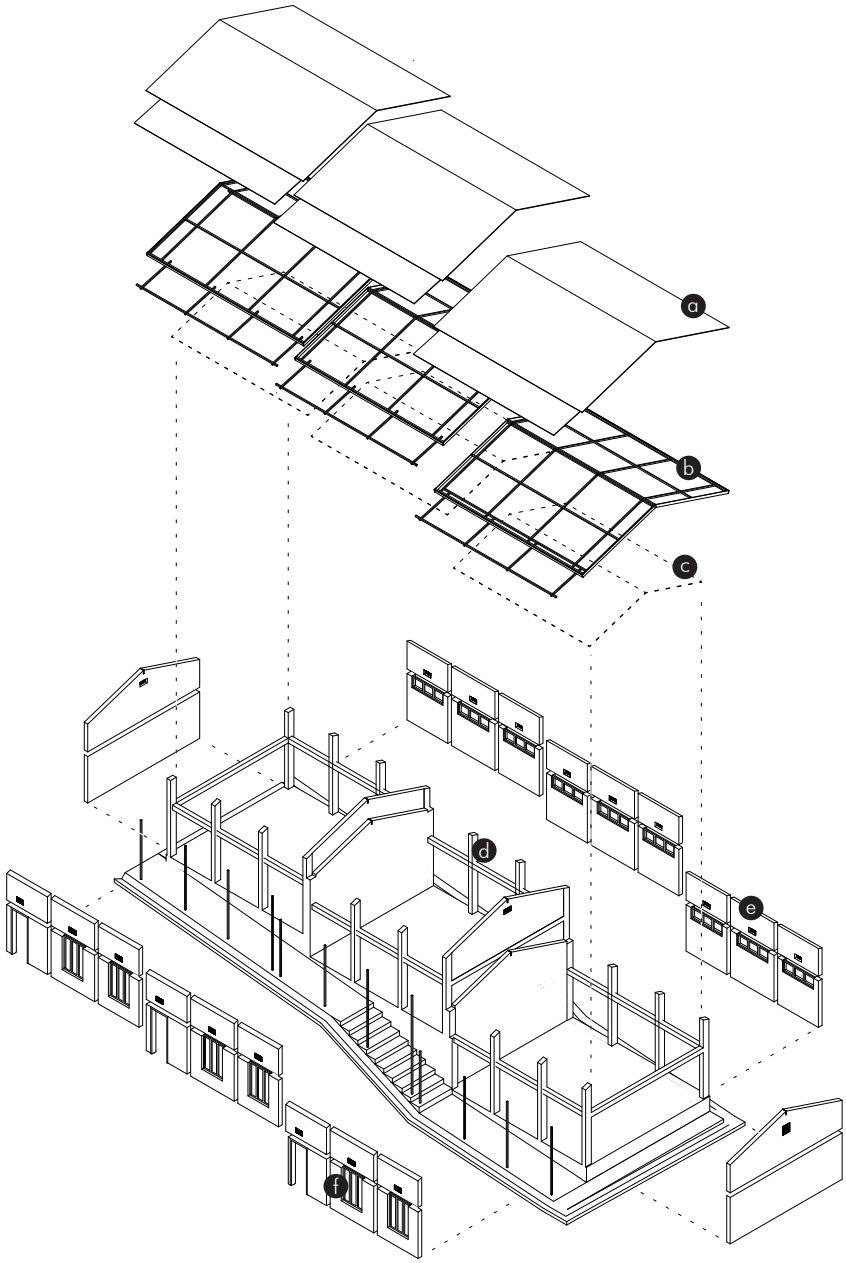
figure 64 - axonometry

Construction class building

Division of space Contrary to any of the analysed buildings in this section, one may detect that the construction class building is oriented in a 90° angle to the contour lines of the terrain. This is striking, since it requires further excavation of the soil. Moreover, this building may be separated in three parts which are equal in size and structure. All of these parts are used as classrooms for teaching at the construction department at *IPK*. Each of the classrooms offer an area of 47m^{2,} including wooden benches and tables and a blackboard. A walkway characterized by stairs, connects the three classrooms and is covered by an extended roof. All walls have ventilation openings, to increase the thermal comfort of the users by exchanging the air, since the building is mostly used during daylight hours and therefore experiences some heat. There are two types of steel-frame windows of which one is facing the west, measuring 1200x1500mm and the other type (1800x500mm) facing the east. The second window type might have been chosen according to the course of the sun, which starts to rise in the east at a very low height in the mornings. Therefore, the direct sunlight shining through the landscape format windows, does not disturb the students as much as if it would arrive through a portrait format window.[1]

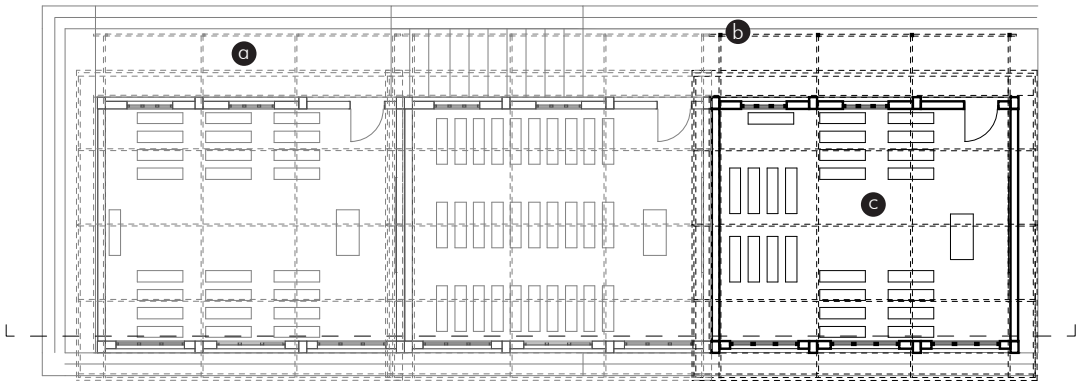
Structure & Materials The structure of the construction class building is determined by a network of concrete columns, which are connected horizontally by a cross beam, as well made of concrete. The usage of concrete implies a change of building materials, since the other buildings in this section are based on walls built up with burned bricks. In the case of the construction class building, the burned bricks are just used to fill up the empty space between the concrete columns. On top of these columns there are purlins and rafters made of steel, supporting a metal roof. Covering the walkway in front of the building, the extension of the roof to the west is based on some steel pillars. Similar to the dormitory buildings analysed before, a suspended ceiling raises the comfort level of the buildings users and drainage pipes conduct the flowing water around the building.

1 see Chapter 3: The site

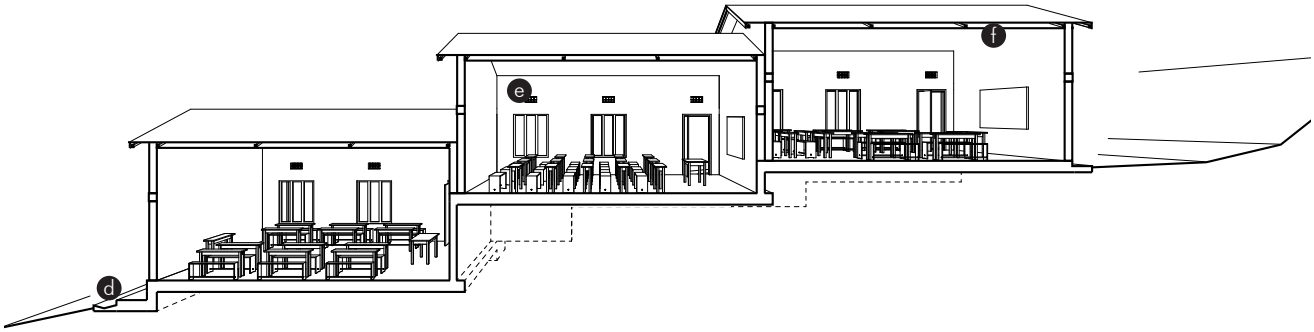


a metal roof
b steel beams
c suspended ceiling
d concrete columns + crossbeams
e brick walls
f steel windows

figure 65- exploded axonometry



0 2m



0 2m

a covered area
b steel pillar
c classroom
d drainage
e ventilation opening
f suspended ceiling

figure 66+67 - ground floor + longitudinal section

figure 68 - toilet building

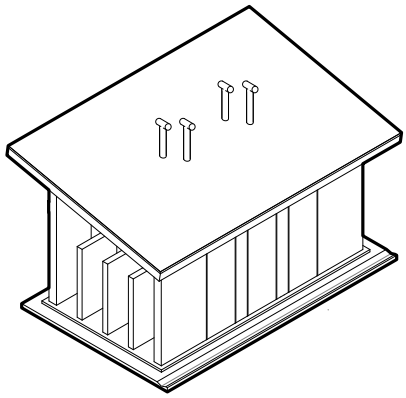
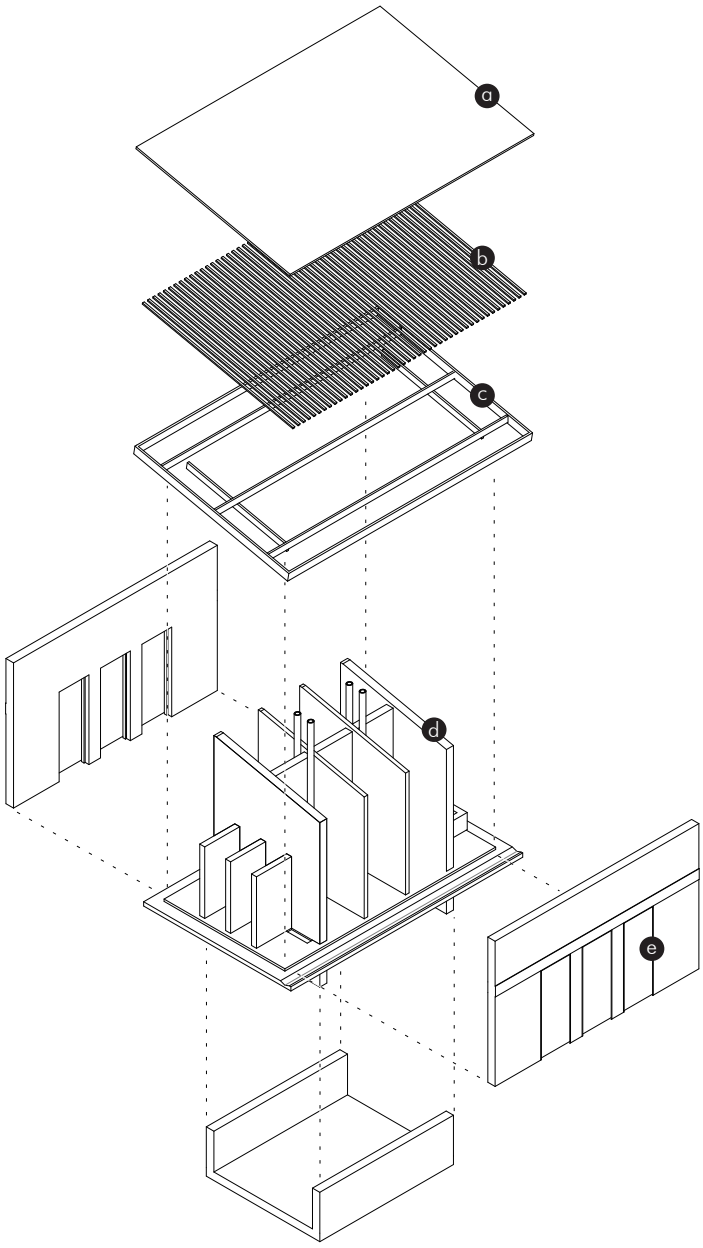


figure 69 - axonometry

Toilet building

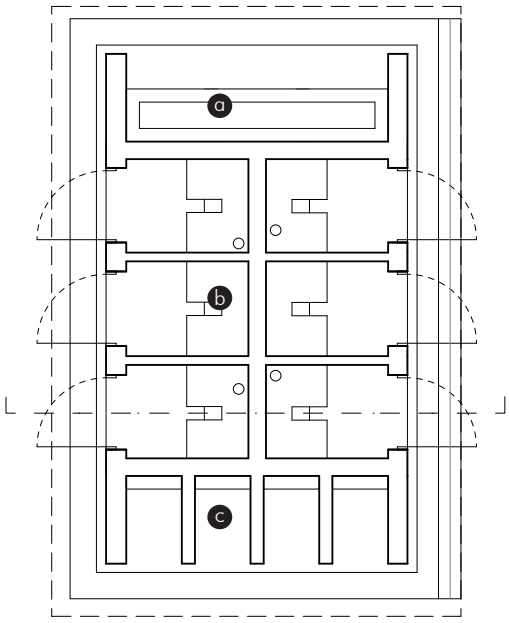
Division of Space The building illustrated on the following two pages, consists of six composting WC's and is dedicated to male students. According to the system practiced at *IPK*, three of those six WC's are used throughout a period of six months, while the remaining three are closed. All of the six WC's are surrounded by walls and a wooden door, to create separate cabins. The compost pit in the basement, emits its smell through a pipe leading from the top of the pit to the top of the roof. In addition to the WC cabins, there is a sink on one side and there are four urinals on the other side.

Structure & Materials The toilet building is set up on a concrete foundation. It covers an area of around 4.8 x 3.4m. Brick walls on top of the foundation are supporting the roof structure, which is based on wooden beams and rafters. On top of this structure, burned tiles create the roof cover. Moreover, the brick walls are partly coated by a layer of cement to resist any water, especially in the area around the sink. Similar to the buildings analysed before, a drainage pipe conducts the flowing water on the north side of the building, which is facing the hill.

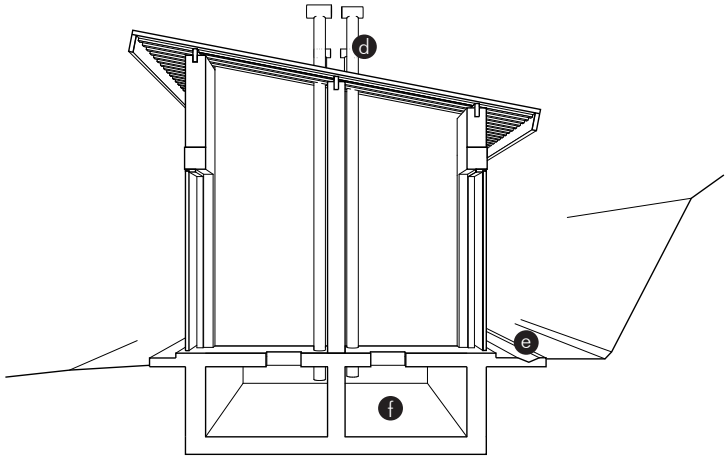


a burned tiles
b wooden rafters
c wooden beams
d brick walls with coating
e wooden doors

figure 70- exploded axonometry



0 1m



0 1m

a sink
b WC - pit opening
c urinal
d ventilation pipe
e drainage
f compost pit

figure 71+72 - ground floor + cross section

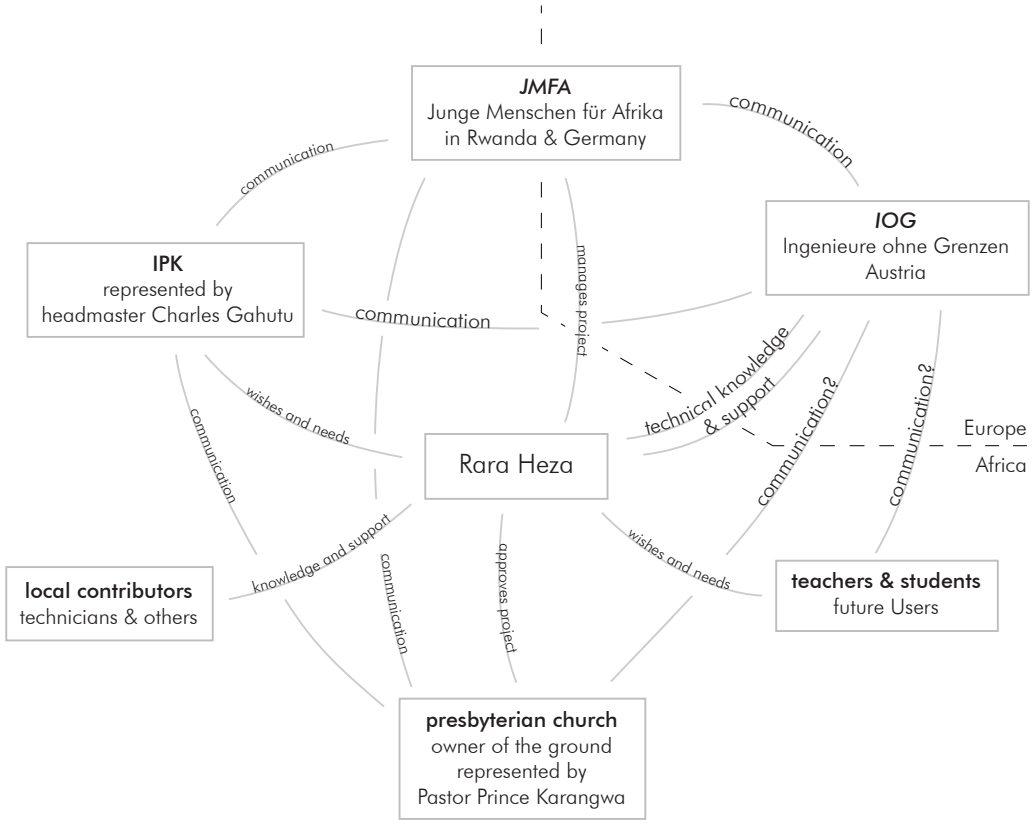


figure 73 - analysis of involved parties

Participation

How to involve future users

Communication To deal with a project in the african context, managed by two associations which are mostly located in Europe, seemed to be quite complex. All parties involved in the planning and building process of Rara Heza are listed in the diagram of figure 73. As one may observe, *IOG's* task is to provide technical knowledge, to support *JMFA* with the realization of the project. Hence there is communication with *JMFA* as well as *IPK*. Yet, in the case of *IOG* it seemed, that the communication with the presbyterian church and especially the students and teachers, was missing before the field trip to Rwanda in early 2019. Since an exchange of information regarding the wishes and needs of future users is presumably crucial for any project, the aim was to interview some of the students and teachers at *IPK*. Moreover, as there was no familiarity with the context of Rwandan culture, peoples habits and their way of living, more information were needed in order to be able to design a future building at this place.

Interviews Referring to the idea of participation, people at *IPK* are involved in the planning process through quantitative interviews.[1] 15 questionnaires[2] were filled out by construction-class students at IPK during the field research in Kirinda, to get some information and also a general impression of their thoughts and preferences concerning their daily life and the future dormitories. The following pages show an overview of eight questions and their corresponding answers. The questions were prepared some time ahead of the field trip and are remaining the same for each participant. Therefore it was possible to evaluate and compare the answers.

Evaluation As one may observe in figure 76 (p.84), the y-axis presents the number of answers, according to the amount of people (0-15). There are five female and ten male participants, of which six are up to 18 years old, eight are between 19 and 23 and one participant is over 23 years of age. In general, the dorms are used between seven and a half and ten hours a day, mainly for sleeping during the night, since the official day schedule at *IPK* designates seven and a half hours of sleep to each student[3]. Question 1 articulates the fact, that the amount of participants which feel comfortable in their dormitory, equals more or less the

1 see RIEGER-JANDL 2018
2 see figure 74, p.82

3 see Chapter 2: *IPK*

//Informant

- Age
(0-18) ✓ (19-23)
(24-30)

- Gender
Female

- Status/occupation
-student

Closed questions
//*Students*

- How much time do you spend in your dorm?
O✓ 1-7.5h | O 8-10h | O >10h

- What is important regarding your dorm/private space?
please rank from 1 (most important) to 6 (least important):
1 privacy
2 good thermal comfort (ventilation and cooling)
3 good hygiene facilities
6 big in size
4 design (traditional or modern?)
5 individuality

- What kind of toilet would you prefer and where?
O Dry toilet O Water flush toilet ✓
O Inside/ O outside the house

- How many people are sharing a toilet, a shower and a sink?
toilet: 10 shower: 11
sink: 10

- Which building material would you prefer?
O Wood O Clay/Mud
✓O Brick O Concrete/cement
O Stone

- In general - are you happy with the situation on the campus?
O Yes ✓ O No

- Do you like living/studying with this school?
✓O Yes O No

- How comfortable do you feel in your current dormitory?
please choose one number ranking from 1 (not comfortable) to 6 (really comfortable) and cross it out:
1✓ 2 3 4 5 6

figure 74 - questionnaire

figure 75 - students at *IPK*

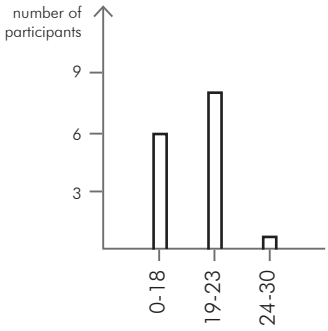
amount feeling uncomfortable. Still, the majority of students seems to be happy with the current situation at *IPK*. Interesting to notice is the fact, that the greater part of students is concerned about the thermal comfort, privacy and the hygiene facilities regarding their dorm and private space, instead of its design, the size or individuality. Moreover the participants which are all construction class students, prefer only three building materials namely brick, concrete/cement and stone.[4]

Observations Another tool to examine the living conditions at *IPK* was, to look at the peoples preferred places on the campus. These places where used during the students and teachers breaks and leisure times, besides scheduled classes. Hence, I noticed the use of benches, which are located throughout the whole campus, several of them providing a great view across the neighbouring hills and the Nyabarongo river. Some of the benches are adjoining classroom buildings to maintain space during the breaks, while others do not have a connection to any building. According to the interviews[5], the students and teachers value these places for offering a great view and the possibility to communicate with each other. Unfortunately just a few of them provide a dry and sun shaded space and are therefore more likely to be used.

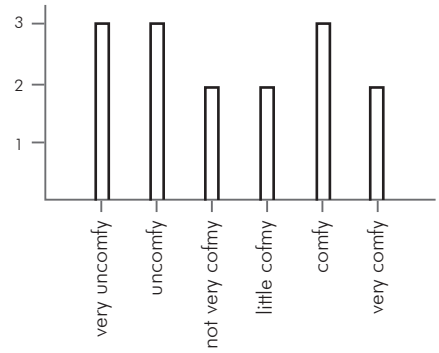
4 see figure 75, p.82

5 see ANNEX

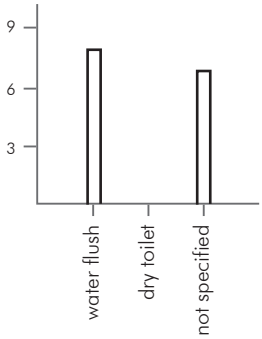
Age of participants



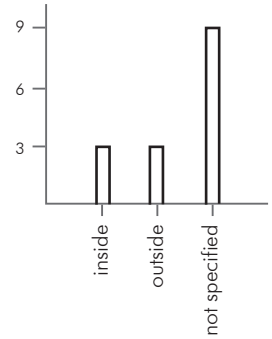
1. How comfortable do you feel in your current dormitory?



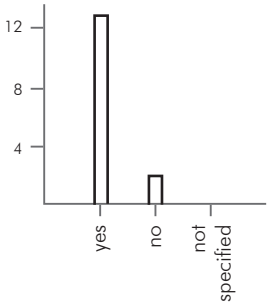
2. What kind of toilet would you prefer?



3. Where should the toilet be placed?



4. In general: Are you happy with the situation on the campus?



5. Do you like living/studying with this school?

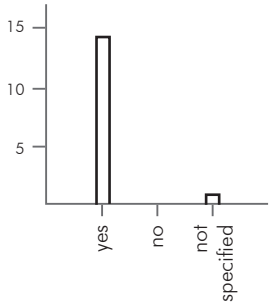
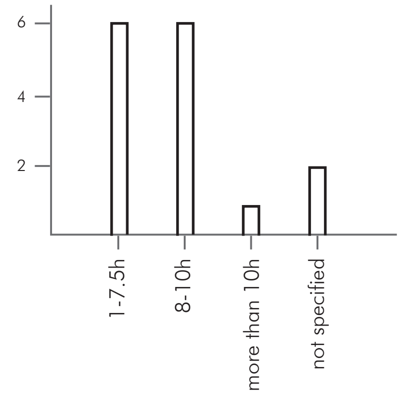
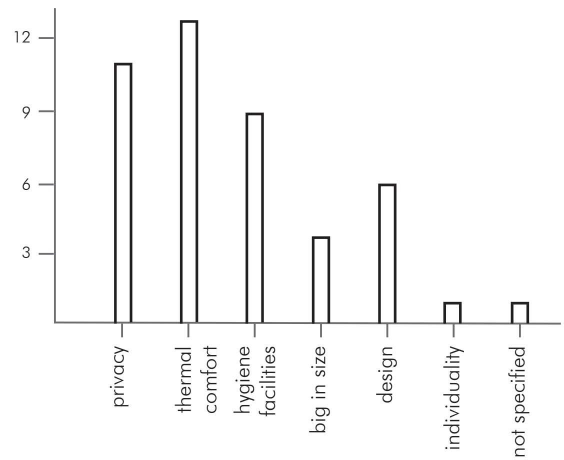


figure 76 - interview evaluation

6. How much time do you spend in your dorm?



7. What is important regarding your dorm/ private space?
(3 most important topics of each participant are counted = 45 answers)



8. Which building materials would you prefer?

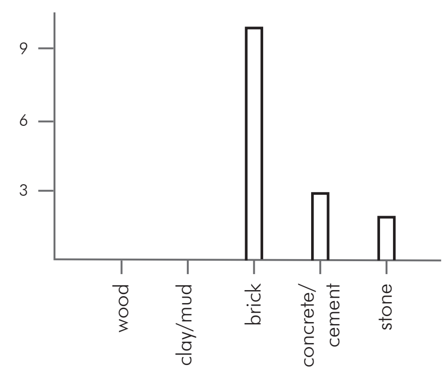


figure 77 - presbyterian church in Kirinda

Typologies

Existing buildings in Kirinda

Kirinda is characterized by several different building typologies. Yet one might observe the following similarities of buildings, which are described in more detail.

In general all buildings in the village consist of just **one storey**. As a landmark there is the presbyterian church[1], which is located on the crest of the hill in the lower part of the village. The church building was erected in the early 20th century according to Charles Gahutu[2] by using burned bricks, wooden beams and burned tiles as the main **materials**. Further, there is a line up of equal buildings providing a sheltered space for the regular food market in Kirinda[3]. It is located at a minor street in the upper part of the village, which connects the market with the district hospital and consists of brick columns. The hospital provides **sheltered walkways** in between its separate buildings and therefore enables the patients to access most of the area without much impact of rainfall and sunlight. Likewise, a great amount of buildings offer sheltered space as **arcades** in front of each building. In other cases some dwellings are defined by **extended or cantilevering roofs**, probably with a similar intention of obtaining sheltered areas.

The walls of the majority of buildings consist of either a grid of concrete columns, concrete beams and burned bricks (to fill up the empty wall spaces) or just burned bricks. All of these options occasionally appear to have a cover of plaster or cement as a minor **material**. On the other hand, not many buildings could be observed, which were erected in a **traditional** way, meaning with the application of adobe, wood and burned tiles. One may detect, that the usage of concrete and burned bricks is common for recently set up buildings. This observation is probably rooted in the change of the use of building materials. According to Theoneste Twagira[4], higher developed countries and their style of building influence the Rwandan idea of a house. Nowadays a building made of concrete and burned bricks, considered as **permanent materials**, may signify wealth of its owner, as well as an important position in the society. Therefore the appearance of buildings in Kirinda probably changed reasonably during the last years.[5]

1 see figure 77
2 GAHUTU, personal communication on 18/2/19
3 see figure 83, p.90

4 TWAGIRA, personal communication on 24/2/19
5 see ANNEX: Qualitative interviews

figure 78, p.86/87 - main street

figure 79 - private dwelling with burned tiles

figure 80 - adobe wall

figure 81 - private dwelling

figure 82 - kindergarten

figure 83 - market

figure 84 - district hospital

Contemporary Rwandan Architecture

Reference Projects

From an architectural point of view, there are several challenges designing and planning in Rwanda. Some of them are illustrated throughout the following pages.

Topography As mentioned in the first chapter, Rwanda is characterized by an undulating landscape. Hence, there is a great amount of buildings, which is erected on the slope of a hill. As displayed in the section of the Umubano Primary School[1,2] in Kigali, one benefit of this in an architectural way, are the possible views from buildings set up vertically on a slope. Since there is a significant height difference between two buildings, users of the upper plot can still look across the building which is located on a lower elevation. On the other hand, steep slopes may force one to consider land erosion through flowing surface water which might cause damages. In addition, a corresponding drainage system might be provided.

Light & Rainfall According to Rwanda's location close to the equator in the southern hemisphere[3], the sunlight during midday arrives in an angle close to 90 degrees. In general, the sun rises in the east, continues in the north and sets in the west.[4] Therefore a typical element in Rwandan architecture is the use of shaded spaces (e.g. arcades, loggias and cantilevering roofs), especially to protect the users of a building from intense sunlight and heat during midday hours. In the sketch of the School of Architecture & Built Environment[5], one might observe shaded walkways along both sides of the campus' courtyard. The majority of entrances are facing these walkways, to enable the users to access every part of the campus without facing the direct sun. Besides, the described walkways also protect people from any rainfall. As an example, Kigali experiences an average precipitation of 1009.1mm each year[6]. Hence one may think of an appropriate rain cover, particularly for access paths. To use even intense sunlight for the exposure of the interior, it seems to be a great idea to work with a split roof, as presented in the section of the Umubano Primary School[7], which reflects the light similar to a mirror and conducts it to the interior.

Ventilation Rwanda experiences comparatively high average temperatures. As an example, the maximum average temperature in Kigali reaches 27°C whereas the minimum is around 15°C[8]. First of all these temperatures may imply no need for insulation and therefore a reduced wall and roof thickness. In comparison to many parts of Europe, this seems to be a great advantage. Secondly one may think of a suitable solution, to deal with the maximum temperatures during midday hours. There are some architectural elements to increase the ventilation and therefore reduce the

1 MASSDESIGNGROUP.ORG, web page visited 21/1/19
2 ACTIVESOCIALARCHITECTURE.COM, web page visited 21/1/19
3 see Chapter 1
4 see Chapter 3: The site
5 see SCHWEITZER-ASSOCIES.COM, web page visited 22/1/19
6 METEOBLUE.COM, web page visited 30/7/19
7 see figure 87, p.94
8 see 6

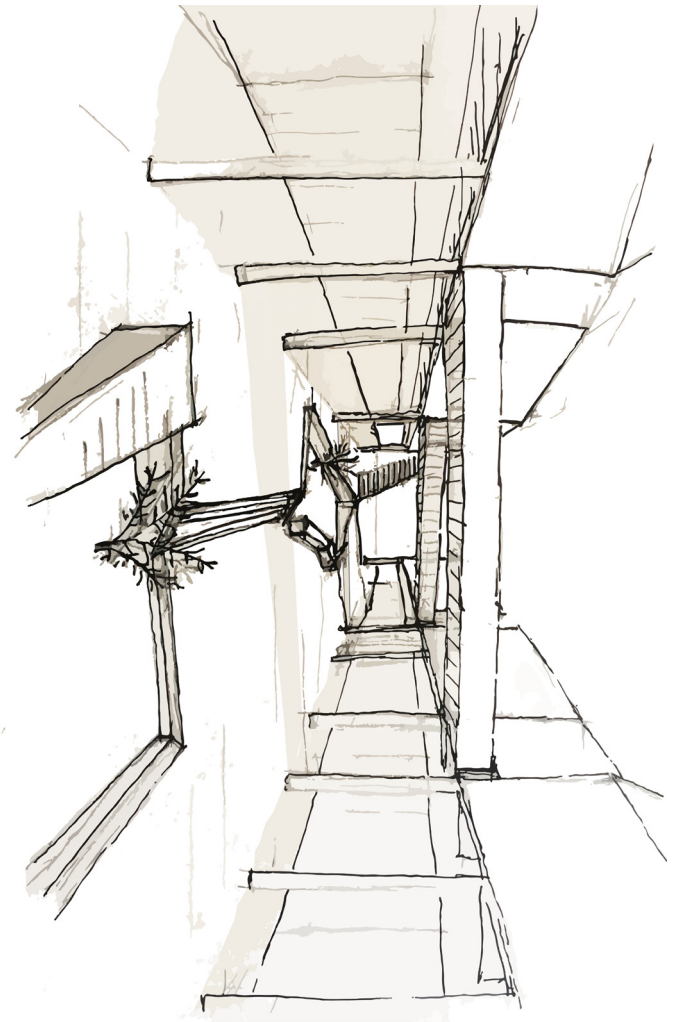


figure 85 - Campus of the School of Architecture & Built Environment, Kigali

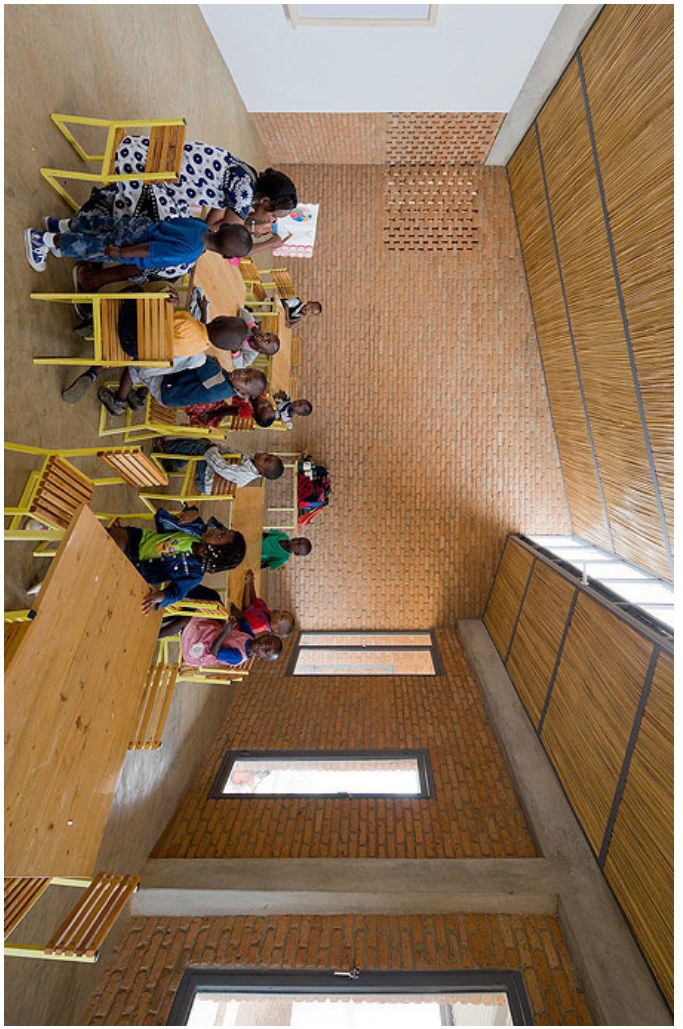


figure 86 - Umubano primary school

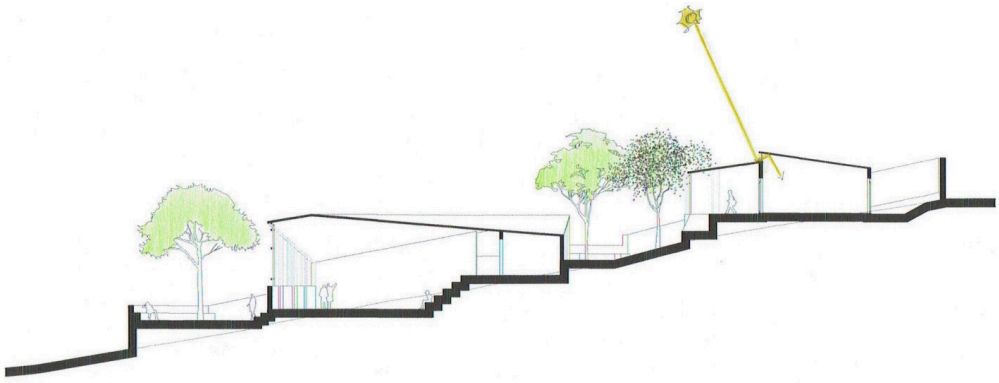


figure 87 - Umubano primary school: terrain

temperature inside and around a building. These are displayed with the ASA dormitory building[9] in Eastern Rwanda, including a detached roof, gaps in the brickwall and walkways, which are just covered by a roof, but no walls. In addition, trees and green spaces may be used close to the building, to cool down the air before entering the building.

Materials The following building materials are applied commonly throughout Rwanda as it was derived during the field trip and through several interviews.[10] Concrete is used for the foundation and structural grid (columns & beams) and burned bricks for the walls. A typical roof structure consists of steel beams, which are covered with metal sheets or alternatively wooden beams and burned tiles. One may also detect steel or wood frame windows and doors. Considering the situation of building materials in Kirinda, it is striking that many building materials need to be transported from Kigali, across the entire country of Rwanda or even imported from other countries including wooden beams, great amounts of concrete/cement, steel beams and metal sheets. Since there is a clay pit and stove in Kirinda, burned bricks for the walls as well as burned tiles for the roof may be produced there. Likewise, a small amount of timber is available and cement/stones to obtain concrete.[11]

Space According to Ildephonse Mbarushimana[12], a construction class teacher at *IPK*, an average Rwandan household is characterized by little privacy, as one may think of in a European definition. As most of the people cannot afford to reside in dwellings with separate rooms it is obvious, that sometimes whole families consisting of five or more people have to live together in just one room.
To get an idea of the size of private spaces, especially in Rwandan dormitory buildings, different projects, which are mentioned in this section, were analysed regarding their size. Figure 91 (p.97) displays the net areas of the dormitories for each project, corresponding to the number of students, including the size of *Rara Heza* (the future dormitories). Moreover, the bathroom sizes for the same range of realized buildings are described, containing numbers according to the Rwandan building regulations.[13]

9 ACTIVESOCIALARCHITECTURE.COM, web page visited 21/1/19
10 see ANNEX

11 TWAGIRA, personal communication on 24/2/19
12 MBARUSHIMAN, personal communication on 21/2/19
13 BPMIS.GOV.RW, p.130, web page visited 7/2/19

figure 88 - ASA dormitories

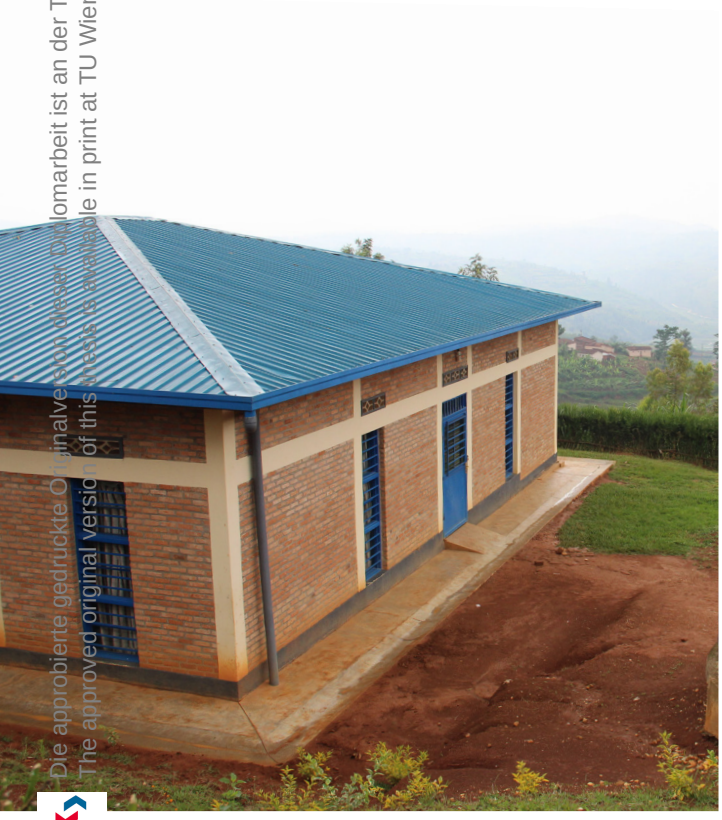


figure 89 - Kirinda dormitories

figure 90 - shaded and ventilated corridor (Kirinda dormitories)

Dormitories

reference building	**students** (per room)	**net area of room** (m^2)	**net area/student** (m^2)
ASA dormitories			
Type A	8	20.7	2.59
Type B	10	28.4	2.84
Type C	14	37.3	2.66
Kirinda dormitories	14	38.44	2.75
IPK girls dormitories (existing)	12	22.2	1.85
Rara Heza	10	24	2.4

Bathrooms

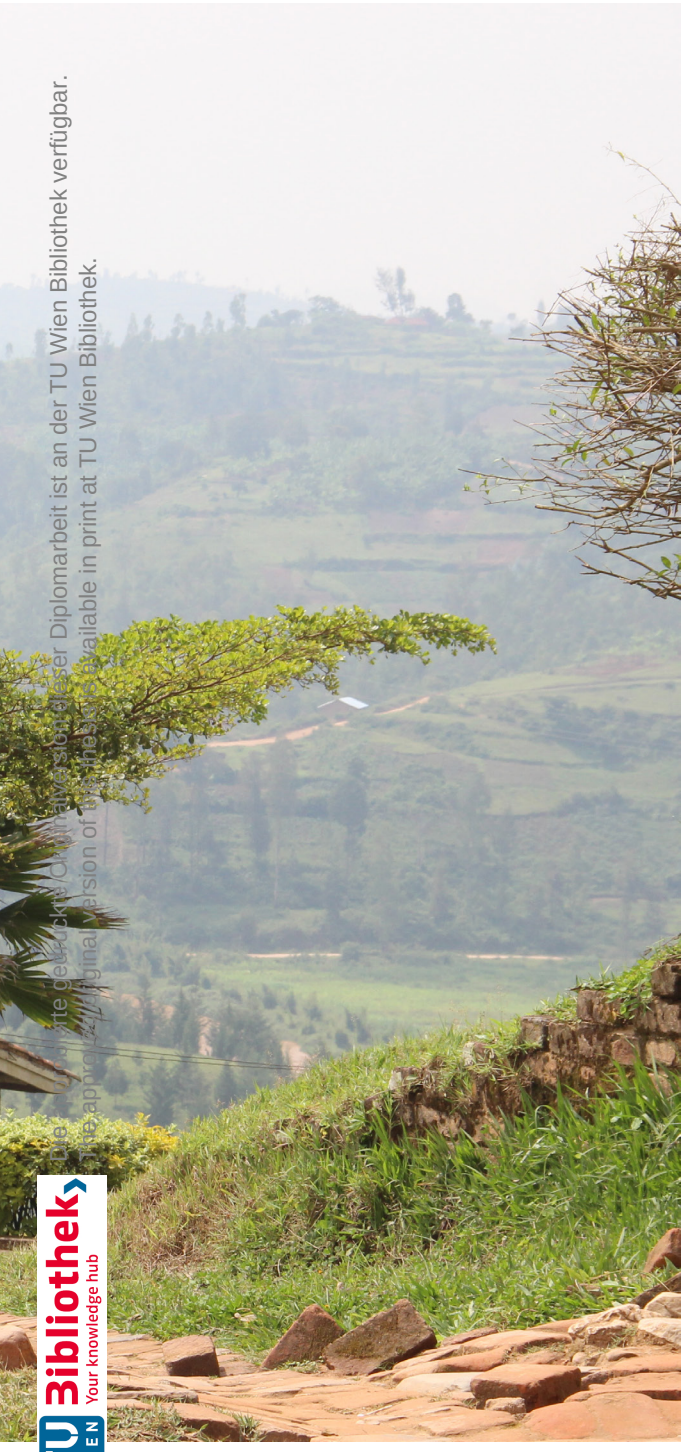
reference building	**students** (in total)	**students using one shower**	**students/WC**	**students for one meter of sink**
ASA dormitories	100	25	14	15
Kirinda dormitories	98	6.5	6.5	12
IPK girls dormitories (existing)	120	10	20	20
Rara Heza	190	7	9.5	8.3

Building regulations[1]:

31-75 female students	= 4 WC's
76-100 f. students	= 8 WC's
101-150 f. students	= 10 WC's
over 150 f. students	= 1 WC per 50 students

1 BPMIS.GOV.RW, website page visited 7/2/19

figure 91 - comparison of space for selected projects



CHAPTER 3

The design of the future dormitories

figure 92 - underneath the tree

figure 93 - view from building plot

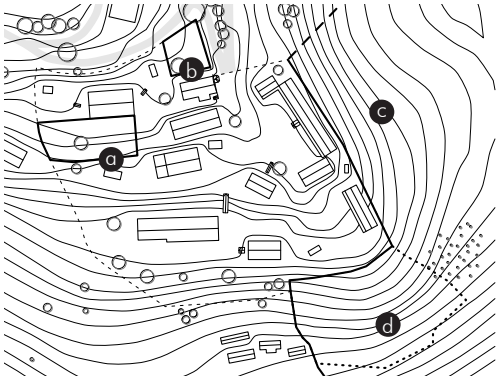
The site

Challenges and advantages

Following the research and analysis of Chapter 1 and 2, this section describes the envisioned design of the extension of *IPK* through dormitory buildings.

Possible building locations There are three different areas which may be considered as possible building plots.[1] The areas a and b, are not spacious enough to form the basis for the new dormitory buildings, as the future site plan will illustrate in the following sections. Area c outlines the possibility of erecting buildings across the fence east of the classrooms, by using the church owned ground, which is extending downhill until the major street to the south and east. Hence, this plot describes a site with loose borders and offers a great amount of space. Besides, area c is characterised by an accumulation of trees which may be considered as a forest.[2,3]

The plot The decision for a building plot in area c was determined by the qualities of the terrain, as the area is defined by a steep slope, according to the contour lines. The northern part however, appears to be less suitable, declining even more than the southern part. Therefore a plot south of the fenced area was chosen. This site is located in the upper parts of the forest, close to the existing construction class and toilet building in the north and an animal farm to the west, which is not part of the school ground of *IPK* anymore and therefore limits the plot. A present path connects the lower parts of Kirinda to the south of *IPK* with the rest of the village, and crosses the proposed site from the southwest to the northeast. Striking, is the gradient of the terrain, as one may observe in the displayed contour lines. Based on measurements taken on site from local specialists (measurements taken on behalf of *IOG* in December 2018) as well as random samples which were carried out during the field trip to Rwanda,



a girls dormitory ground
b garden/fields
c forest
d building plot

figure 94 - possible building locations

1 see figure 94
2 see Chapter 2: plan of Kirinda, p.44 & site plan *IPK*, p. 52
3 KARANGWA, personal communication on 21/2/19

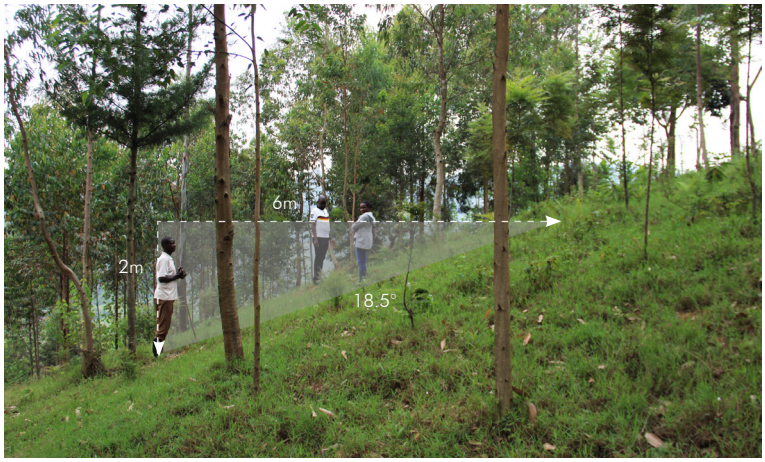


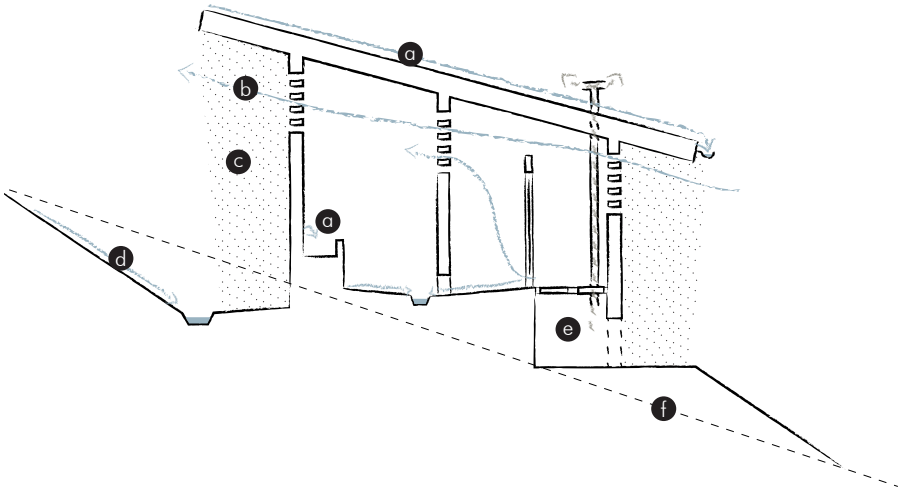
figure 95 - terrain

these contour lines are assumed to be reliable for further designing and planning. As an example of one of the random samples, figure 95 reveals a slope with an angle of around 18.5°.[4]

The design The diagrams (figures 96+97) of the dormitory and sanitary building reveal the design principles of the envisioned architecture for the chosen plot. Both buildings are developing according to the **terrain**. To reduce the risk of erosion, a maximum slope of 33° is applied and accompanied by drainage pipes, which run parallel to the structure. The buildings are placed on the slope in the presented way, to achieve a ratio of 1:1.2 for the excavation (1) on the one hand and the filling (1.2) on the other hand. As one may observe, both structures are rather narrow in cross section but extending further, parallel to the slope of the hill.[5] Through the described ratio, as well as the narrow design of the buildings, the intention is, to reduce the excavation work to a minimum. Considering the **climate** of Kirinda[6], both, the dormitory building as well as the sanitary building, offer sun shaded and rain covered space through cantilevering roofs, especially during the high midday temperatures (sun) and the heavy rainfalls of the rainy season.
In more detail, the two storey dormitory building is divided into two areas. Firstly there are rooms which accommodate the students on both floors. In addition, the structure is extended by creating a second layer in front of the dormitories. An arcade functions as a horizontal connection of the rooms of the first floor and offers **views**, especially since the terrain is declining. Seats are provided on the ground and first floor of the dormitory building to encourage communication between the students. Therefore, this area functions as a semi-private **community** space for all students and at the same time extends the covered space to protect the users from the intense sun and rain, as mentioned before. In addition, the described line of seats forms a barrier which protects the community space from splashing water of heavy rainfalls. **Natural light** is re-

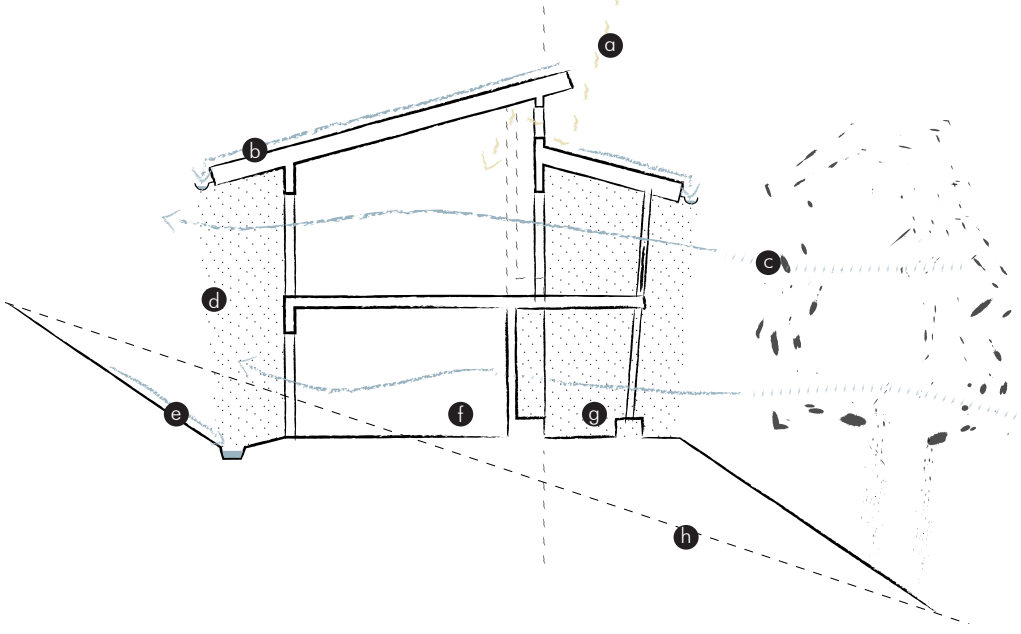
4 see figures 96+97, p.103
5 see floor plan in the following section

6 see Chapter 2: Context



a rainwater usage
b ventilation
c shade+covered area (rain)
d drainage
e pit+vent
f slope (18.5°)

figure 96 - section diagram sanitary



a natural light
b rainwater usage
c ventilation
d shade+covered area (rain)
e drainage
f dormitory (private)
g community (semi-private)
h slope (18.5°)

figure 97 - section diagram dormitory

figure 98 - building plot

flected by the roof and creates an indirect illumination of the rooms on the first floor. In addition, all windows are offering light down to the ground of each storey and the doors are made transparent through the usage of glass. According to the analysis of the interviews of the future users[7], the majority of the students spend 8-10 hours a day in the dormitories, of which the students sleep around 7.5 hours[8]. Again in regard to the climate of Kirinda, with a minimum of 14°C at night[9], one may recognize that there is no need for any cooling to achieve comfortable temperatures. Instead, flexible elements are installed, such as windows and doors, with the ability to open these and therefore enable the user to regulate the room temperature and air quality, by **ventilation** according to his/her needs. Analogous to this, the enclosed space keeps the warmth of the day and increases the thermal comfort inside the dormitories during the night. On the other hand, the community space experiences natural cooling, by being shaded

7 see Chapter 2: Participation
8 see Chapter 2: *IPK*
9 METEOBLUE.COM, web page visited 30/7/19

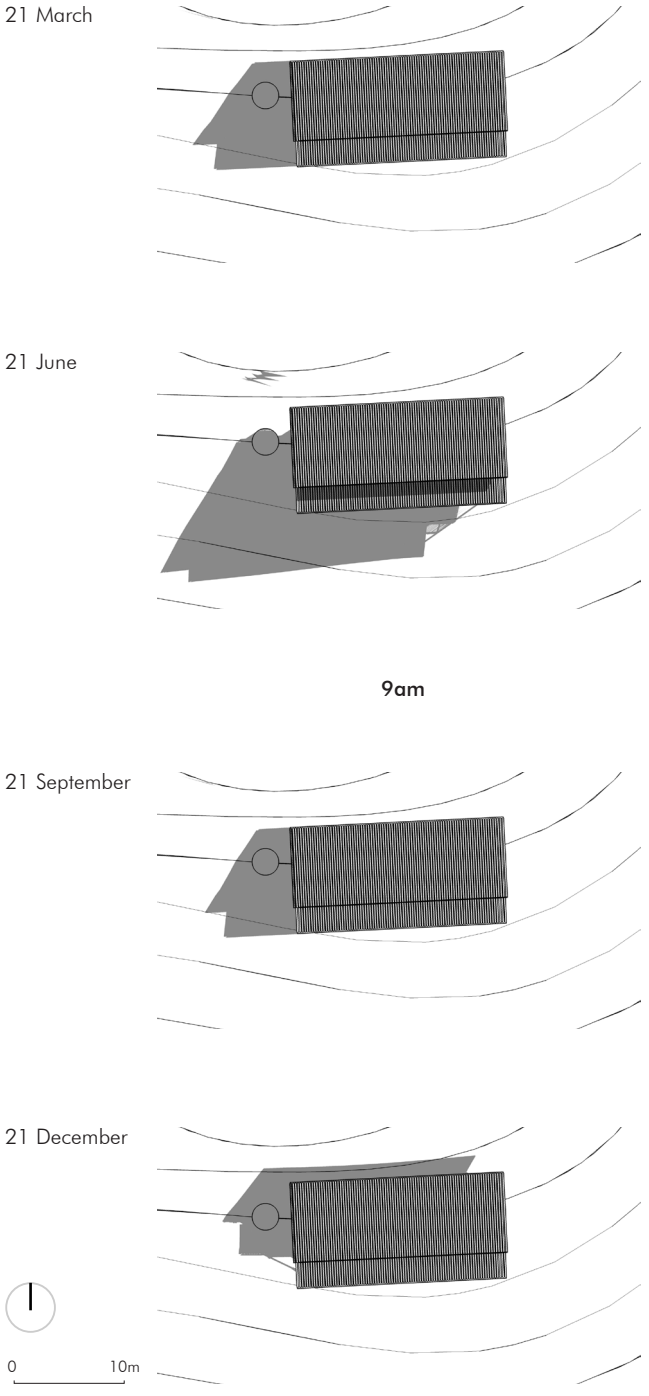
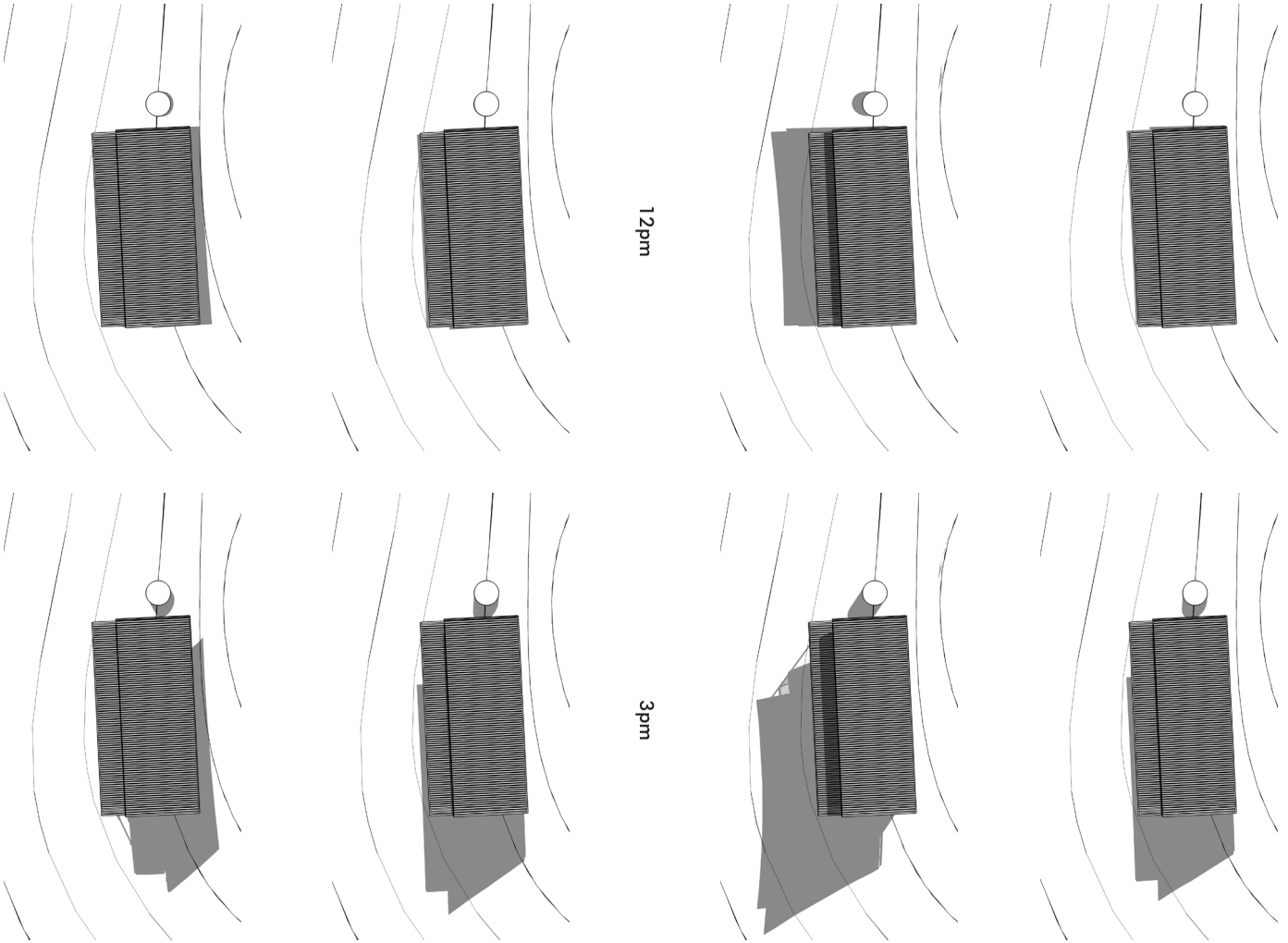


figure 99 - sunshade throughout one year



from the sun and through ventilation along the corridor of the building. At the same time, neighbouring trees reduce the temperature of the air in the trees' shade, which is then carried to the inside of the building and increases the cooling process. Moreover, gutters at the bottom of the roof structure, collect the **rainwater** and conduct it to a water tank at the side of the building.
To illustrate **the rise of the sun**, figure 99 (p.106f.) shows the approximate shadow which the proposed building in this section casts on the existing terrain at the site. According to different times a day and different months a year, one may observe, that the shadow during midday hours (12pm) is significantly tiny, but it increases during the morning and afternoon hours. At the same time, the sun shines from every direction throughout a year based on Kirindas location close to the equator.[10] The orientation of the building as presented in these diagrams, offers the advantage of having two shorter walls facing the morning and evening sun, whereas the longer walls are facing south and north and are not reached by any sunlight. Therefore, the probable increase of the temperature inside the building, especially during the morning, will be reduced.
Contrary to the dormitory building, the sanitary building provides intense ventilation. Wall openings function as the base for a continuous exchange of air, which originates in the usage of compost toilets. Since the toilets in general are considered as unclean, the intention is to cut down the stench to a minimum. In addition, a ventilation pipe is running all along the back wall of each toilet to ensure, that the air of the composting pit is emitted on top of the building. To reach the pit, a wall opens up to the side and allows for the removal of the faeces. The water supply of the sink, located on the other side of the building, is ensured by rainwater. Similarly to the dormitory building, the rainwater is collected in a tank at the side of the building.

10 see Chapter 1: introduction

figure 100 - JPK students in the midday shade

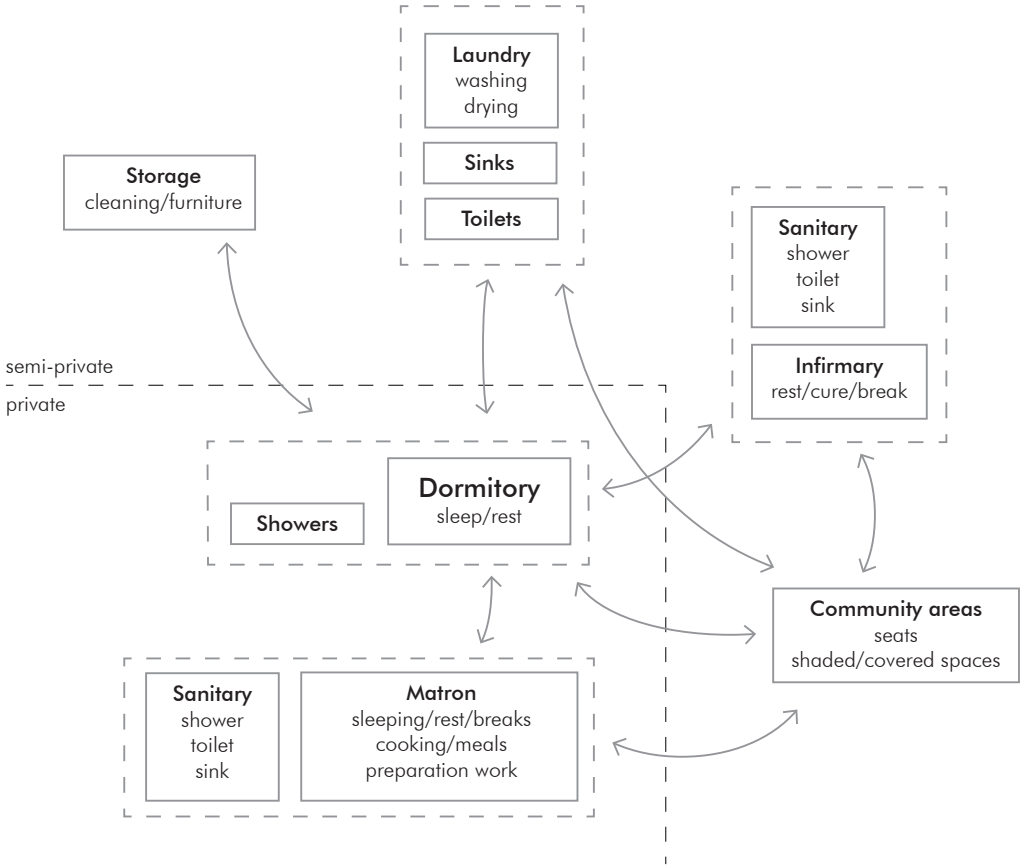


figure 101 - room schedule

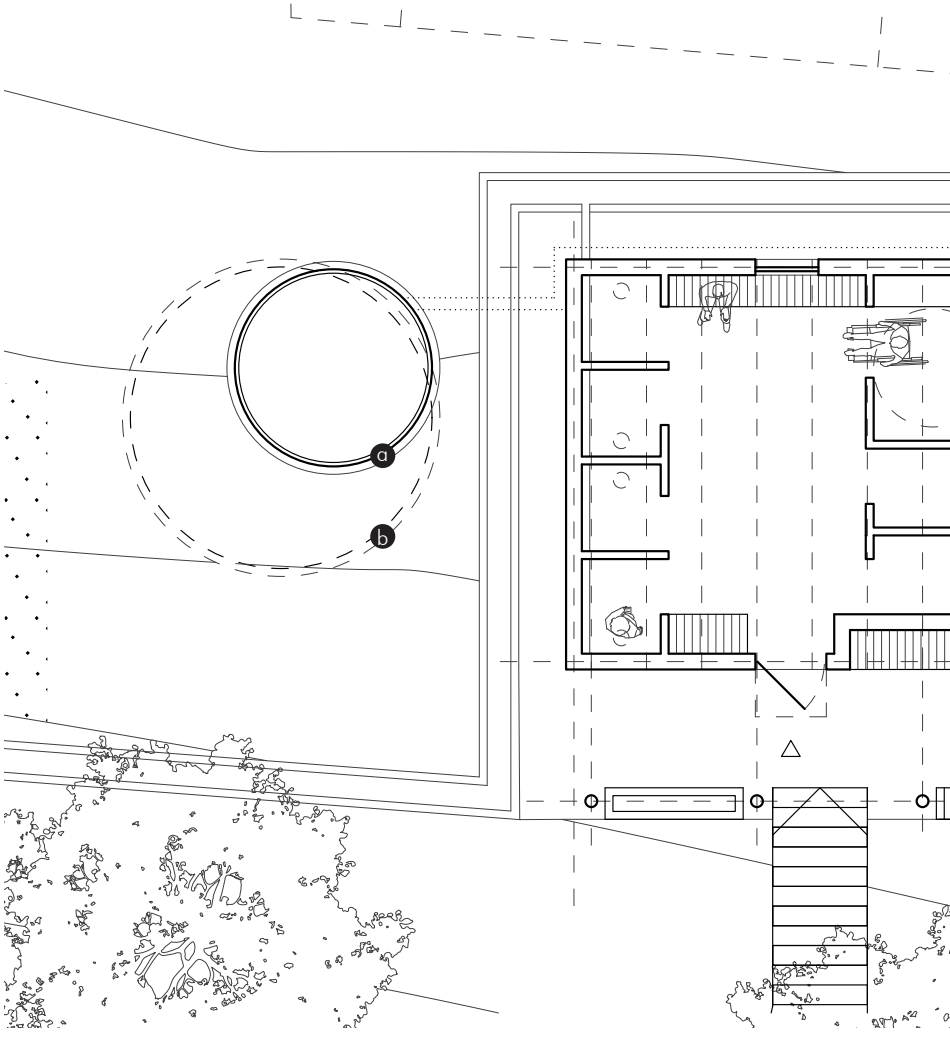
The proposal

One part of the buildings as a role model

As identified during the field trip to Rwanda, the ideal draft would be to accommodate around 200 students in the near future.[1] The planning of these dormitory spaces is accompanied by the need for sanitary facilities, an infirmary, a room for the matron[2] and some storage space. Figure 101 illustrates the room schedule and the necessary connections between each part. The dormitories as the main element are accompanied by showers, which are located in the same building. This direct connection increases the comfort of the users, by providing a sheltered access. Since the toilets are considered unclean, they are separated from the dormitories and together with the sinks and clothes lines they form a sanitary building. Apart from these functions there is space dedicated to the matron and an infirmary (presented in the master plan further in this Chapter), both equipped with an own sanitary section. Moreover, community areas enable the students to spend their leisure time together and besides, additional space may be used as storage.

Dormitory building The design of the dormitory buildings is envisioned to function as a module, which may be extended at any time in the future. A module consists of two storeys, based on a room measuring 5.4x5m, which offers space for up to 10 students on each floor and is connected with the neighbouring modules through a corridor. On the first floor this connection is created by an arcade. The dimensions of one room were chosen according to a bed length of 2m and a minimum space of 80cm in between the beds, as well as the maximum available length of the wooden beams, which are used as the base for the ceiling.[3] A door is placed on the same axis as the window, to lead the view of the user across the room, while entering the space. One part of the wall of each room and storey facing the corridor is pushed back by 50cm, to create space for a bench. On the ground floor, corresponding seats on the other side of the corridor and accompanying flowerbeds, are framing the walkway. To reach the first floor of each module, an adjoining staircase is added. At the same time, the remaining space underneath the staircase may be used as a storage room.
The described module is duplicated to obtain three similar building parts which are sharing one staircase, as presented in the following drawings. At the same time, one dormitory space is replaced by a shower unit according to the room schedule. To meet the requirements of safety for a school dormitory, which is frequented by a great amount of students each day, the modules of the dorms are arranged along one line. Therefore, a straight escape path is created leading the students directly to another area outside the building plot, in case of a fire. Moreover, referring to the idea of supervision through teachers and the matron, the presented design offers the opportunity for clear observations along one building.

1 see GAHUTU, personal communication on 18/2/19
2 see Chapter 2: Matron building, p.69
3 see dormitory variations and detailing further in this section



Ground floor

existing forest

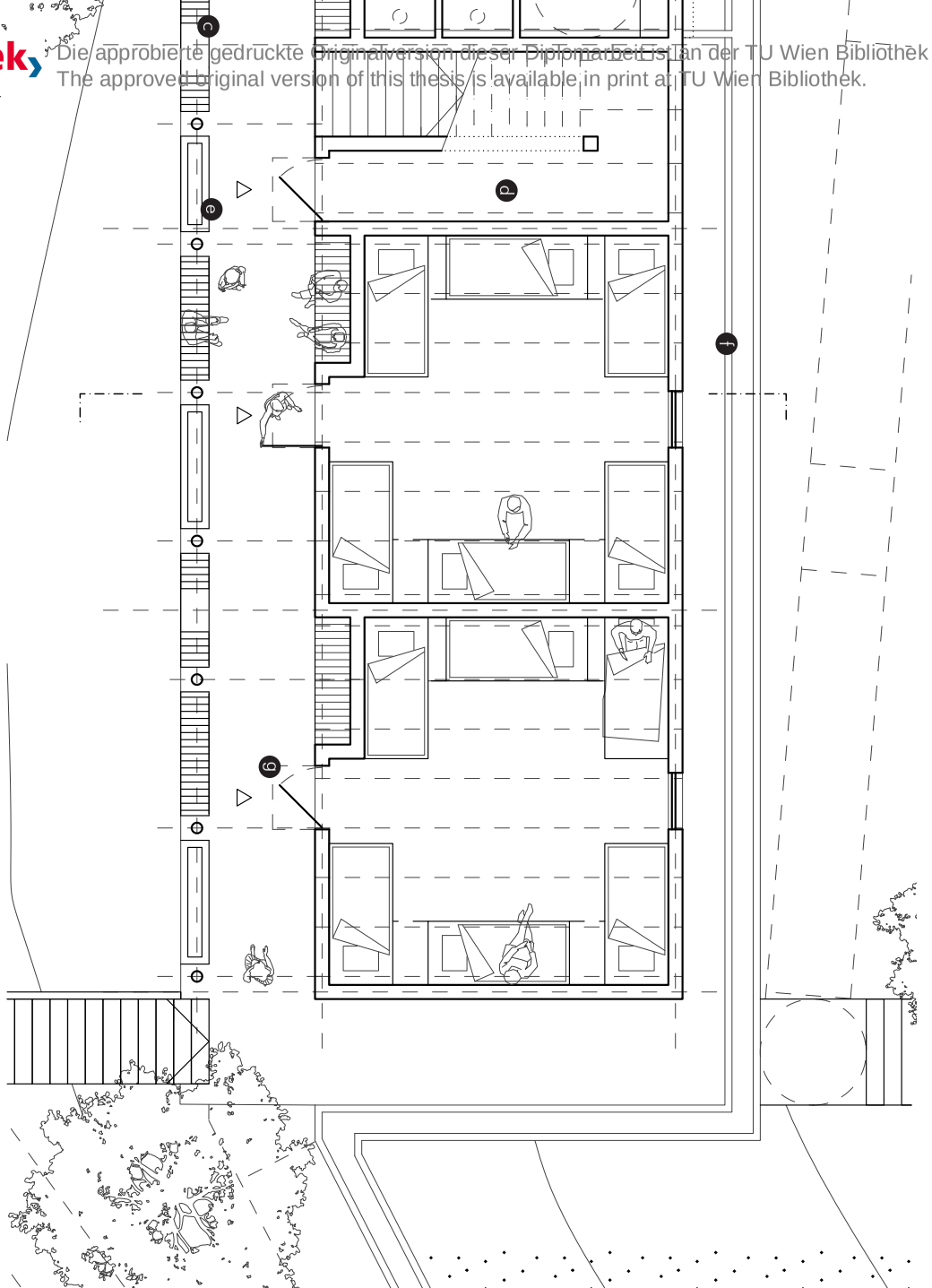
elevation lines

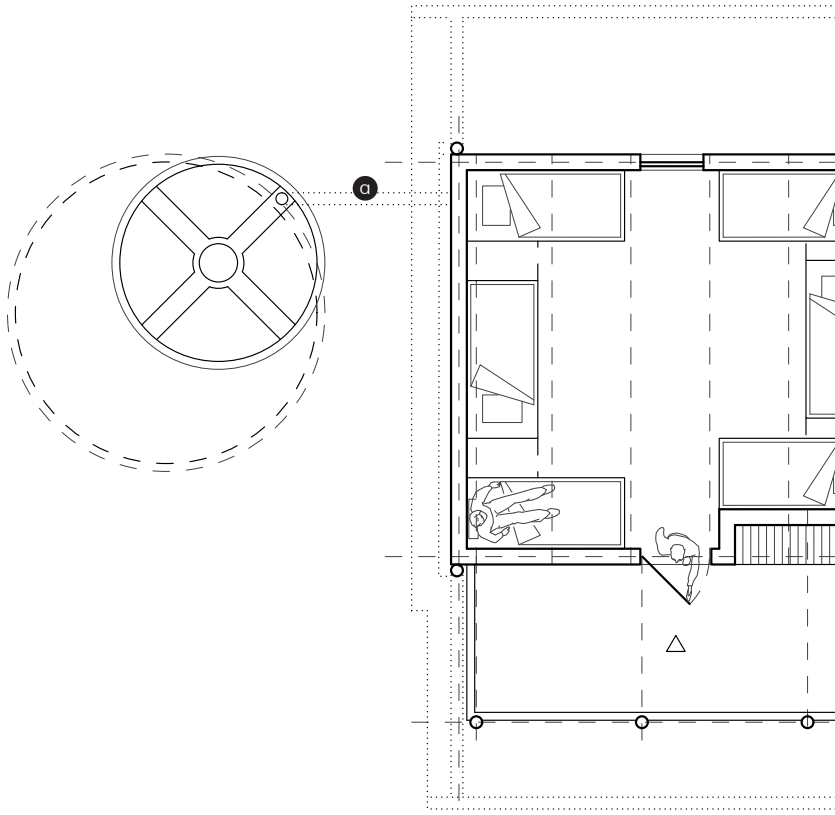
water tank:
a 10.000 L
b 32.000 L

c bench
d storage
e flowerbed
f drainage
g optional ramp

0 2m

figure 102 - ground floor



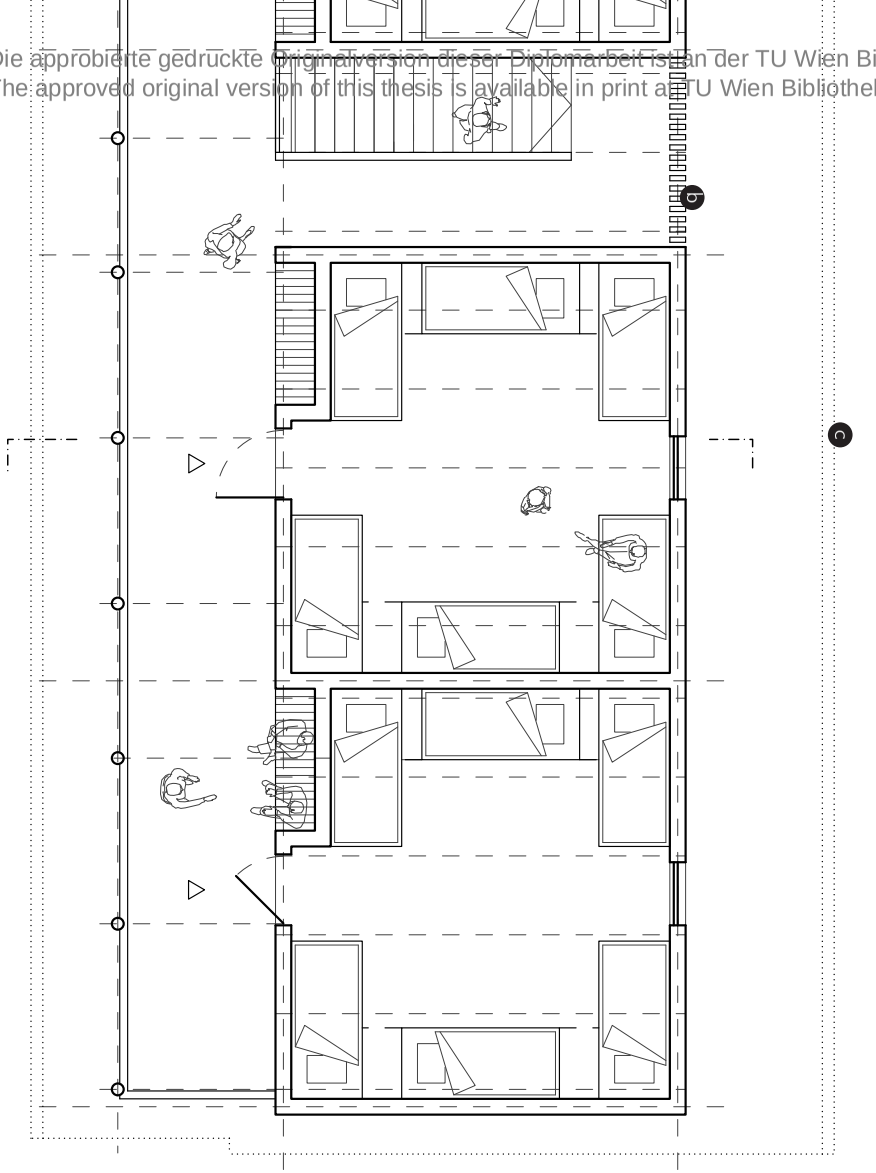


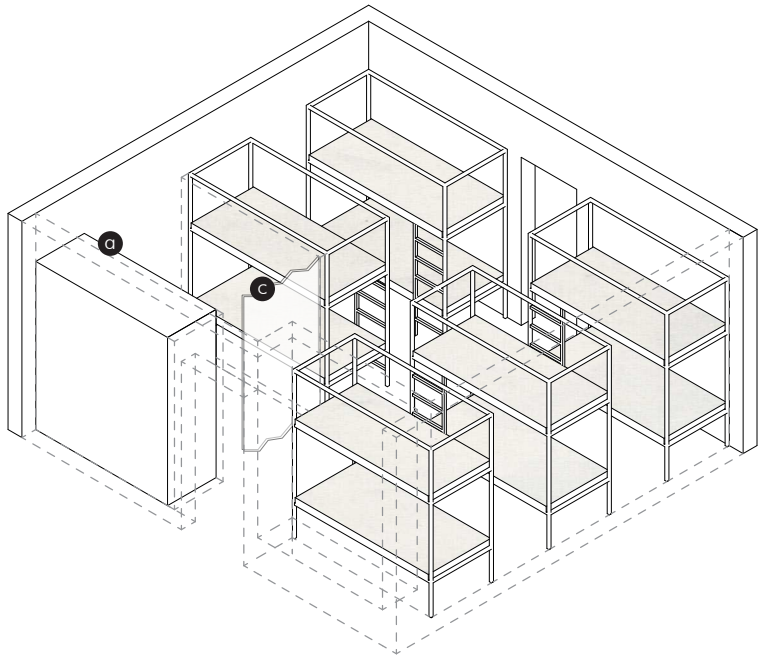
First floor

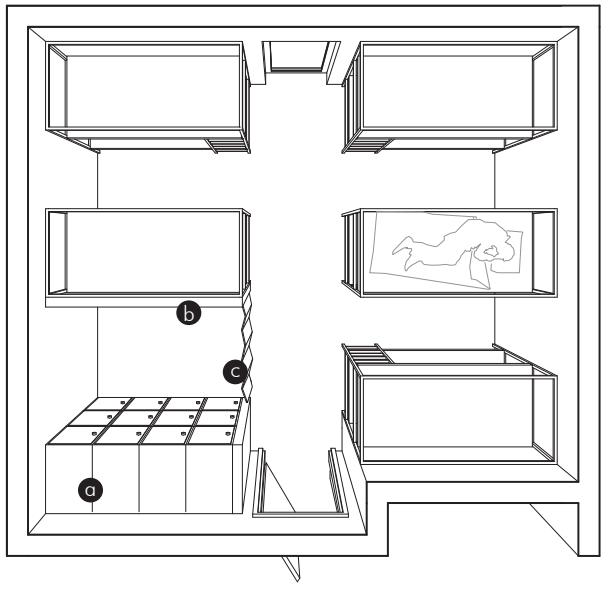
a connecting pipe
b ventilation opening
c roof overhang + gutter

0 2m

figure 103 - first floor





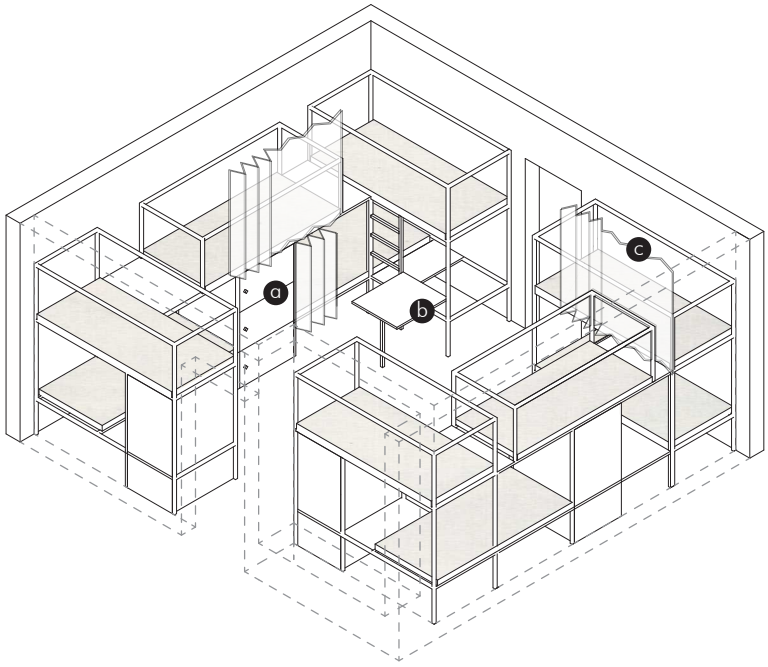


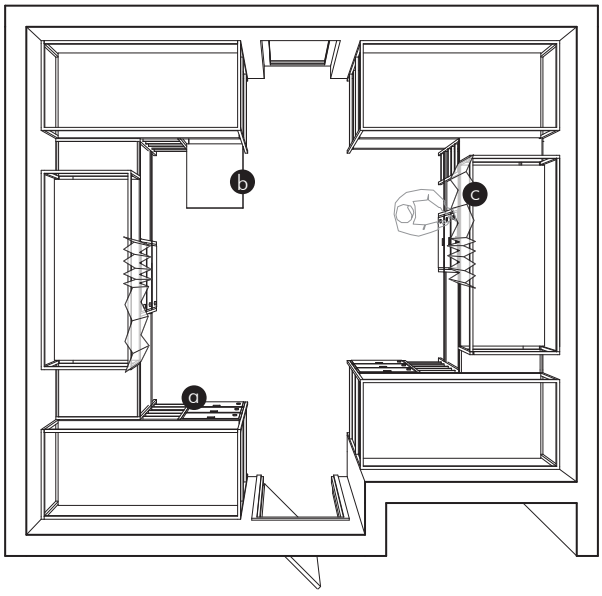
Dormitory 01

a locker
b lightweight construction
c partition

0 1.5m

figure 104 - dormitory 01





Dormitory 02

a locker
b folding elements
c curtain (privacy)

0 1.5m

figure 105 - dormitory 02

The shower unit consists of seven showers including one shower, which is suitable for disabled people. In the same regard, a ramp may be added at the entrance door of a shower unit as well as a dormitory for uncomplicated wheelchair access.[4] Next to the showers, benches serve as changing space. Through the staircase, which is placed between a dormitory and a shower unit, a buffer zone is created to increase the privacy of the shower unit. At the same time, the walking distance of the users of the upper floor, to reach the shower unit, is reduced by being located right next to the staircase. Overall, this module of five dormitories and one shower accommodates 50 students.

Water tank A tank for rainwater collection is placed in the same line as the dormitory building and sanitary building, to reduce the excavation work on the existing ground. The ground floor of the dormitory building (figure 102, p.112) as well as the following plan of the sanitary building (figure 115, p.130), both show two different tank sizes which are based on the amount of water, which is going to be used by the students. Assuming that there is an average amount of 20L of water at each students disposal per day and considering 50 students in one dormitory building, two tanks with a volume of 10000L would serve as a reservoir for a maximum of 20 days during the dry season of three to four months. To increase the amount, a greater 32000L tank is proposed by a dashed line. This water tank would provide water for 64 days, considering the same amount of water usage per day. In general, the collected water may be used for the showers in the dormitory building and the sinks in the sanitary building.

Dormitory variations There are different possible arrangements of the dormitory space of which two are presented in figure 104 and 105 (p.116f.). Since the space is limited and to make use of the height of the room, bunk beds are provided. The first option outlines a regular and strict plan, with the beds standing in rows. Therefore a corridor between the door at one side and the window on the other side, is maintained. In addition, a separate part functions as storage space for the students belongings, being divided from the rest of the room by a lightweight wall and a flexible curtain. The alternative, second option, describes an arrangement, in which the beds are all placed next to the wall. Hence, a wide open space in the centre of the dormitory is created, to encourage the communication between the students. Lockers are placed in between the beds as a part of the overall structure. Moreover, curtains may be added to ensure the privacy of the user of each bed and its surrounding structure. Both options provide a steel frame which serves as an underlaying structure for a mosquito net.
In contrast to the first option, the second variation seems to offer more privacy, since the beds are facing the wall and may be closed off from any views through

4 see detailing further in this Chapter

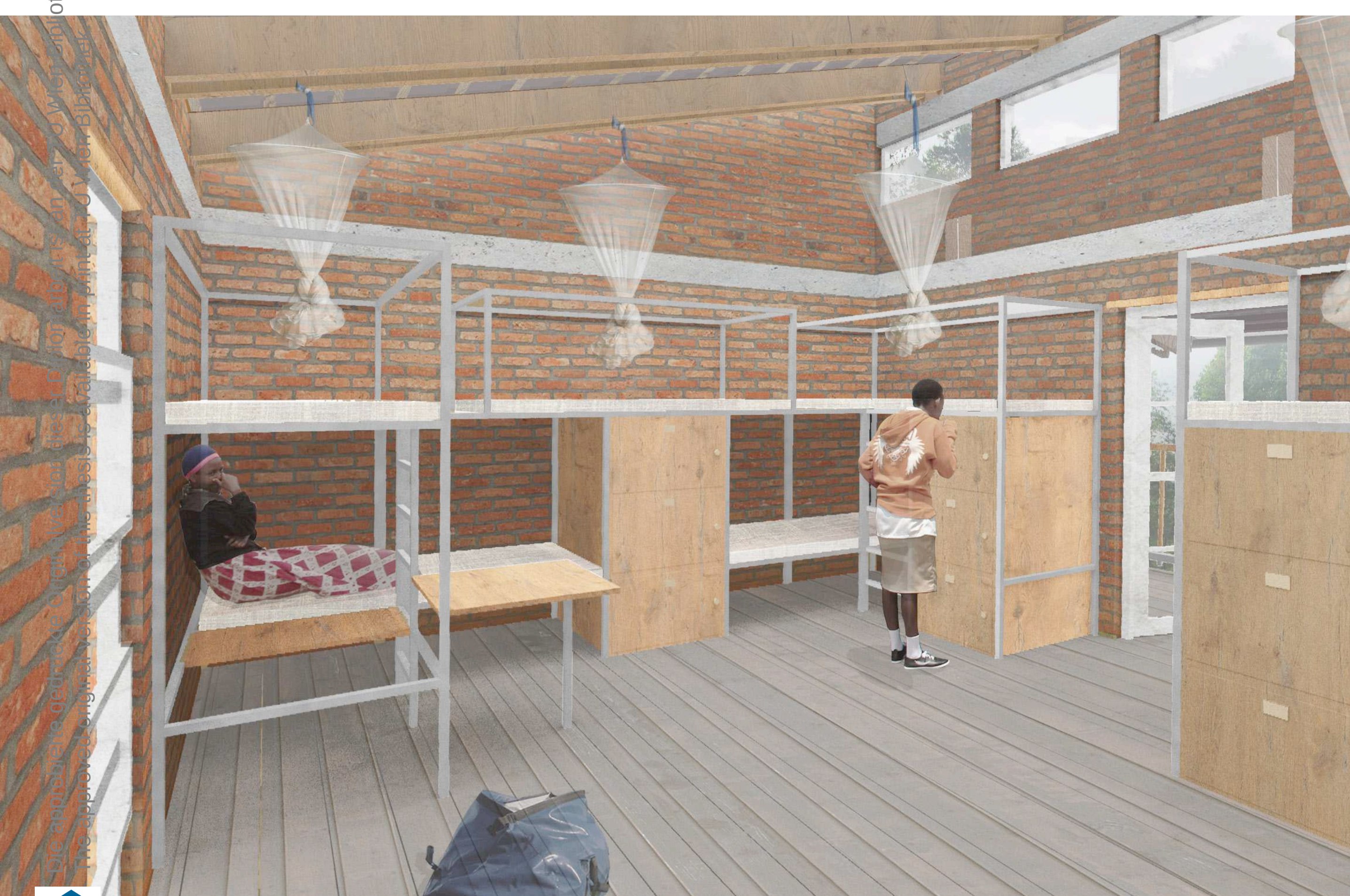
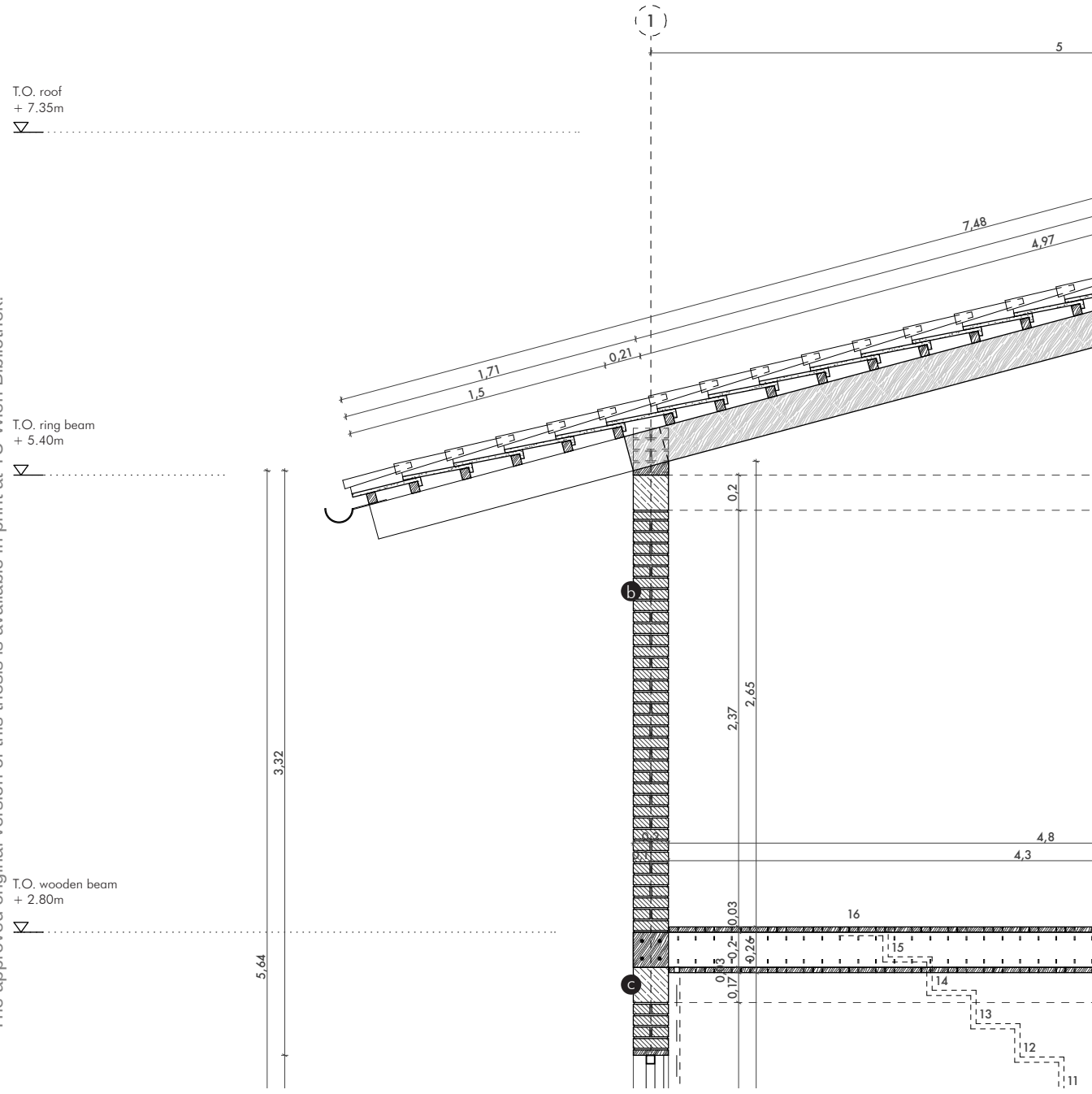


figure 106 - dormitory interior

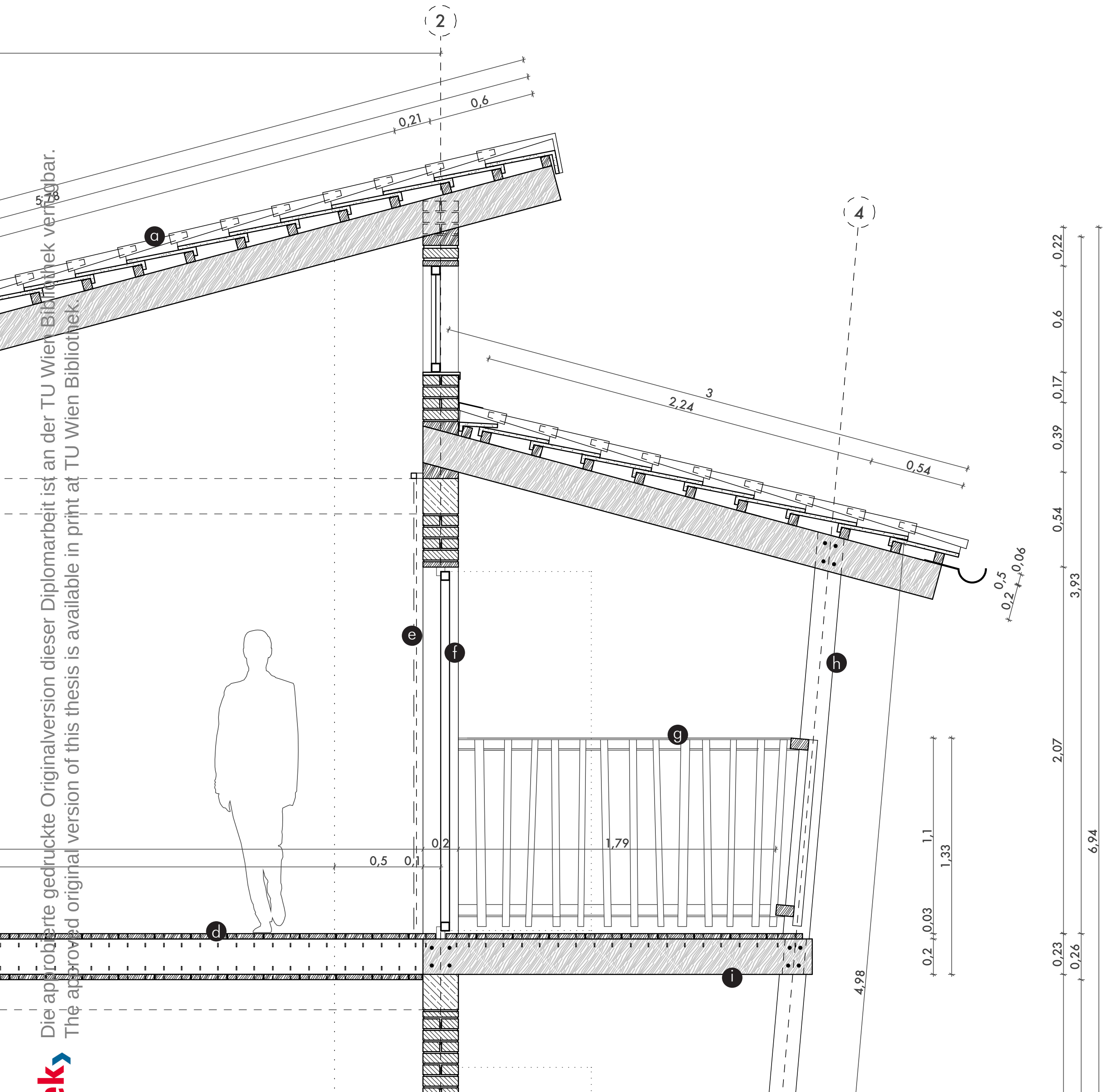


Detail section

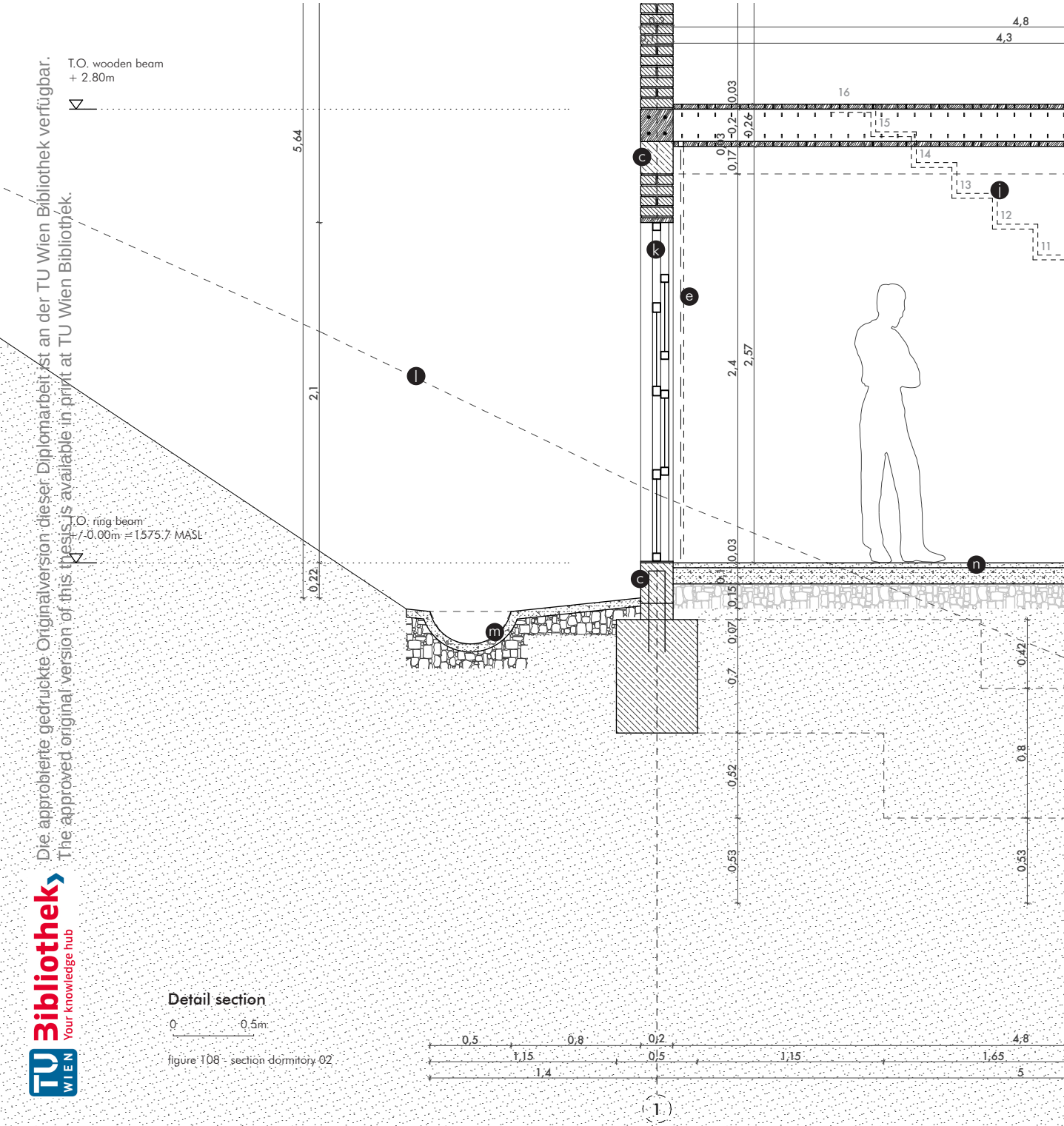
0 0.5m

figure 107 - section dormitory 01

a	burned tiles	d	wooden floor + ceiling
b	burned bricks	e	curtain
c	ring beam (reinforced concrete)	f	door (partly glass)



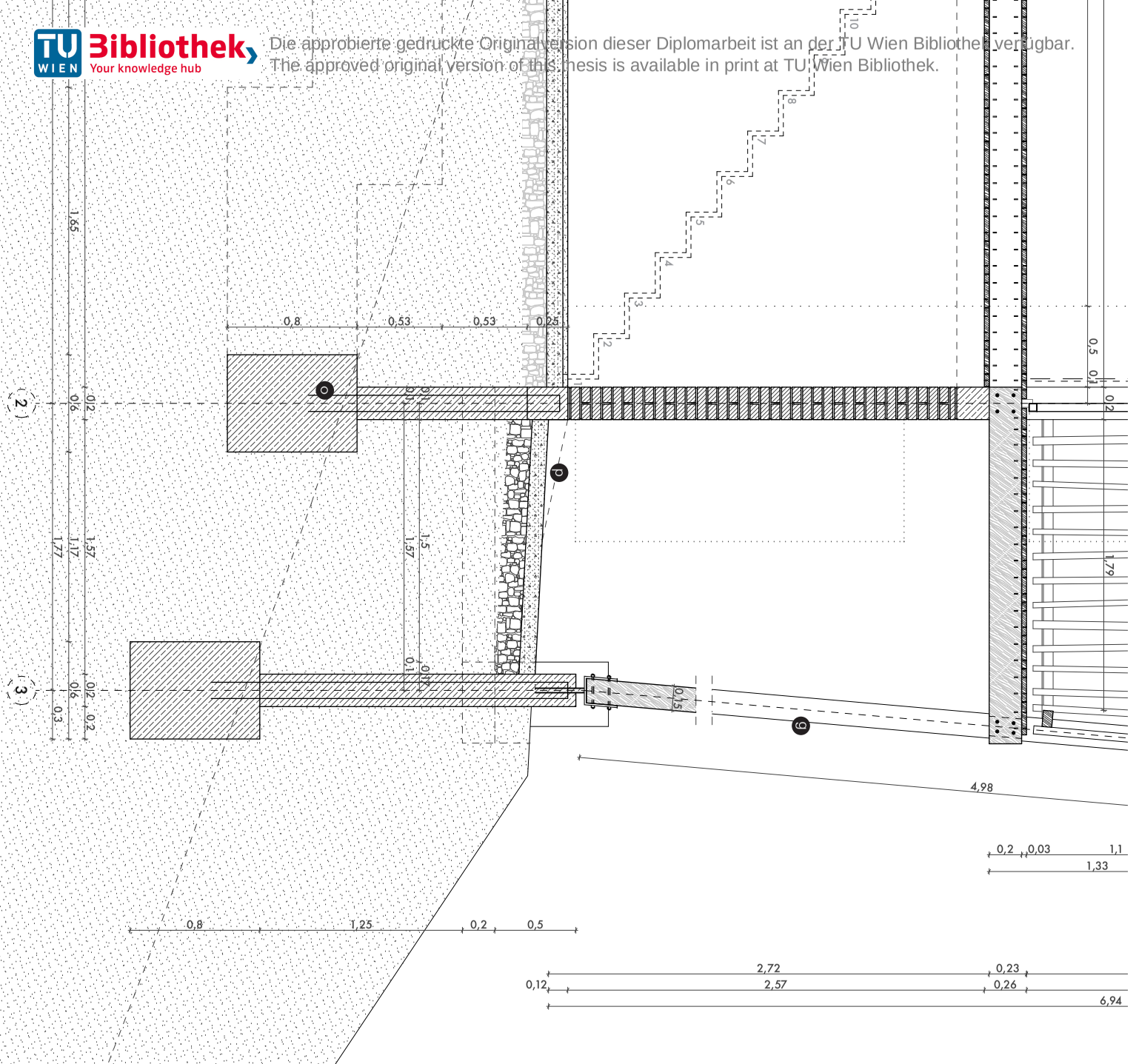
g railing (from existing trees)
h wooden column
i wooden beam
j wooden stairs
k window (ventilation opening)
l existing slope
m drainage
n floor: tiles/cement, concrete, gravel
o foundation (reinforced concrete)
p optional ramp

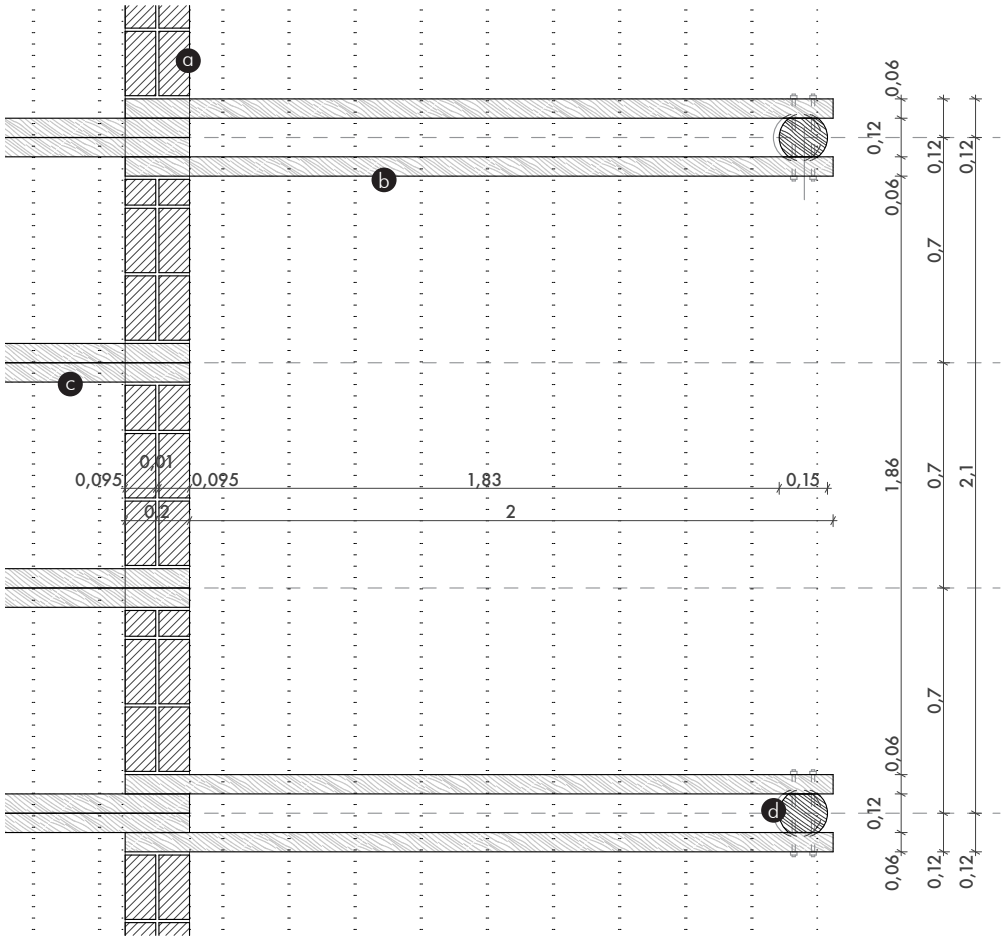


Detail section

0 0,5m

figure 108 - section dormitory 02



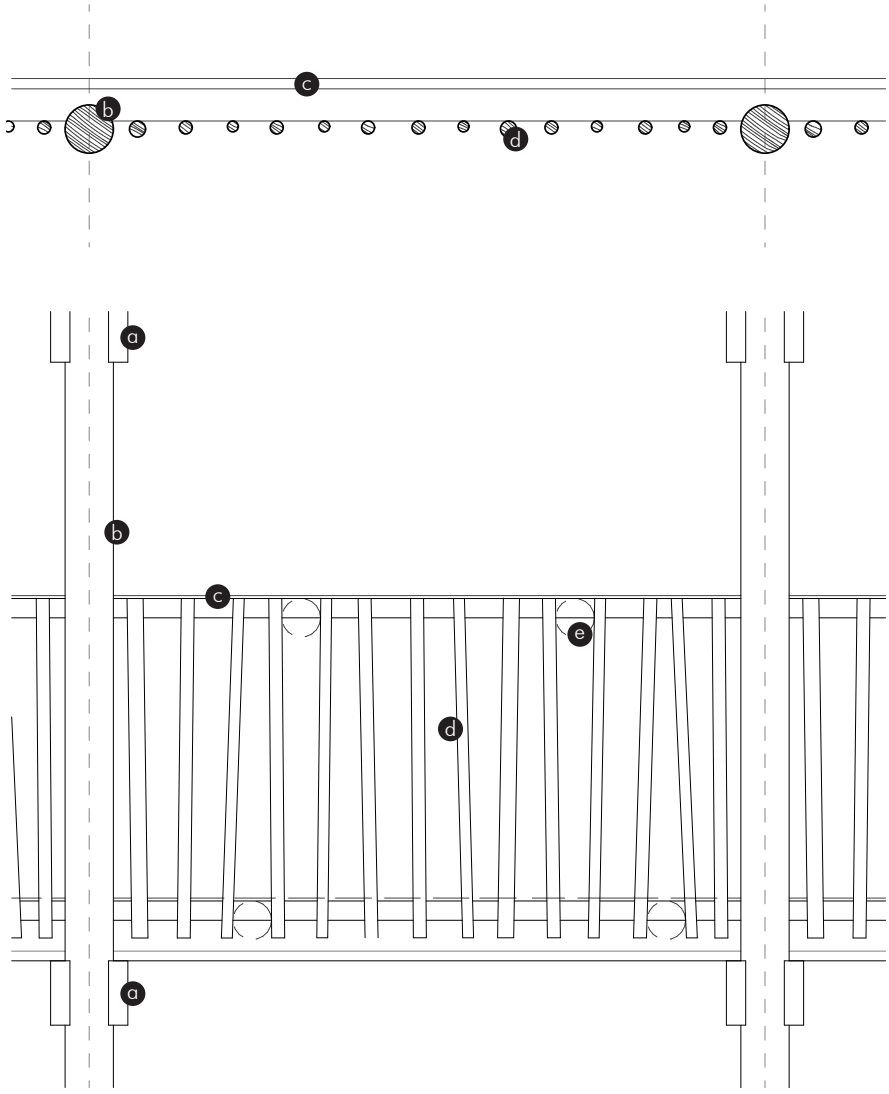


a burned bricks
b wooden beam (20x6cm) base for terrace
c wooden beam (20x6cm), base for ceiling
d wooden column (diametre: 15cm), connected to wooden beam (b)

Detailing

0 0.5m

figure 109 - wooden beams of arcade

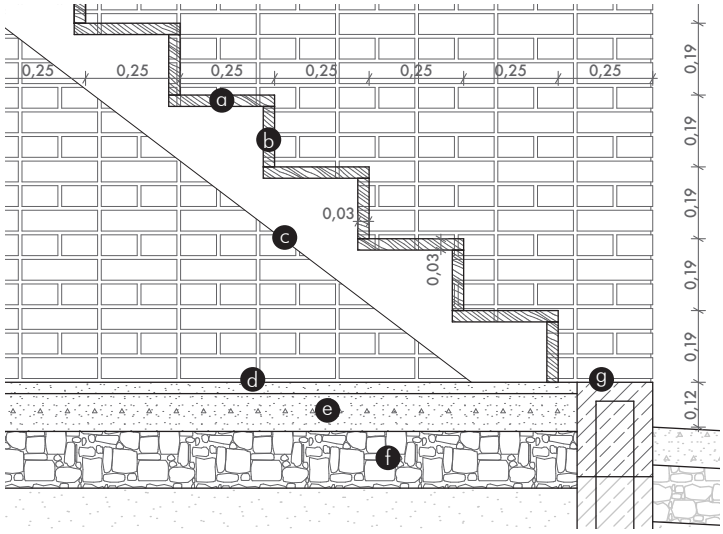


a wooden beam (20x6cm) base for terrace
b wooden column (diametre: 15cm)
c cross beam (10x6cm), base for railing connected with the wooden column (b)
d wooden mullions (diametre: up to 5cm) from existing trees (site clearance)
e security margin (12cm)

Detailing

0 0.5m

figure 110 - wooden columns + railing

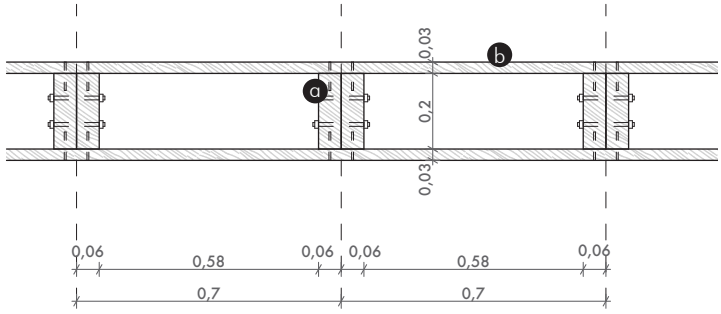


a wooden tread
b wooden riser
both (a+b) supported by c
c wooden crossbeam
d tiles/cement (2-3cm)
e concrete (10cm)
f gravel (15cm)
g ring beam, reinforced concrete (25x20cm)

Detailing

0 25cm

figure 111 - detail staircase + section of wooden ceiling



a wooden beam
(2x 20x60cm, connected to each other)
b wooden panels (floor + ceiling, 20x3cm)

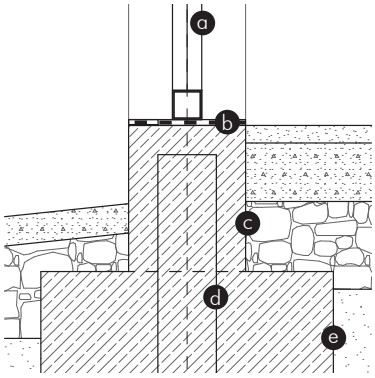
Detailing

0 25cm

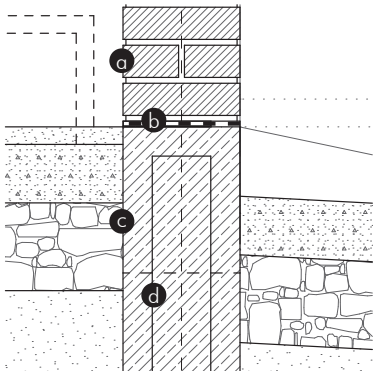
figure 112 - detail staircase + section of wooden ceiling

the flexible curtain. In addition, the open space in the centre contributes to the climate of the room, by increasing the possible ventilation space.

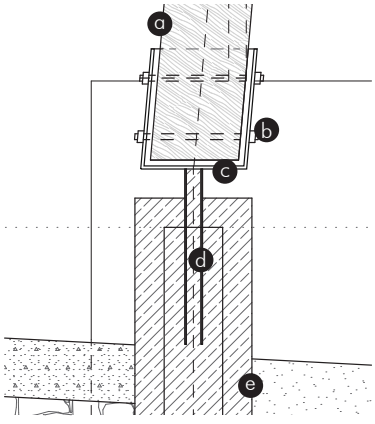
Detailing The dormitory building is based on strip foundations of reinforced concrete, which are running parallel to the slope. Each foundation is placed at least 60cm below the line of the existing soil, to prevent surface water to seep between the foundation and the soil and therefore reduces the risk of damage, which may be caused by any movements. A concrete ring beam runs along the perimeter of the building to support the walls and to increase the stiffening of the whole structure. On top of the ring beam, walls are erected by using burned bricks with a layer of sealing in between the ring beam and the brick wall. This barrier protects the brick walls from damage caused by rising water. In the same regard as at the bottom of the ground floor, a ring beam is duplicated to the top of the ceiling of the ground floor, as well as to the top of the first floor walls. These walls are made from burned bricks analogous to the ground floor. To reduce the weight of the whole structure, wooden beams are installed, to create a base for a ceiling and a roof. Since the length and the width of the wooden beams are limited, some adjustments were made to strengthen the construction. The roof beams are split into two parts to obtain shorter beams. In addition, two wooden beams are joined to form one stronger beam which is used instead of a single beam for the roof and the ceiling of the ground floor. The arcade to the front of the building is an extension of the wooden beams, which are forming the ceiling of the ground floor. It is supported by the ring beam and brick walls on one side and wooden columns on the other side. Individual foundations reaching the existing soil, similar to the strip foundations, set the ground for these columns. A wooden floor from planks, which are placed in cross direction to the wooden beams, generates a continuous surface across the entire first floor. As a limiting element, a railing up to the height of 110cm, is placed at the perimeter of the arcade. One idea for the struts of the railing would be to use leftover wood, which arises from clearing the plot. By adding wooden cross beams and burned tiles on top of the roof beams, a building cover, consisting of two parts, is formed. Both (bottom) ends of the roof are equipped with a gutter to collect the rainwater. Moreover a drainage pipe runs parallel to three sides of the buildings' ground floor. The remaining side on the ground floor is characterised by benches and elements to grow flowers or small plants which fill up the empty spaces between the wooden columns of the arcade.



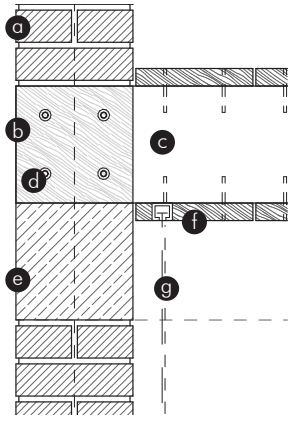
a wood/metal frame windows
b sealing to protect from rising water
c ring beam, reinforced concrete (25x20cm)
d reinforcement of foundation
e strip foundation, reinforced concrete (50x70cm)



a masonry of burned bricks
b sealing to protect from rising water
c ring beam, reinforced concrete (25x20cm)
d reinforcement of foundation



a circular wooden column (diameter: 12cm)
b connecting bolts
c supporting metal stand
d steel tube, lined with concrete
e reinforced concrete wall with individual foundation

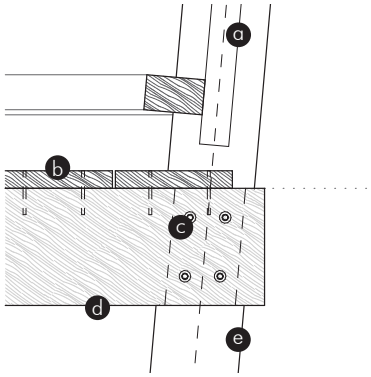


a masonry of burned bricks
b wooden connection for wooden beam (c)
c wooden beam (20x6cm), supported by ring beam
d connecting bolts
e ring beam, reinforced concrete (20x20cm)
f wooden panels (floor cover)
g curtain

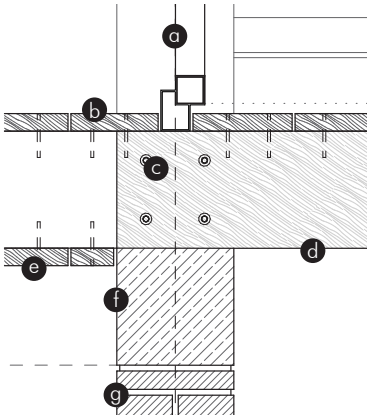
Detailing

0 30cm

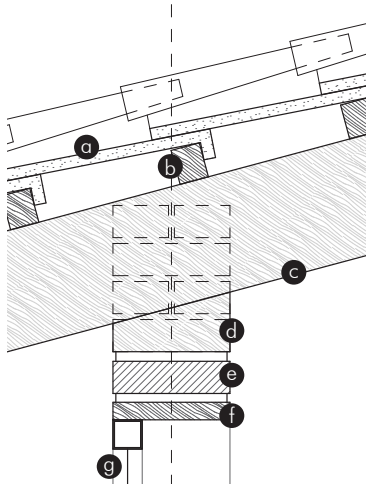
figure 113 - details dormitory



a railing
b wooden panels (floor cover, 20x3cm)
c connecting bolts
d wooden beam (20x6cm), supported by column
e circular wooden column (diameter: 12cm)



a wood/metal frame door
b wooden panels (floor cover, 20x3cm)
c connecting bolts
d wooden beam (20x6cm), supported by column
e wooden panels (ceiling, 20x3cm)
f ring beam, reinforced concrete (20x20cm)
g masonry of burned bricks

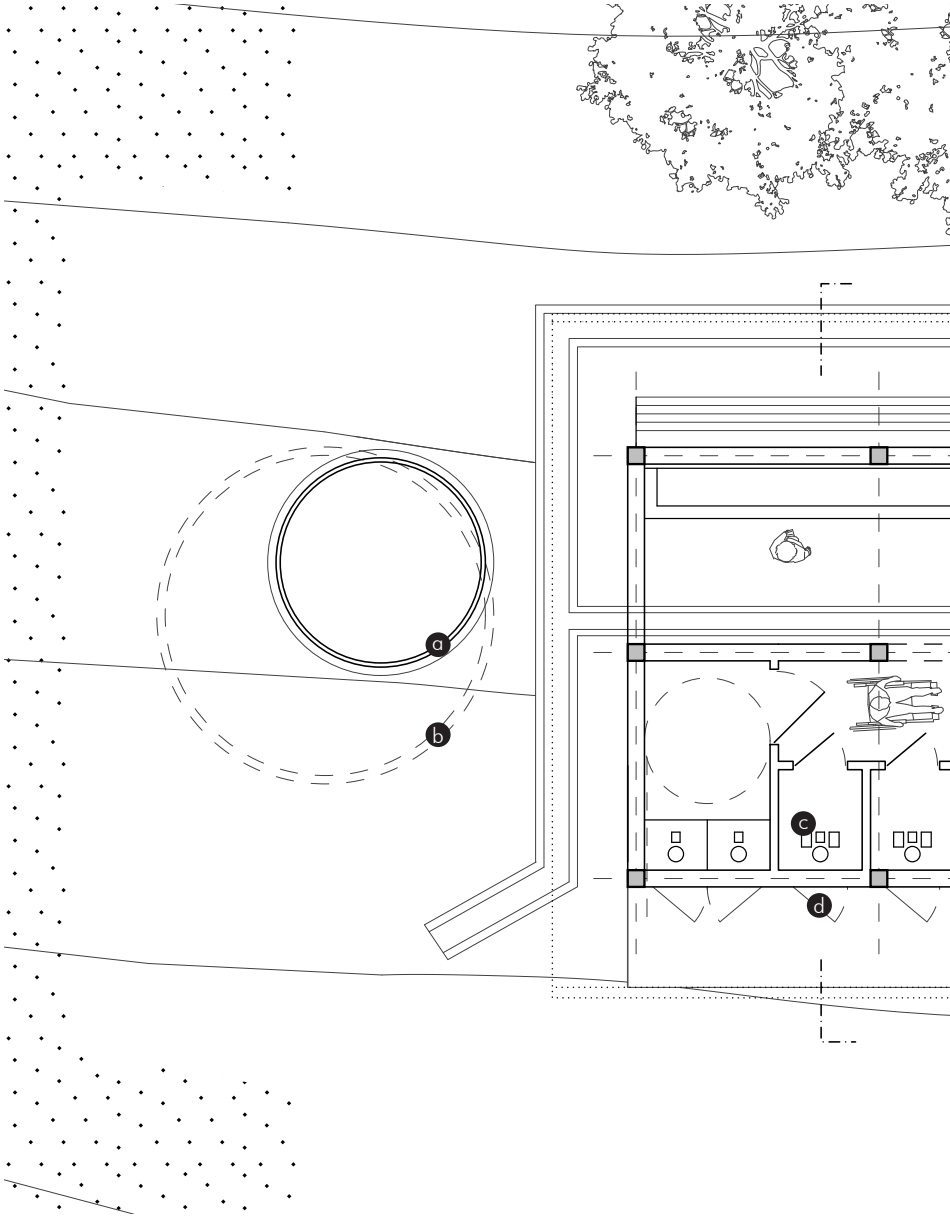


a roof cover of burned tiles
b wooden cross beams (5x6cm)
c wooden beam (20x6cm), nailed on (d)
d wooden connection for wooden beam
e masonry of burned bricks
f wooden panel as lintel
g wood/metal frame window

Detailing

0 30cm

figure 114 - details dormitory 02



Sanitary facilities

existing forest

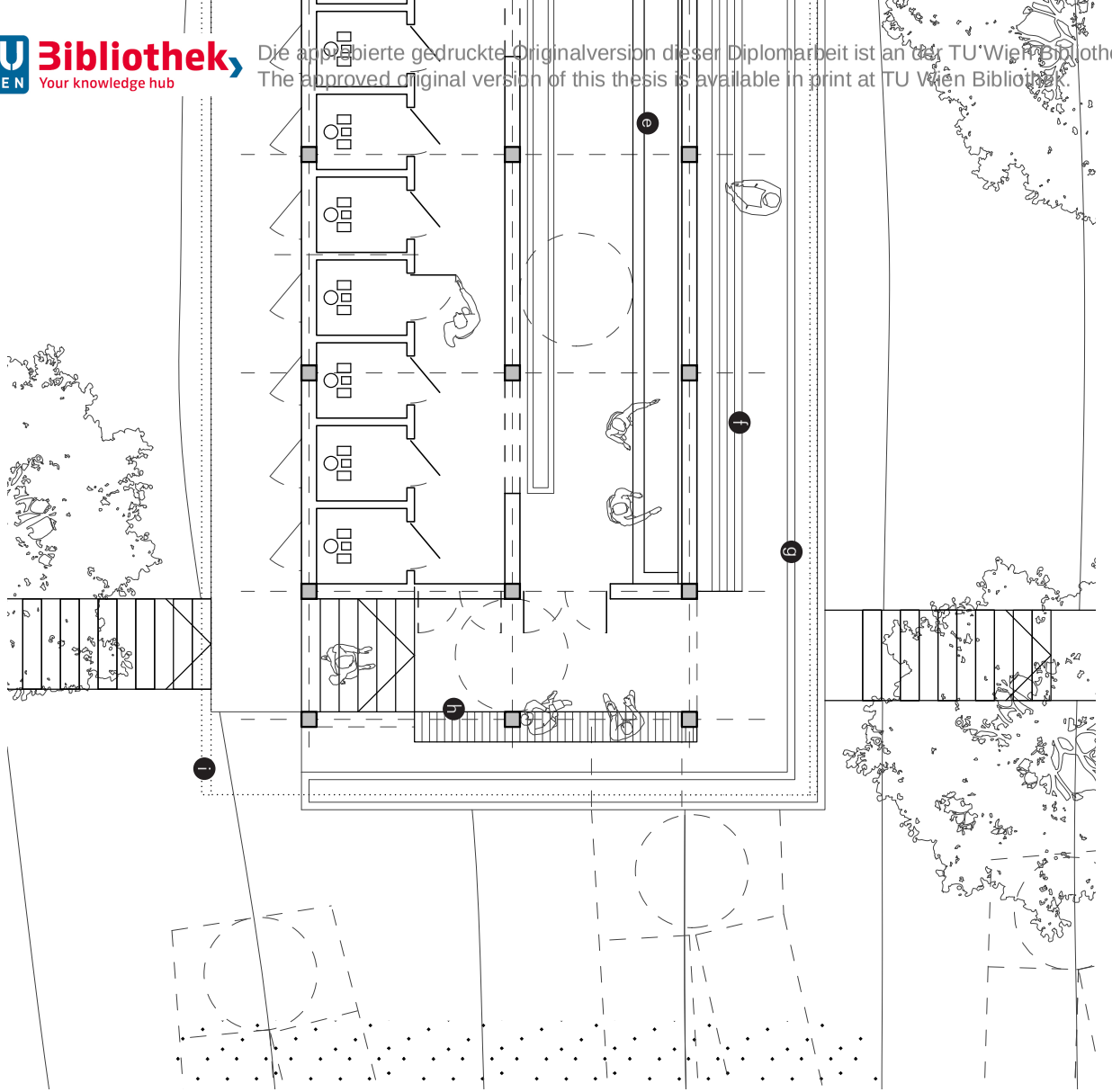
elevation lines

water tank:
a 10.000 L
b 32.000 L

c compost toilets
d pit opening
e sink
f clothes line
g drainage
h bench
i roof overhang + gutter

0 2m

figure 115 - sanitary facilities

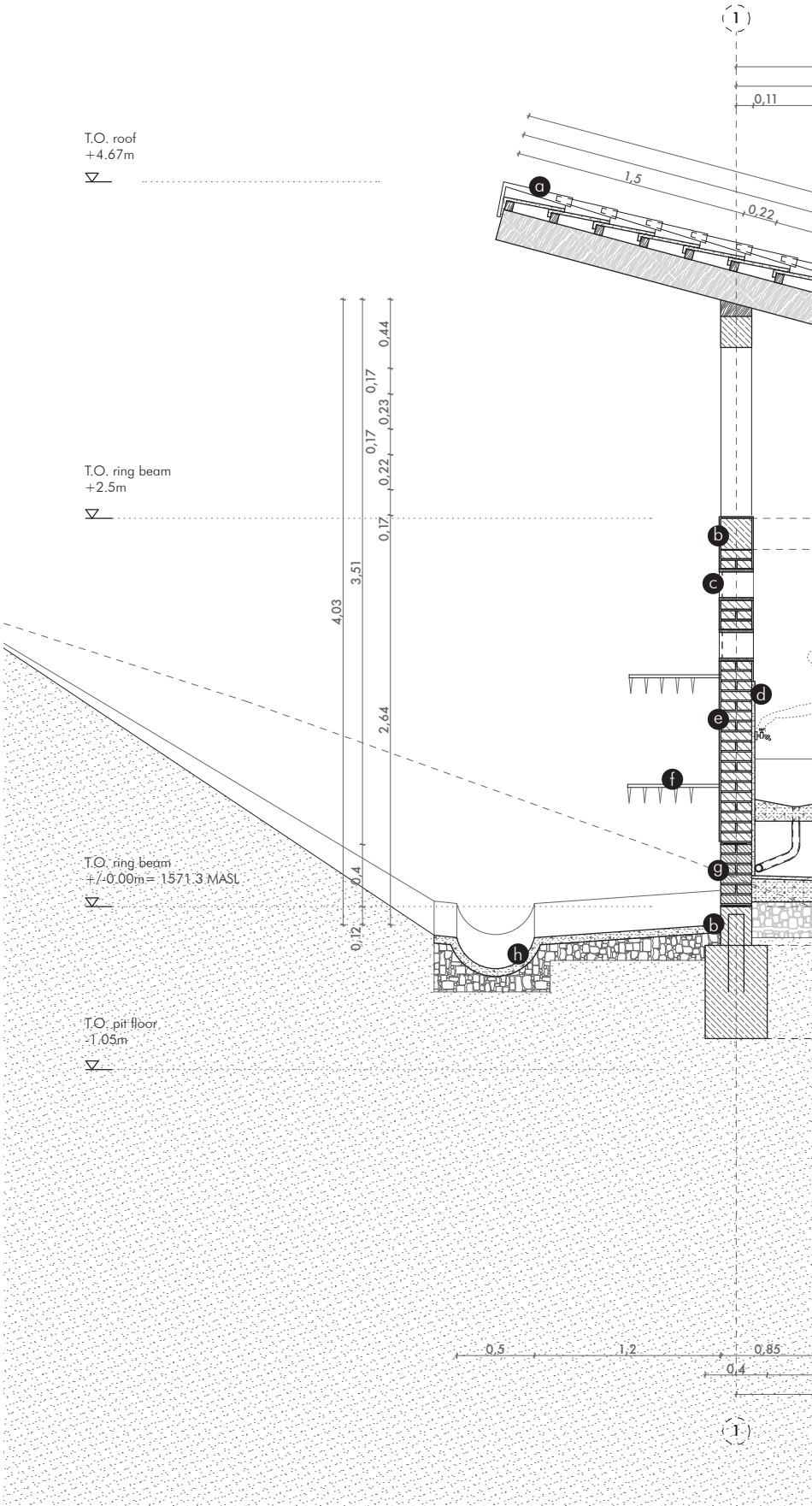


Sanitary building The sanitary building may be divided into two parts. On the one hand, there are compost toilets, which are accessed by a corridor. A separate walkway, divided from the toilets through a wall to the south, is running along an arrangement of sinks. According to the Rwandan building regulations[1], a total amount of 10 toilets, including a toilet suitable for disabled people, is provided. Next to the entrance of the sanitary building, underneath the cantilevering roof, a bench similar to the dormitories, offers sheltered space for communication. To enable a sufficient ventilation and therefore the reduction of stench which may be emitted by the compost pit, the upper parts of the walls are left empty. In addition, wall openings supported by wooden frames, are added at the back wall of the sinks. The compost pit may be entered through a door at the bottom part of the building. Here, the separation of faeces ensures the usage as fertilizer on the fields.

Detailing In contrast to the dormitory building, the structure of the sanitary building is based on a grid of concrete columns and beams. Through these columns and beams, which are supporting the roof structure, all remaining walls are non bearing. Hence, there is the possibility of using Adobe, made from local soil, to fill up the space between the concrete columns. To reduce the risk of any damage caused by humidity, certain precautionary measures were taken. Firstly the roof overhang is extended. The bottom part (40cm) of each wall facing the outside is erected by using burned bricks. On top of this layer of bricks, a sealing is protecting the upper part from any rising water. Moreover, the adobe walls are covered with a layer of plaster. In the case of the sinks, a layer of cement is provided, to serve as an additional protection from the regular water usage. Any interior surface water is conducted to an internal drainage pipe which is leaving the water at another pipe surrounding the sanitary building.

1 BPMIS.GOV.RW 2012, web site last visited 9/9/19

figure 116, p.132 - sanitary interior

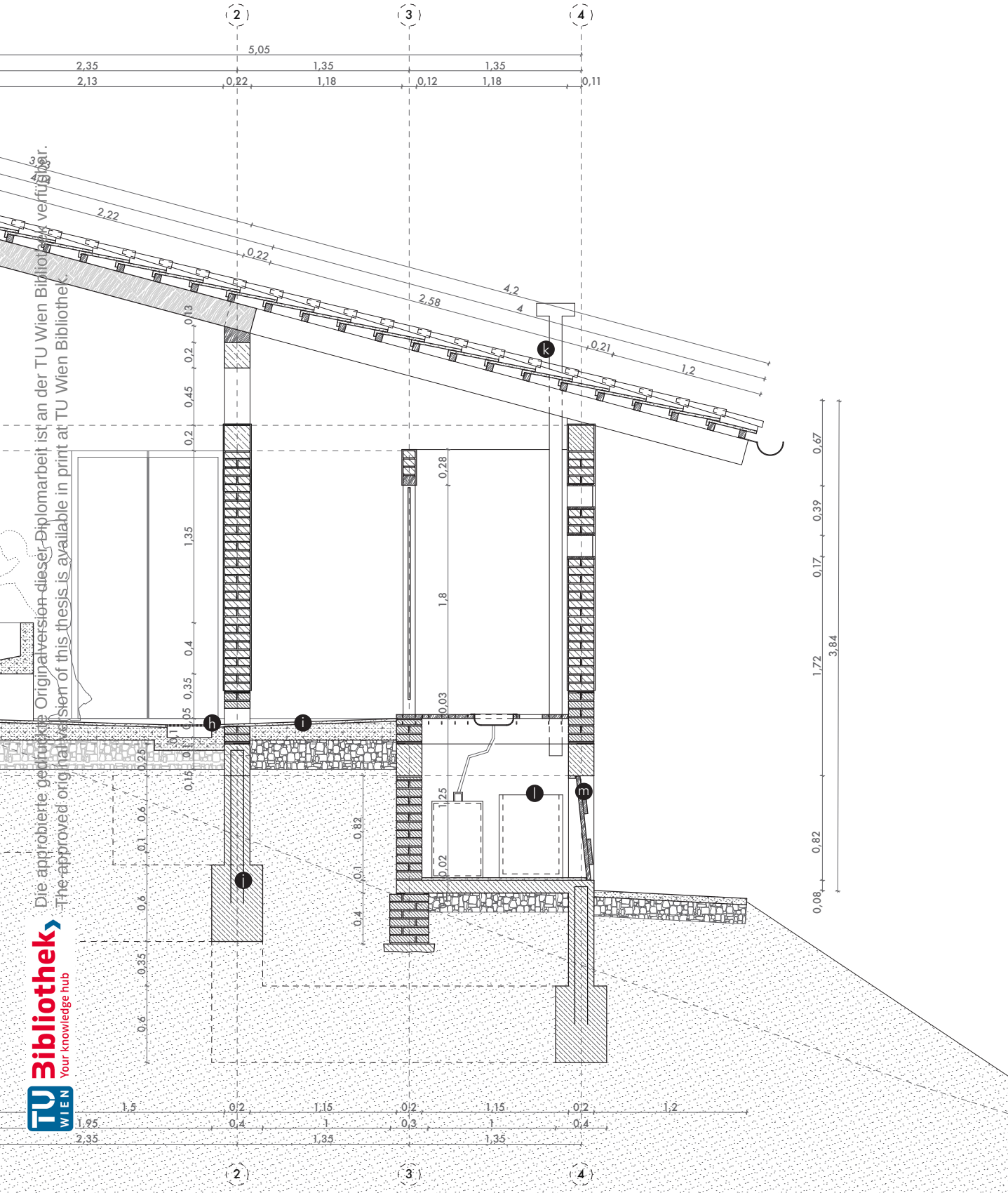


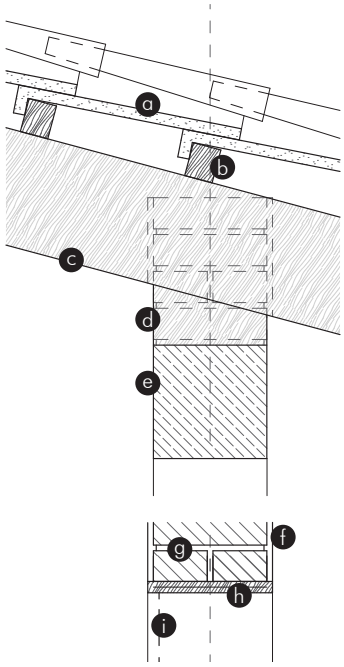
a	burned tiles
b	ring beam (reinforced concrete)
c	ventilation opening + protection screen
d	tiles as water protection for adobe
e	adobe + layer of plaster
f	clothes line
g	burned bricks
h	drainage
i	floor: tiles/cement, concrete, gravel
j	foundation (reinforced concrete)
k	ventilation pipe
l	collector tank
m	pit opening (wood)

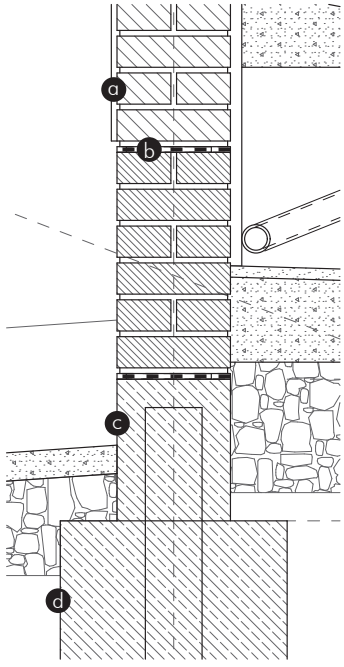
Detail section

0 1m

figure 117 - section sanitary







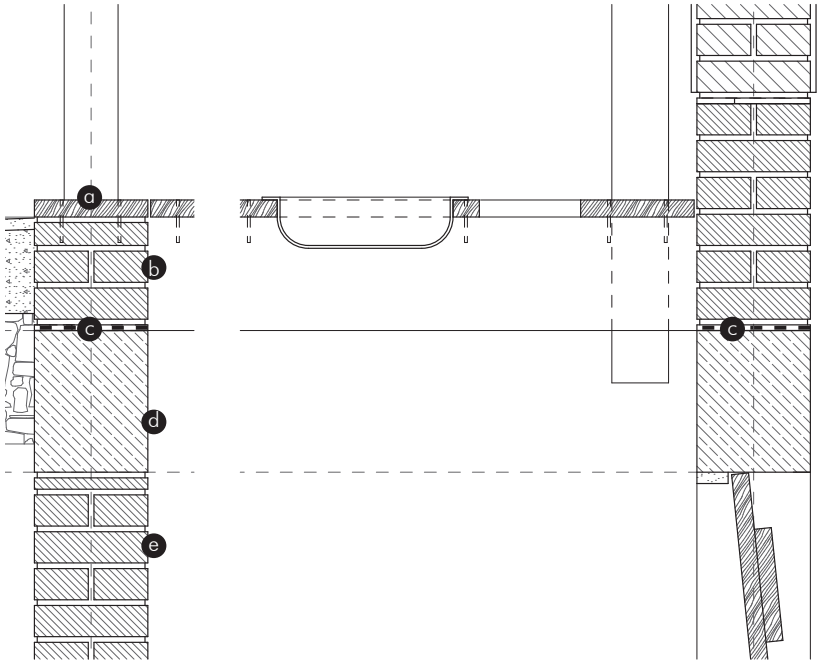
a roof cover of burned tiles
b wooden cross beams (5x6cm)
c wooden beam (20x6cm), nailed on (d)
d wooden connection for wooden beam
e ring beam, reinforced concrete (20x20cm)
f layer of plaster
g masonry of adobe
h wood frame wall opening
i optional protection screen

a masonry of burned bricks
b sealing to protect from rising water
c ring beam, reinforced conrete (25x20cm)
d strip foundation, reinforced concrete (40x60cm)

Detailing

0 30cm

figure 118 - detail roof + foundation



a wooden panels (floor, 20x3cm)
b masonry of burned bricks
c sealing to protect from rising water
d ring beam, reinforced concrete (20x20cm)
e masonry, supported by strip foundation (30x40cm), both of burned bricks

Detailing

0 30cm

figure 119 - detail toilet pit

figure 120 - signpost

Masterplan

Future campus of *IPK*

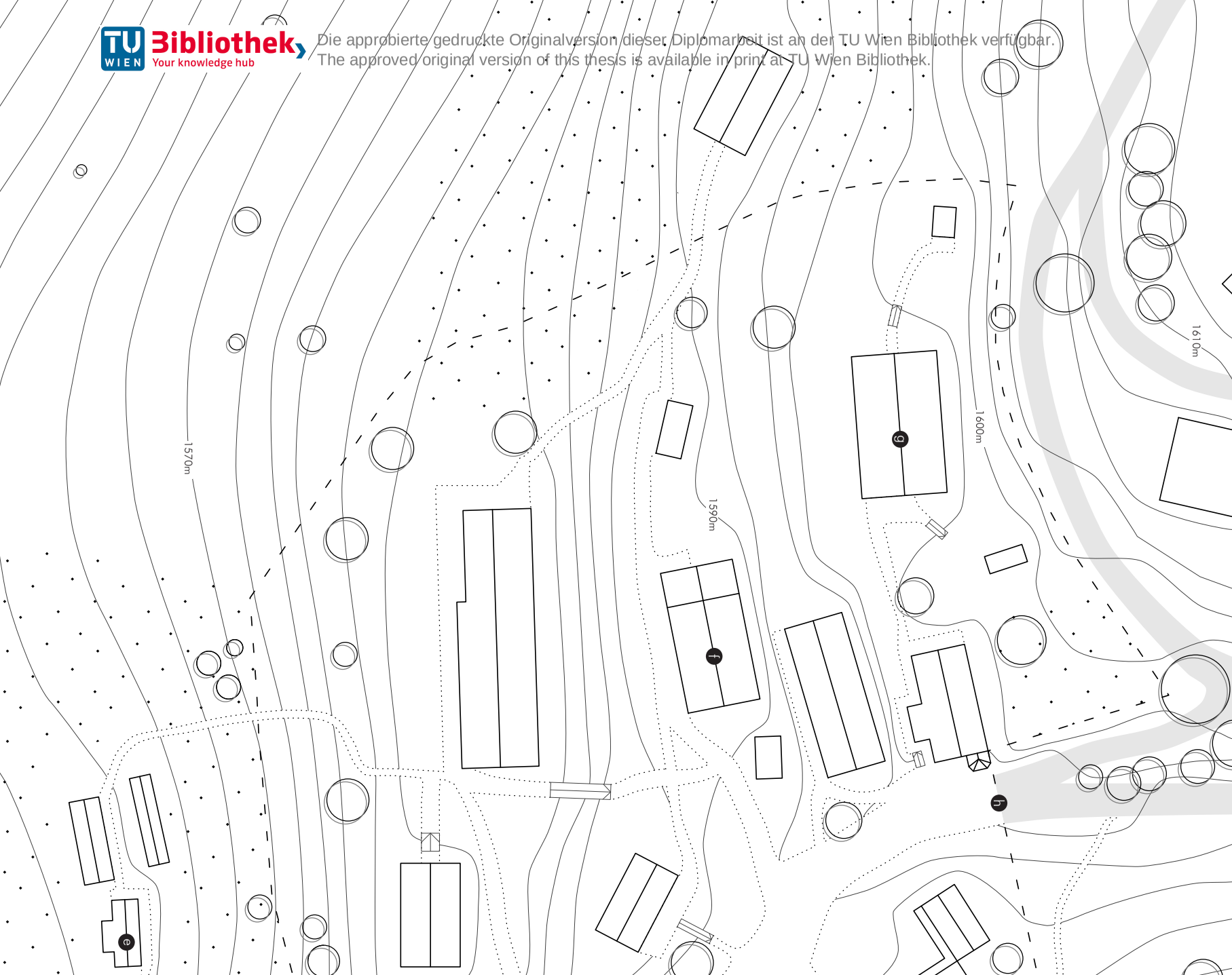
The proposal of Rara Heza is supposed to accommodate around 200 students of *IPK*.[1] As described in the last section, the envisioned building for 50 students, may be extended by duplicating the modules and creating an arrangement of several buildings. This is what is referred to as the Masterplan in this section.

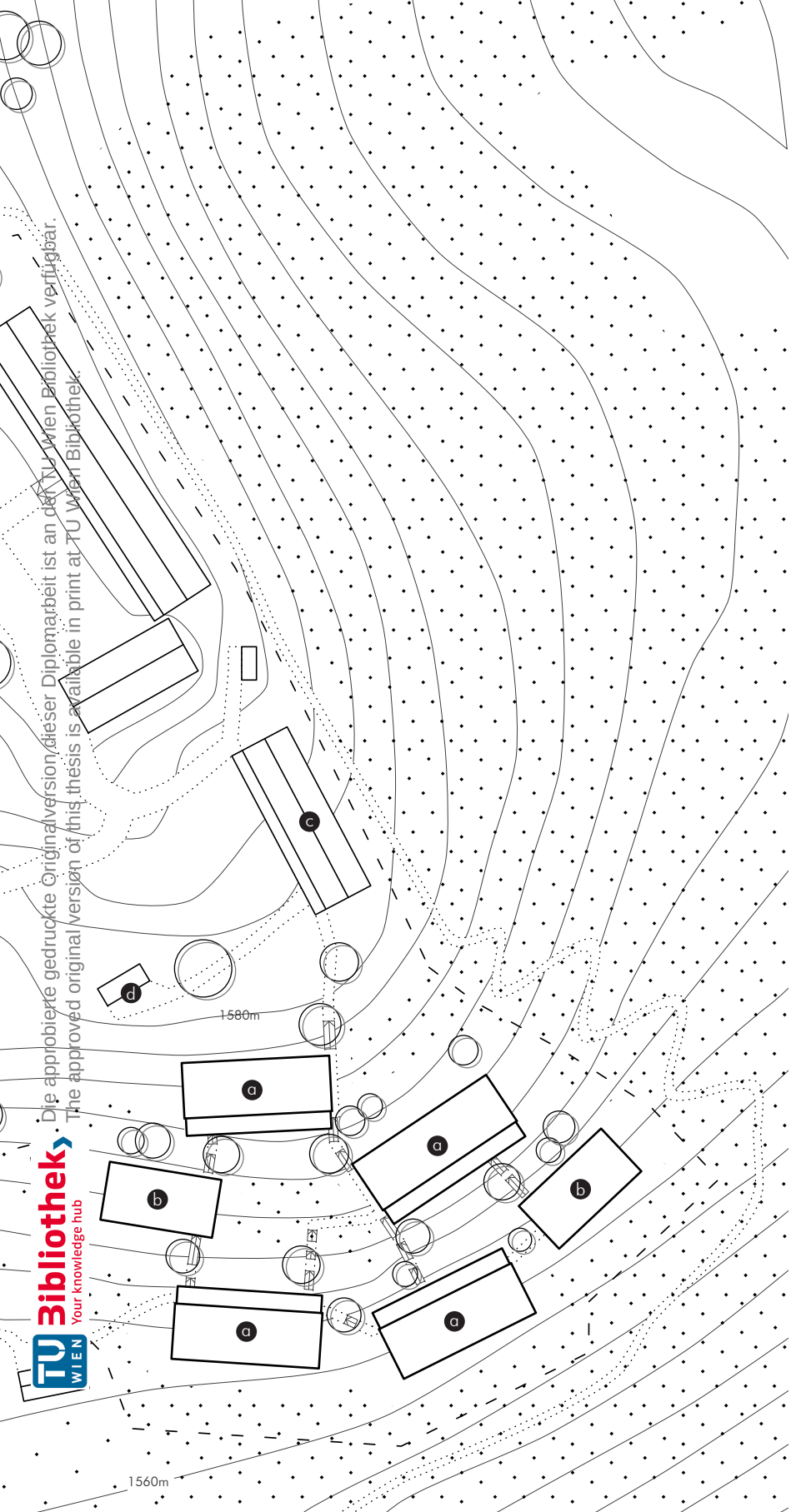
Site arrangement According to the modular system of the dormitory buildings, the master plan is characterised by separate buildings, which are placed parallel to the contour lines of the existing terrain. Through this adjustment, the excavation of the ground will be reduced. The buildings are arranged in the presented way, to create a space in the centre, which is limited by the plots to each side. Initially, the idea was to obtain a private area in between the buildings, by installing walls, even though a fence will be erected at the perimeter of the campus. Instead, the recent site plan shows that privacy is provided through the organisation of the buildings. On the other hand, the layout of the buildings allows for sufficient ventilation of each building. This is the main reason why the sanitary buildings are located on the western and eastern end of the proposal. As mentioned in Chapter 2, the winds in Kirinda are mostly originated in the east and south-east. Therefore the buildings location with open spaces facing the south and east, supports the ventilation.
In addition to the dormitories and sanitary buildings, the master plan outlines a space for the matron as well as for an infirmary. Both spaces are located approximately at the centre of the plan, to keep the walking distances short. Especially since the matron is supposed to take care of the students, the dedicated space enables this person to easily get an overview of the area.[2] As mentioned before, the shower units are separated from the dormitories by a staircase to increase the privacy. At the same time, the showers are placed at the western end of each building (except one building), to absorb the afternoon sunlight and its emitting heat. Hence, the dormitories maintain a lower inside temperature and provide a more comfortable climate to sleep.[3,4]

Accessibility The future dormitories will be reachable through the extension of a walkway which is running along the construction class buildings. This will be the only connection between the dormitory buildings and the rest of the campus of *IPK* and therefore increases the privacy of the students, since there is no path crossing this area. Stairs and paths enable the users to access the different functions of the buildings. Hence, a circular walkway is created, which enhances the communication between the users, even considering the steep slope.
As described in the section before, access ways for disabled people are provided. To extend this accessibility throughout the proposed area, possible ramps are outlined in the master plan through dashed lines. These ramps are designed considering the terrain, with

1 see Chapter 3: The proposal

2 see Chapter 2: Matron building, p.69
3 see figure 121, p. 140f.
4 see figure 99, p.106f.





Future site plan

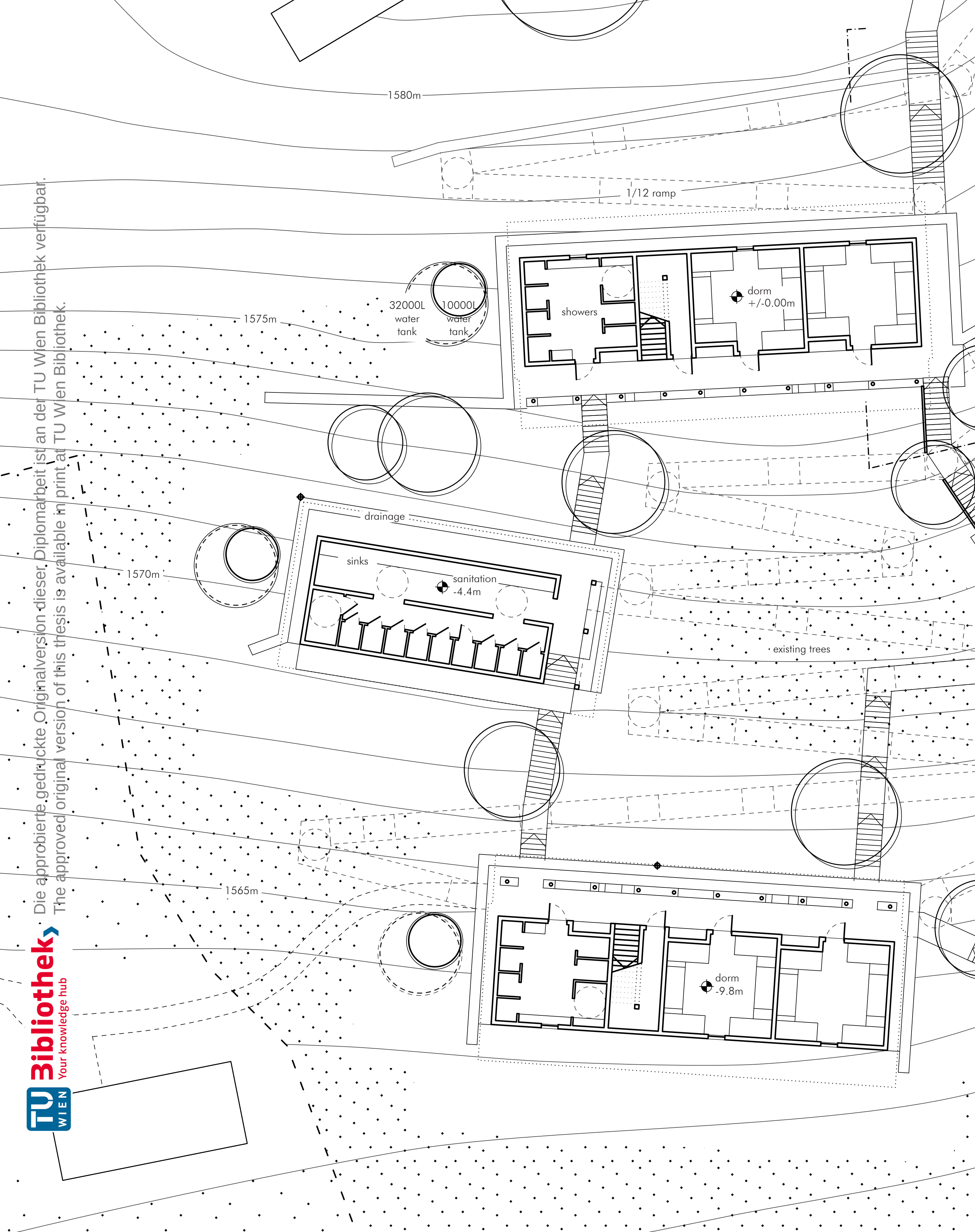
- forest
- fields
- fence
- street
- path
- elevation lines

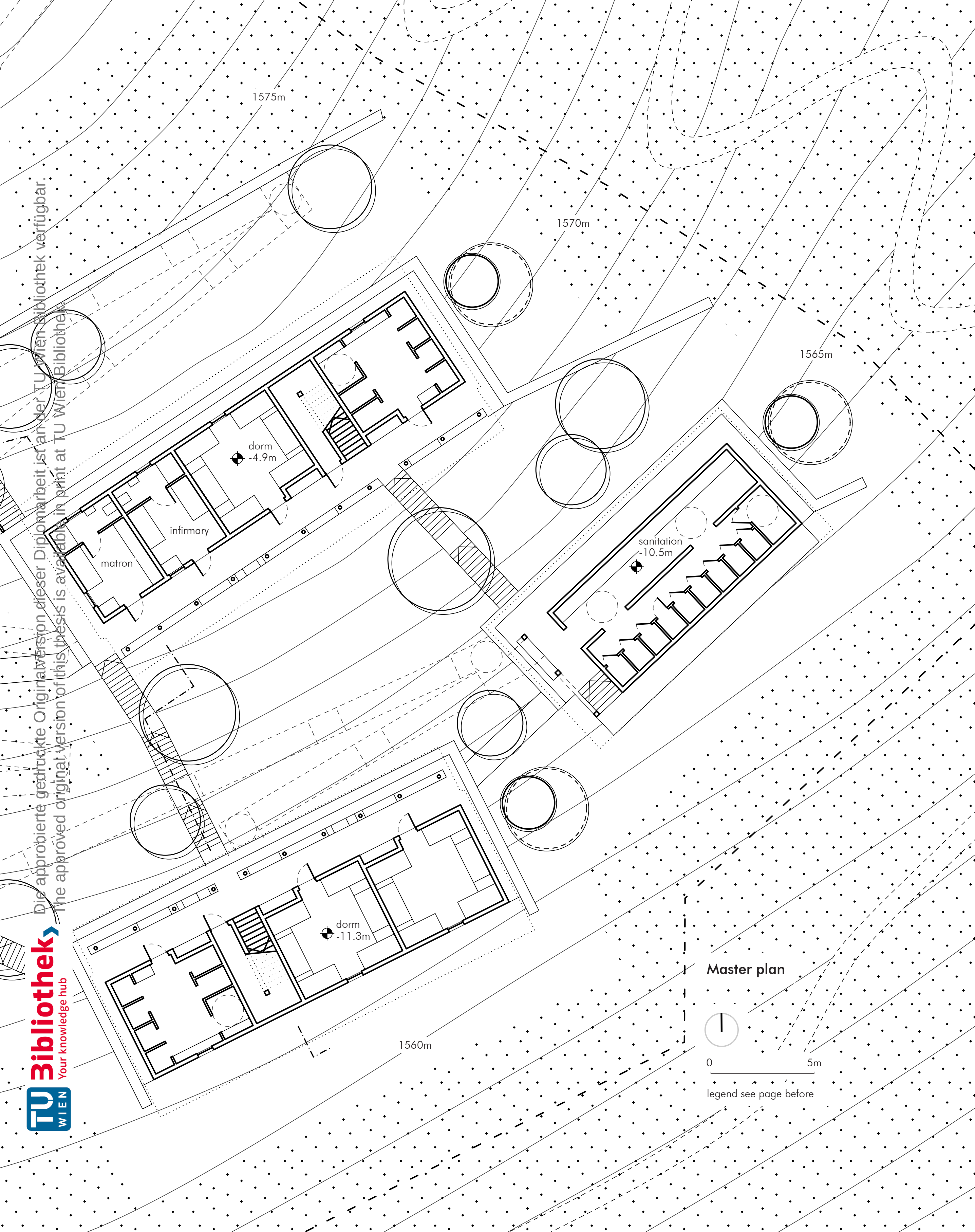
a future dormitory
b future sanitation

c classrooms
d toilet building
e farm
f boys dormitory
g girls dormitory
h main entrance

0 20m

figure 121 - future site plan
figure 122, p.140 - master plan





Master plan

legend see page before

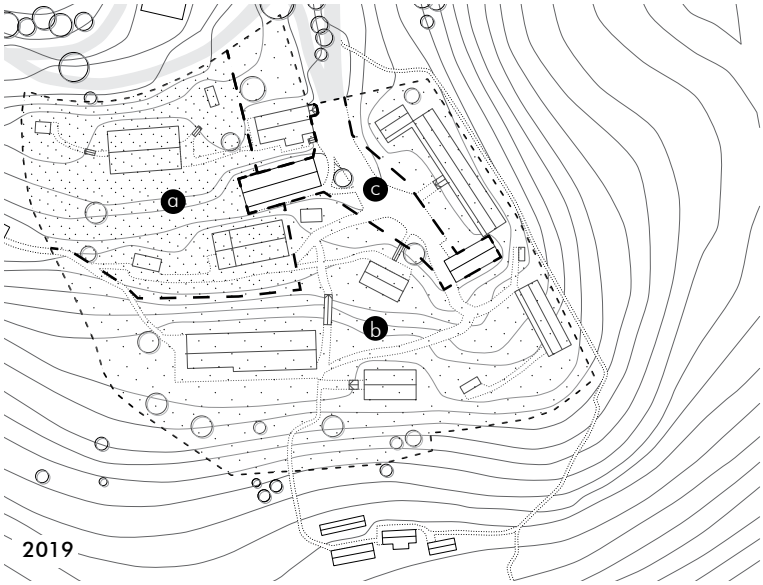


figure 123 - zoning 2019

a maximum ascent of 8,3% (ratio 1/12) and a platform after every six metres.[5,6]

Drainage In order to prevent the proposed buildings to be damaged by erosion, a network of drainage pipes conducts the surface water along the plots to the sides of the area, where the existing soil is able to absorb the water or to transport it to areas below the building plot. In addition, the drainage pipes absorb any water from the building plots, which is not collected by the gutter of the roof.
Since the clearance of the site will reduce the amount of existing greenery, an equal amount of trees is planted across the area and in areas where there is no forest yet. These trees provide shaded spaces across the area and reduce the risk of erosion by strengthening the soil. One part of the existing trees may be kept in the centre of the area.

Construction phases The proposed design is supposed to be realised in the near future and therefore the aspect of financing such a project is of great importance. The financial means of *IOG* are mostly based on donations. While planning and designing, the team of *IOG* realised, that the erection of all buildings presented in the following drawings at the same time, would be too costly. Therefore, the idea is, to split the proposal and costs into four parts. Likewise, at least one dormitory and one sanitary building will be provided during the first construction phase.

Zoning In the first section of this chapter, possible building locations are described. Although some of the mentioned areas are not chosen to erect the future building, there might still be another way to make use of these spaces. The campus of *IPK* today may be divided into different zones, according to the access of different groups of people.[7] Since the meeting hall, the

5 see BPMIS.GOV.RW 2012, web site last visited 9/9/19
6 see figure 122, p.142f.

7 see figure 123

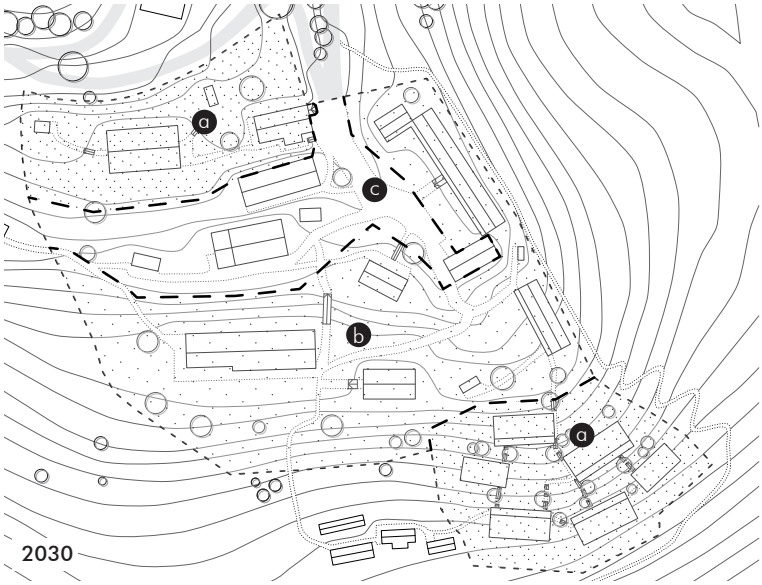
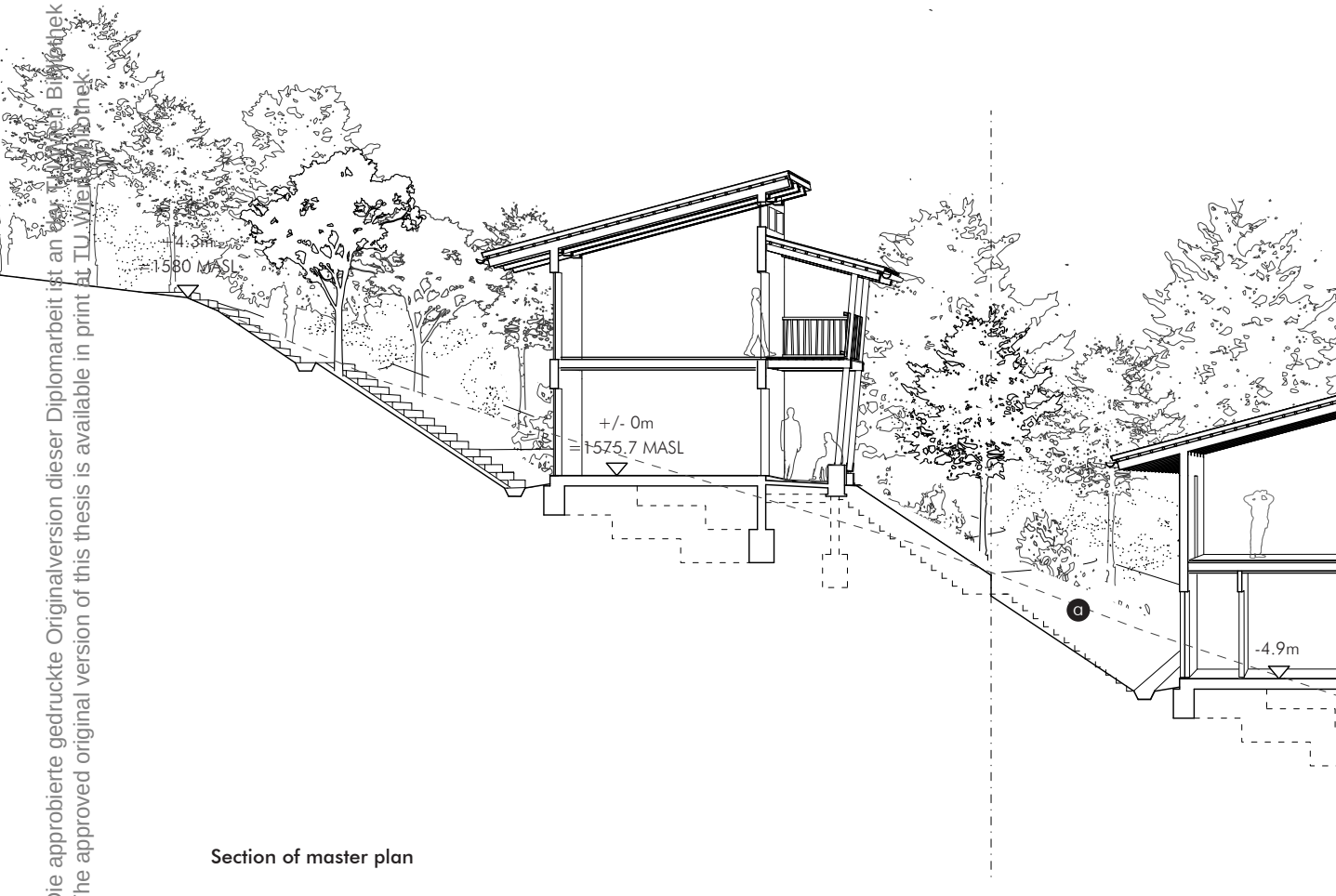


figure 124 - zoning 2030

administration building and the space in between both buildings are open to the public (in this case people from the village, e.g. for events or donations of blood), they are referred to as semi-public. In contrast to the semi-public space, there is an area, which is usually dedicated to the students only and therefore strictly private. This privacy applies to the girls' and boys' dormitory and the adjoining sanitary facilities. Among the semi-public and private space, a third area is functioning as a buffer. Consisting mostly of classroom buildings this area is considered as semi-private.
As a proposal for the campus plan of *IPK*, figure 124, presents a possible zoning in the near future. Based on the design of the future dormitories, another private area will be created in the south of the campus. The existing private area will change its appearance, since the current boys' dormitory will transform into the former event space and therefore will be part of the semi-public space. The male students therefore may move into the present girl's dormitory, which may be refurbished beforehand. In addition, with a possible building ground at today's matron building, the dormitory space may extend further to the east and the matron's accommodation will be moved to the dormitory building in the south of the campus, as described before. In general, the rearrangement of the campus' zoning offers the opportunity of a distribution into male and female dormitory areas, to meet the peoples requirements of privacy. Moreover, the semi-private area comprises all facilities according to the daily school schedule (teaching, studying, meals, etc.), including the classrooms, the workshop, the canteen and the library.



Section of master plan

a existing slope (19°)
b slope (33°)
c section cut - direction turn
d fence

0 5m

figure 125 - master plan section
figure 126, p.148 - site view

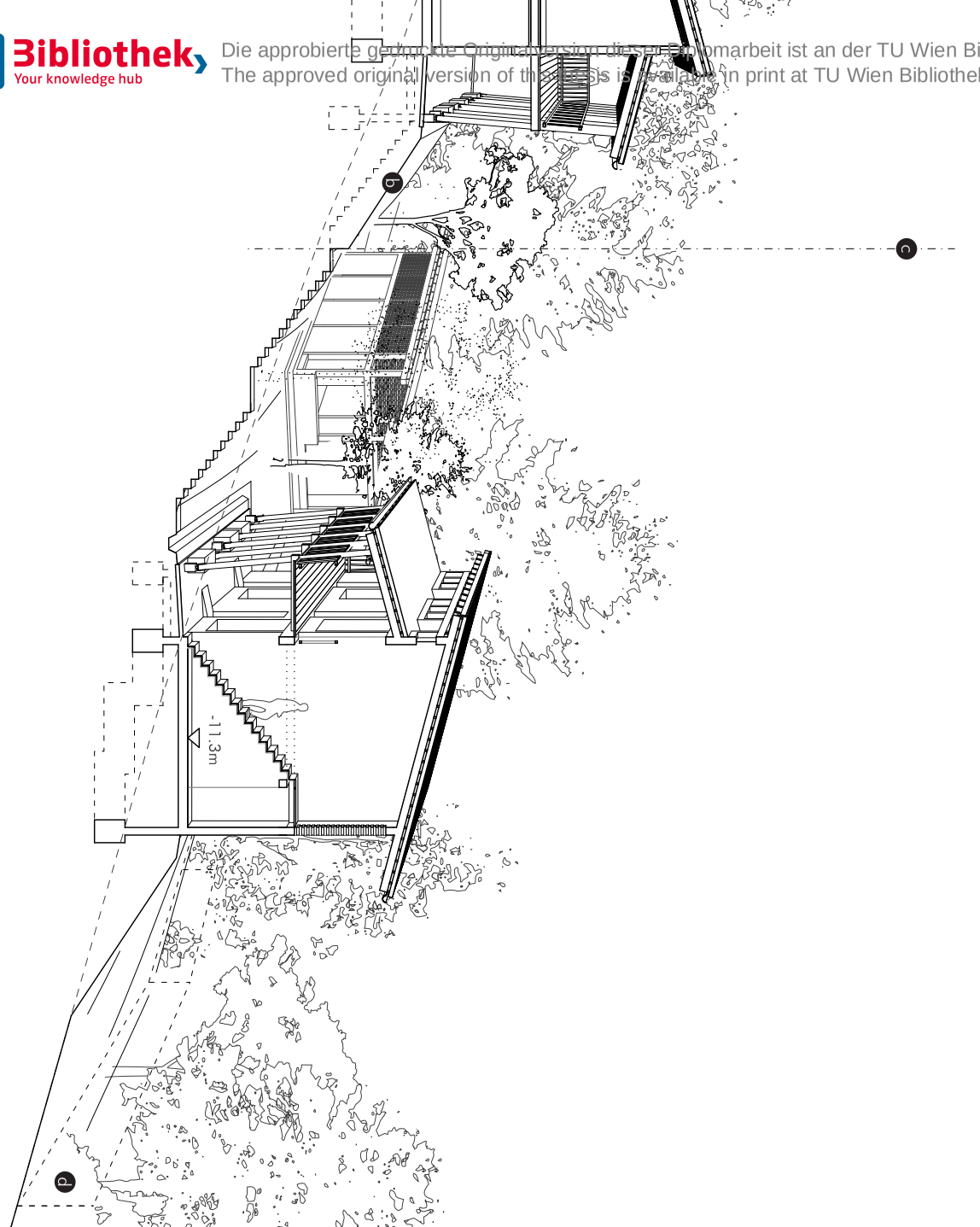


figure 127 - view across developing Kigali

Sustainability

What to consider while planning & building

The word sustainability in general probably covers a great range of topics. With the project of Rara Heza the approach is to implement sustainability through the planning and building process by focusing on the following three topics.

Teaching The initial idea while working on the project was, to somehow let the local people at *IPK* be part of the planning and building process. Since there is a construction department at *IPK*[1], one of the reasons for involving local people is to have an exchange of knowledge with the students as well as with the teachers. Especially the teachers may benefit from this opportunity, to gain additional knowledge and therefore to teach future students attending *IPK*. In addition, the students may increase their chances regarding future jobs through their possible improvement of skills and knowledge. Another reason to include local people in the project, is to increase the acceptance of the proposal, which is designed and planned mostly by people in Europe. The design illustrated in this thesis might just be the first step of future buildings to set up. Therefore it is essential to provide confidence regarding the work which is supposed to happen as team work.
During the planning process at *IPK,* a meeting with the students and teachers of the construction department was set up. The meeting consisted of different parts, including a presentation of the at that time latest design, a questionnaire[2] regarding the wishes and needs of the students and a workshop with one of the construction class teachers. For the presentation some plans, sections, some perspective drawings as well as a model in 1:100 scale of the future buildings were provided. Remarkable was the interest and understanding the students showed towards the scale model which, already presented a two-storey building, including dormitory space and an arcade/balcony. Hence, the intention of the presentation was to provide a first concept of what is going to happen at *IPK* at the beginning of the design stage.

"[...] A 2012 Housing Market study in the City of Kigali showed that 340,000 new housing units are needed by 2022. [...]"[3]

Architecture The design of Rara Heza is envisioned as long lasting. Regarding the location of the project, specific conditions need to be considered, including the regular rainfalls and the possibility of earthquakes. To provide a stable building which resists even the event of an earthquake, its foundation is made of reinforced concrete. In addition, every part of the foundation is carved into the existing soil by at least 600mm. On top of the foundation, reinforced concrete columns and beams form the structural grid. Moreover, as described before[4], the roof is cantilevering to the back

1 see Chapter 2: *IPK*

2 see Chapter 2: Participation
3 NEWTIMES.CO.RW, web page visited 22/1/19
4 see Chapter 3: The proposal

(north) side to protect a great amount of the wall from the rain. A drainage system collects rainwater (surface runoff) which is originated in the upper parts of the site and conducts the water around the future dormitories to protect the buildings from any water damage, as well as to reduce the risk of land erosion, which would cause damage to the buildings. Another important point to mention is, that the planned building is going to consist of two storeys. As far as it was derived from an interview with the headmaster Charles Gahutu[5] and as well from the observations made in Kirinda, the new dormitory building would be the first one in the whole village being built with two storeys. In particular, since Rwanda's population is estimated to double by 2050[6] and accordingly, the need for dwellings will likely increase, it seems unavoidable that even in rural parts of Rwanda, buildings will start to grow in height, to accommodate people in the near future. Thereforem the proposal of Rara Heza is contributing to the ongoing urbanization process in Rwanda.

Building materials During the field trip in Rwanda, the trend of setting up a just little amount of houses, based on wood/mud as a main building material, was remarkable. This observation is supported by the statistics of the Rwandan Population and Housing Census. It examines that in 2012, just 36% of private housing units are made from wood/mud walls.[7] In comparison, the traditional way of building[8] some decades ago was presumably 100% based on wood/mud walls, as the only source for building materials were locally available materials. Reasons why people tend to use other materials than wood/mud is referred to in Chapter 2 (Typologies). Following this observation, one thought regarding the project of Rara Heza was, what kind of impact the use of materials has on the environment. The production process of burned bricks for example is supposed to emit more CO_2 than the usage of traditional materials. The idea behind it was, to analyse which building material it is worth following up on in detail regarding the reduction of emitted CO_2 emissions.[9]

"Urbanisation in Rwanda is growing at [a] faster rate hence making very important for Rwanda to put in place all measures possible for sustainable development of which green building key pillar."[10]

The following example illustrated in figure 131 and 133 (p.155+157), compares two concepts (**A+B**) based on the design of one dormitory building, which differ by the choice of building materials. Bricks and reinforced concrete are taken into consideration as the main materials (covering around 94% of the structural volume[11]) based on the analysis of local available ma-

5 GAHUTU, personal communication on 20/2/19
6 POPULATION.UN.ORG, web page visited 29/6/19
7 STATISTICS.GOV.RW 2015, p.94, web page visited 1/7/19

8 see Chapter 1: Vernacular architecture in Rwanda
9 see STATISTICS.GOV.RW 2015, web page visited 1/7/19
10 NEWTIMES.CO.RW, web page visited 2/4/19
11 see figure 130, p.154

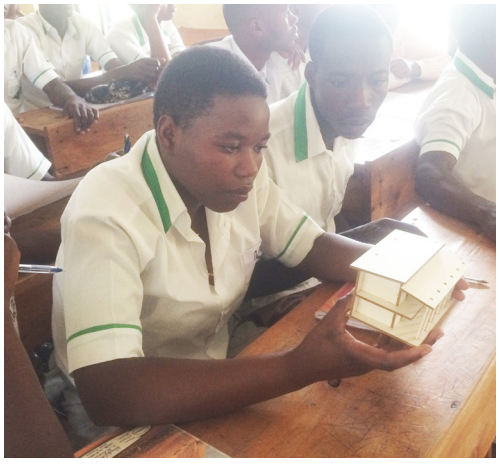


figure 128 - presentation at *IPK*

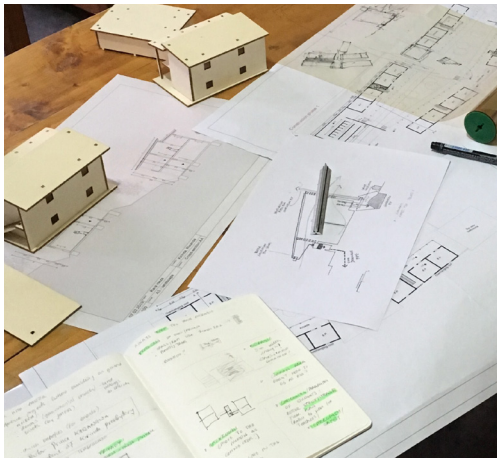


figure 129 - design workshop

terials[12]. Concept **A**[13] presents the use of a reinforced concrete foundation and bearing walls made of burned bricks, which are supported by ring beams made of reinforced concrete. Concept **B**[14] similarly proposes a reinforced concrete foundation but instead of bearing walls, it displays a grid of reinforced concrete columns and beams as the main structural elements. The remaining parts of the walls are filled with adobe and are therefore not supporting the structure. Moreover, a calculation is provided to show the differences in volume, density and global warming potential (GWP). Further, results concerning the CO_2 emissions are outlined.

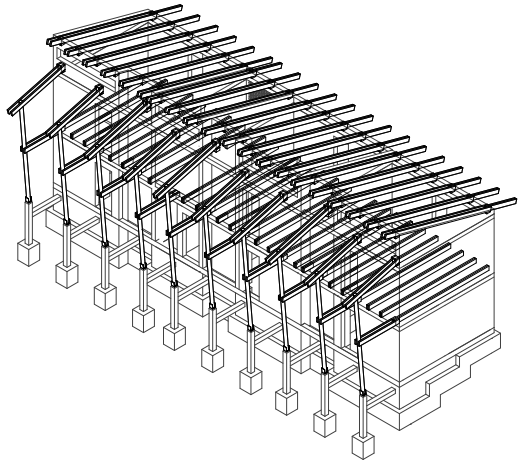
As it seems to be quite complex to do research on the origin of building materials for any project, the situation in Kirinda is similar. In general, it was not possible to obtain detailed information about common building materials in Rwanda. Therefore the choice of materials was analysed in the european context. The calculations (figure 131+133) are based on two sources to be able to compare the results of two databases. On the one hand there is data of Archiphysik[15] and Baubook[16] which provide details of a great amount of building materials according to the Austrian market (sections **A1+B1**). Archiphysik works with Ökoindex OI3[17], a tool to evaluate the sustainability of buildings. On the other hand Ökobaudat[18] offers a similar overview in the german context (sections **A2,A3+B2,B3**). Both sources present a value of CO_2 emissions and the density of a substantial range of materials.
In the case of Archiphysik , a demo-version with the data of the baubook library was used. A CO_2 value is displayed for many materials by the global warming potential (GWP). For the following calculation the amount of **GWP 100 Summe** (kg CO_2/kg) was used for the listed materials.[19]
Ökobaudat similarly presents different details of materials listed in groups including their CO_2 value

12 see Chapter 2: Typologies
13 see 11
14 see figure 132, p.156

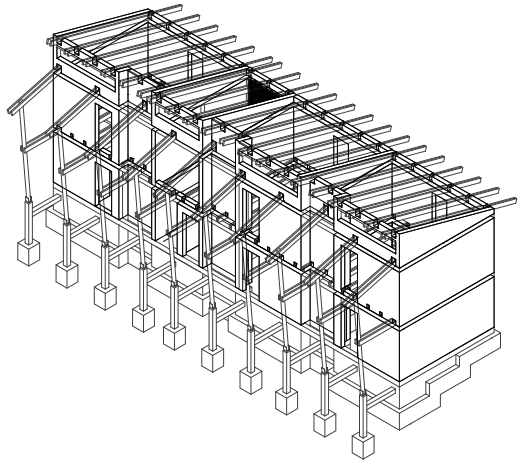
15 ARCHIPHYSIK.AT I, web page visited 17/7/19
16 BAUBOOK.INFO I, web page visited 17/7/19
17 ARCHIPHYSIK.AT II, web page visited 18/7/19
18 OEKOBAUDAT.DE, web page visited 17/7/19
19 see BAUBOOK.INFO II, web page visited 17/7/19

Concept A - burned bricks

wood
volume: 7.10 m^3
(5.7% of whole structural volume)



burned bricks
volume: 68.71 m^3
(55.7% of whole structural volume)



reinforced concrete
volume: 47.67 m^3
(38.6% of whole structural volume)

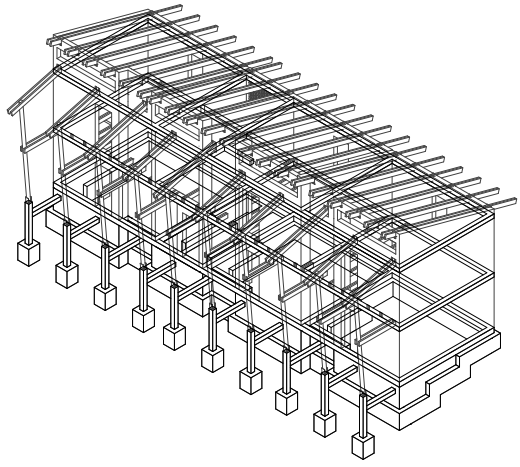


figure 130 - main structural elements - concept A

	material (specified description)	volume (m^3)	density (kg/m^3)	weight (kg)	GWP ($kg\ CO_2/kg$)	GWP ($kg\ CO_2/m^3$)	sum CO_2 ($kg\ CO_2$)
A1	burned bricks (Mauerziegel voll + Normalmörtel)	68.71	1600	109936	0.181	289.6	19898.42
	reinforced concrete (Stahlbeton, 120 kg/m^3 Bewehrungsstahl)	47.67	2350	112024.5	0.148	347.8	16579.63
	sum	116.38					**36478.05**

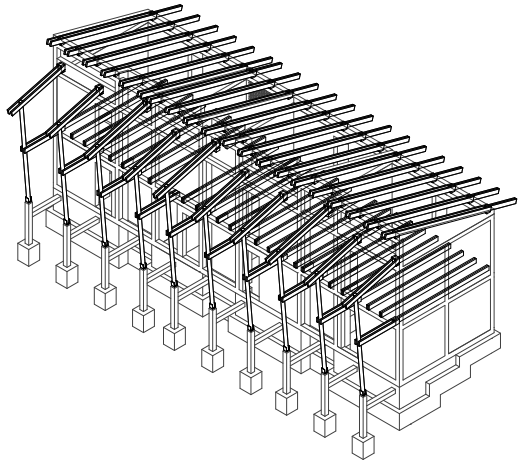
	material (specified description)	volume (m^3)	density (kg/m^3)	GWP fabrication ($kg\ CO_2/m^3$)	GWP transport ($kg\ CO_2/m^3$)	GWP construction ($kg\ CO_2/m^3$)	sum GWP ($kg\ CO_2/m^3$)	sum CO_2 ($kg\ CO_2$)
A2	burned bricks (DE 2015, Mauerziegel)	68.71	575	138.3	3.47	7.5	149.27	10256.55
	reinforced concrete (DE 2017, Betonfertigteil Wand 12cm)	47.67	2427.5	325	4.5[1]	1.8	331.3	15793.07
	sum	116.38						**26049.62**
A3	burned bricks (DE2017, Fassadenklinker)	68.71	2000	542	3.47[2]	7.5	552.97	37994.78
	reinforced concrete (DE 2017, Betonfertigteil Decke 20cm)	47.67	2520	423.5	4.5	1.8	429.8	20488.57
	sum	116.38						**58483.35**

1 assumed values (grey) based on concrete C30/37
2 assumed values (grey) based on burned bricks (see A1))

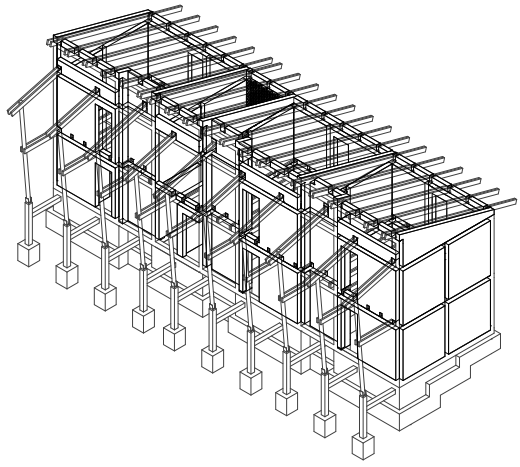
figure 131 - concept A

Concept B - adobe

wood
volume: 7.10 m^3
(5.7% of whole structural volume)



adobe
volume: 62.92 m^3
(51% of whole structural volume)



reinforced concrete
volume: 53.46 m^3
(43.3% of whole structural volume)

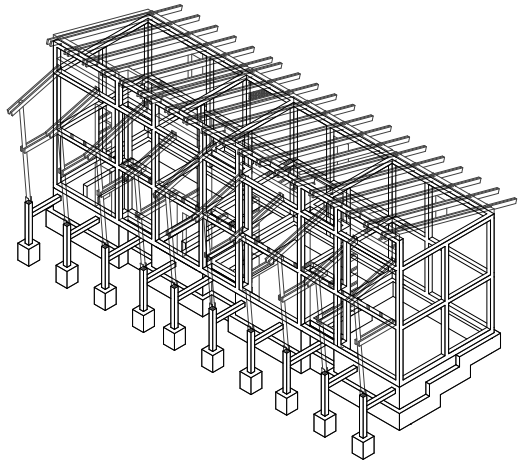


figure 132 - main structural elements - concept B

	material (specified description)	volume (m^3)	density (kg/m^3)	weight (kg)	GWP (kg CO_2/kg)	GWP (kg CO_2/m^3)	sum CO_2 (kg CO_2)
B1	adobe (Lehm - Massivlehm)	62.92	2000	125840	0.021	42	2642.64
	reinforced concrete (Stahlbeton, 120 kg/m^3 Bewehrungsstahl)	53.46	2350	125631	0.148	347.8	18593.39
	sum	116.38					**21236.03**

	material (specified description)	volume (m^3)	density (kg/m^3)	GWP fabrication	GWP transport	GWP construction	sum GWP (kg CO_2/m^3)	sum CO_2 (kg CO_2)
				(kg CO_2/m^3)				
B2	adobe (DE 2017 Lehmstein)	62.92	1200	93.84	3.47[1]	7.5	104.81	6594.83
	reinforced concrete (DE 2017, Betonfertigteil Wand 12cm)	53.46	2427.5	325	4.5[2]	1.8	331.3	17711.3
	sum	116.38						**24306.13**
B3	adobe (DE 2017 Lehmstein)	62.92	1200	93.84	3.47	7.5	104.81	6594.83
	reinforced concrete (DE 2017, Betonfertigteil Decke 20cm)	53.46	2520	423.5	4.5	1.8	429.8	22977.11
	sum	116.38						**29571.94**

1 assumed values (grey) based on burned bricks (see A1))
2 assumed values (grey) based on concrete C30/37

figure 133 - concept B

(*Globales Erwärmungspotential*, *GWP*)[20]. Contrary to Archiphysik, this value is stated in kg CO_2/m^3 and depending on the chosen material, the *GWP* is divided into different parts, of which the **GWP** during **fabrication, transport and construction** on site was taken into consideration. These are added up to obtain the **sum GWP**. The value of Archiphysik was converted from kg CO_2/kg to kg CO_2/m^3, to obtain a value which is easier to compare, by knowing the volume and density and therefore the weight of the listed materials. In addition one pair of parameters in the case of Archiphysik/Baubook (**A1**+**B1**) and two pairs of parameters in the case of Ökobaudat (**A2**,**A3**+**B2**,**B3**) were used, to present an overview of different types (density) of each material and the resulting outcome.[21,22]

Result To obtain the sum CO_2 (kg CO_2), the volume (m^3) of each material needs to be multiplied by its *GWP* (kg CO_2/m^3). As one may observe, the sum CO_2 in concept **B** (figure X) in any of the three options, in which adobe is used instead of burned bricks (B1-B3), is lower than the sum CO_2 of concept **A** (figure X, A1-A3). The greatest difference of the sum CO_2, illustrates case A3+B3. In comparison, option B3 outlines a result of **29571.94** kg CO2, which is 51% lower than option A3 displaying **58483.35** kg CO_2. Even the smallest difference of options A2 and B2 adds up to 7%, the lower value presented by option B2. Accordingly the use of adobe instead of burned bricks in any illustrated case is resulting in a lower global warming potential (kg CO_2). Another striking factor is the density of the chosen building materials. In the case of option A2, a burned brick with a density of 575 kg/m^3 and a sum CO_2 of 10256.55 kg CO_2 is taken into consideration. Related to option A3 (burned brick with a density of 2000 kg/m^3 and a sum of 37994.78 kg CO_2), a discrepancy of 73% is demonstrated.
Therefore, besides the observation of differences between the usage of adobe and burned bricks, it also does matter significantly, which type of burned brick regarding its density, is used to erect a building. It probably already results in a comparably low GWP value, if low density bricks are chosen. On the other hand, a test to detect this density might be difficult considering local building materials on site in rural parts of Rwanda. A more successful way of reaching a lower *GWP* value, will thus be to use adobe instead of burned bricks, if available.

20 see 18
21 see 15
22 see 19

figure 134 - physical model at *IPK*

figure 135 - hosts in Kirinda

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A great "thank you" to Ingenieure ohne Grenzen (*IOG*) for enabling me to work on the project of *Rara Heza*. Especially to Sarah Beyer, who initially linked me to the project and Harald Tafatsch as well as the project team, for the intense and fruitful discussions and the feedback.

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Lastly, I would like to thank my family and friends, especially Andrea, for being patient regarding my study projects and to calm me down during busy periods, while keeping me good company along the way.

GLOSSARY & ABBREVIATIONS

Clubs	Voluntary group meetings besides regular classes at *IPK* to improve certain skills. E.g. an english *club* to improve the english language skills of the students.
GWP	Global warming potential - in this Thesis described by the amount of CO_2 emissions
IOG	Ingenieure ohne Grenzen - Engineers without borders
IPK	Institute Presbytérien de Kirinda
JMFA	Junge Menschen für Afrika e.V. - Young People for Africa
KUWI-program	Kurzfristige Wissenschaftliche Arbeiten im Ausland - scholarship for field trips at short notice at Vienna Technical University
Rara Heza	An expression in Kinyarwandan language which translates into “sleep in good conditions” and represents the name of the project
Self learning	Time period of the daily routine in which the students of *IPK* can prepare themselves for the classes, do homework or study for upcoming exams.

cm	centimetre
CO_2	carbon dioxide
h/year	hours per year
km	kilometre
km^2	square kilometre
km/h	kilometre per hour
L	litre
m	metre
m^3	cubic metre
mm	milimetre
MASL	metres above (mean) sea level
T.O.	top of

FIGURES

All photographs, drawings and illustrations not listed, are made by the author.

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Interviewed people/personal communication

Billy Musayioizi, Josue Gitangaza, Paccy Nsekerukunze & Peace Buranga (20/2/19)	students at *IPK*
Carly (27/2/2019)	Young architect based in Kigali which manages a great variety of projects throughout Rwanda
Charles Gahutu (18-24/2/2019)	Headmaster of *IPK*
Francine Musabeyezu (17-25/2/2019)	Based in Kirinda, Francine is managing all matters of agriculture at *IPK* and works for *JMFA* as a local mediator
Franz Eichinger and Janvier Bunani (15/2/2019)	Deputy Director Employee at the Coordination Office Kigali, Partnership Rhineland-Palatinate/Rwanda
Ildephonse Mbarushiman (19+21/2/19)	Construction class teacher at *IPK* and Rwandan architect
Kathrina Rieger (8/2/2019)	Professional in the field of user participation during planning and construction of buildings
Manlio Michieletto (15/2/19)	Dean of the School of Architecture & Built Environment at the College of Science and Technology in Kigali
Obed Niyitegeka (17/2/19)	Level 5 accounting teacher at *IPK*
Pastor Prince Karangwa (21/2/19)	President of Kirinda Presbytery
Theoneste Twagira (24/2/19)	Construction engineer based in Rwanda and former student at *IPK*

As well as other people including students and teachers at IPK, the hosts in Kirinda, the headmaster of another secondary school in Kirinda and employees of the Coordination Office Kigali (Partnership Rhineland-Palatinate/Rwanda)

ANNEX

Qualitative interviews

The following pages illustrate a summary of interviews taken during the authors field trip in Rwanda. The presented questions and answers are derived from notes, which were taken during several different interviews and therefore show a destilled version of the interviews, to serve the reader with an illustrative overview.

General facts

- Which is your favorite room/place on the campus for you and why? And which room/place do you dislike most and why?

In general the toilet buildings are considered as unclean as there are mostly composting WC's which emit smell. Therefore they are usually separate buildings and there is no sheltered access from the main buildings. Favorite places instead are benches on the whole campus, preferably shaded by sun and rain. Most of the these places experience natural cooling through the wind and therefore are more likely to be used during midday. In addition, some benches offer views across the valley of the Nyabarongo river and serve as meeting places to communicate. Similarly the shaded space underneath some trees is used. In general, in the rainy season, students at *IPK* tend to spend more time in their dormitories than in the dry season. Likewise the teaching hours are extended occasionally in rainy season and the students have the opportunity to use the classrooms.

- Where do people spend time outside? Are there any private, semi-private or public outdoor facilities?

There are some places closes to the campus of *IPK* which provide additional space for the students including a soccer field and basketball field.

- How many weekends do you spend your time on the campus/school?

Students usually spend a whole term of teaching at *IPK* which is around three months.

Wants and desires

- What kind of furniture do you use?

There is one bed and one cupboard for each female student. The male students do just have on bed each but no cupboard and therefore use their own bags during their stay at *IPK*. Besides there are chairs und tables in each classroom.

- Is there any planned usage for the future dormitories besides accomodating the students?

When the students are on holidays there is the possibility of accomodating people in the unused dormitories. This would be the case for guests of people living in Kirinda for example during festivities.

Social Spaces

- What do you define as strictly private?

Strictly private in a European way meaning a person being on its own without anybody around just holds for the bathrooms at *IPK*. Female and male students are separated by different dormitory as well as toilet buildings. Everything else may be shared throughout both groups. The administration building and the meeting hall are the only buildings ususally entered by people not being part of *IPK*.

- Are traditional gender divisions executed in the house in the same or different way as in the village/in public areas?

Bathrooms in public areas are similarly divided into female and male as they are at *IPK*. The amount of rooms in private houses in Kirinda seems to be more likely based on financial reasons than of the desired separation between male and female family members.

- Does the house stay cool during the dry season? Do you use the wind to cool down the house?

Classrooms heat up in the course of a day and therefore are less comfortable to use during dry season. The wind is used to a little degree through ventilation openings. However, the dormitories are used mainly during the night and according to the lower night temperatures they stay cool even in dry season.

- How far away from the campus do you live?

Some teachers are residing in Kirinda including Charles Gahutu, the headmaster of *IPK*. There are other teachers which are temporarily staying in Kirinda although their families are living in Kigali or other parts of Rwanda. Therefore they need to travel several weekends of each teaching term to see their relatives.

- From how far away do the students come to school? Where do they live apart from school?

Similar to the teachers, there are both, students residing with their families in Kirinda and students which have their home in other parts of Rwanda and are staying in the dormitories at IPK or with guest families in Kirinda.

- How many students are there usually in one classroom?

There are generally between 20-30 students using one classroom.

Construction

- When was the school/campus built - since when is it existing? Which materials have been used so far?

IPK was established in 1981, the first building being the matron building. Materials which are commonly used are concrete for the foundation, burned bricks for the walls, steel or wooden beams and metal sheets or burned tiles for the roof, steel or wood framed windows and doors, wooden chairs and tables and preferably beds and cupboards from steel frames instead of wood since they are longer lasting.

- Where did the building materials come from?

Since there is a clay pit and stove in Kirinda, burned bricks for the walls as well as burned tiles for the roof may be produced there. Likewise a small amount of timber is available and cement/stones to obtain concrete. Many other building materials need to be transported from Kigali, Rwanda or even imported from other countries including wooden beams, great amounts of concrete/cement, steel beams and metal sheets.

- Which building materials would you prefer for a future building?

Traditional building materials alike adobe and wood are considered as weak and not suitable for the erection of permanent buildings. This is presumably originated in the construction techniques of the higher developed countries, which seem to build mainly with concrete, steel and glass. Thus the idea of the usage of these materials works as a role model for less developed countries including Rwanda. Likewise buildings erected with materials considered as permanent may implement a certain wealth and important position of the owner in the society. Similarly living in a house consisting of traditional building materials may signify the opposite, a low income and status in the society.

- Who is doing the construction work?

Most of the buildings on the campus of *IPK* were errected with the knowledge of local technicians.

- Which measurements are taken to keep up the house? Who is responsible for the maintenance of the house?

Uzziel, a local technician based in Kigali, is in charge of the buildings at *IPK*. He is doing regular maintenance work and gives advice to assure that any damages are detected and repaired.

- Is there any water supply?

IPK is connected to the public water supply of Kirinda and therefore it is possible to set up water flushing WC's in some existing buildings on the campus. However the errection of a water tank and according gutters to collect the rainwater of a future dormitory building is preferred.

General questions regarding the school/campus

- How is the school organized? Who is in charge for the education?

IPK is classified as a higher secondary school in the Rwandan educational system teaching 319 students (2019) in three levels (L1-L3) in the following three disciplines:

1. Accountancy Department: since 1981, 130 students
2. Computer Science Department: since 2014, 119 students
3. Construction Department: since 2017, 70 students

Charles Gahutu is the headmaster of *IPK* since the year 2000. There are nine teachers (three for each department) and one matron. Moreover a pastor from the presbyterian church functions as a coordinator to ensure the communication between the school and the church.

- What are your thoughts about the future development of the school/campus?

As there are several private schools closing throughout Rwanda, the number of students at *IPK* will increase. Hence there is a need of space to accommodate future students. Additionally the accomodation of the male students should be transferred to another place since the current boys dormitory building was a meeting and event space before and people at IPK would like to use it in its original way.

- Any tabus, where you cannot build (future buildings)?

The presbyterian church of Kirinda owns a great amount of land around the campus of *IPK*. Therefore the most limiting circumstance for future buildings is the slope and it is crucial to plan accordingly. Likewise any building may be erected on the fields bordering the campus.

- Are there any possessions of the students and/or teachers which have to be considered?

Beds and lockers need to be provided for the students of the future dormitories to be able to store their valuables.

- Are there any neighbouring buildings of importance?

The presbyterian church is located a bit further up on the same hill as *IPK*. It was erected in the early 20th century as the first building of the presbyterian church in Kirinda. In addition there is a Kindergarden and a primary school, both in close distance to *IPK*.