Design of transitional beehives for low income Ethiopian households by co-creation

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UNIVERSITEIT GENT

DESIGN OF TRANSITIONAL BEEHIVES FOR LOW-INCOME ETHIOPIAN HOUSEHOLDS BY CO-CREATION

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ADIS

ABSTRACT

‘Adis’ is een tool om bijenkasten te maken, op maat van de Ethiopische small-scale imkers. In deze masterproef werd vertrokken vanuit de onderzoeksvraag: “ het ontwerpen van een transitionele bijenkast voor Ethiopische huishoudens met een laag inkomen, door middel van co-creatie”.

Project

Deze thesis kadert in het BEETH-project waarbij doormiddel van imkersmaterieel en cursussen een weg uit de armoede geboden wordt aan Ethiopische boeren. Door het houden van slechts 1 bijenkolonie kan het jaarlijks inkomen van een kleinschalige landbouwer met de helft vermeerderd worden. Bijkomende voordelen van het bijenhouden zijn de lage instap kost en de weinige tijd die erin moet geïnvesteerd worden.
De rol van deze thesis in dit project is het ontwerpen van een bijenkast van het transitionele type, die goedkoop en maatvast is en bij voorkeur in Ethiopië geproduceerd kan worden.

Focus

De grote uitdaging in dit project was ontwerpen met en voor personen die in een compleet andere cultuur en context leven. Er werd dan ook veel tijd besteed aan het in kaart brengen van zowel de directe context (het dagelijkse leven van een imker uit een huishouden met een laag inkomen), de bredere context (de waardeketen van Ethiopische honing, het systeem van ‘farmers extension’, mogelijke samenwerkingen tussen universiteiten en boeren) als de algemene context (algemene cultuur, beschikbare materialen, algemeen gebruikte productie technieken,…)

Vanuit deze context analyse werden de remmingen voor het gebruik en productie van de transitionele bijenkasten bepaald. Daarna werden deze constraints omgebogen tot kansen om tot een eindproduct te komen waarmee boeren zelf transitionele bijenkasten kunnen maken.

ADIS

ABSTRACT

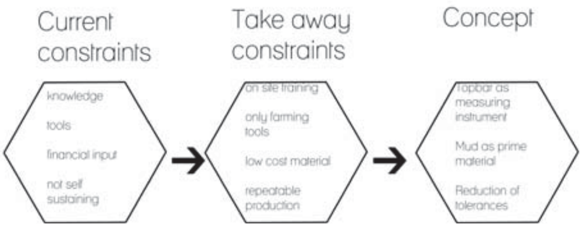
Achtergrond

Een transitionele bijenkast bestaat uit een kast op zich, in de vorm van een trapezoide, met daarop 'top bars'. Deze top bars zijn latjes waaraan het bijenvolk haar honingraten maakt. Deze kasten worden vooral in ontwikkelingslanden gebruikt en worden uit hout vervaardigd. In Ethiopië zijn deze transitionele bijenkasten nog niet ingeburgerd: 95% procent van de 1 miljoen imkers die het land rijk is gebruiken nog steeds traditionele imkerij methodes. Deze methodes houden in dat korven in een boom gehangen worden en wanneer de tijd rijp is, wordt de honing geoogst door de kolonie te verjagen. Dit is een gevaarlijke methode waarbij telkens het bijenvolk verjaagd wordt. Deze methode gaat gepaard met een lage opbrengst.

De overstap naar moderne imkerij verloopt moeizaam. Moderne kasten, zoals ze in België gebruikt worden, zijn te duur en vragen een bijhorende opleiding. De transitionele kasten zijn heel wat goedkoper maar de imkers hebben niet de tools en kennis om ze zelf te bouwen.

ADIS

ABSTRACT



Concept

Het eindproduct, Adis, is een toolkit voor Ethiopische boeren waarmee ze zelf, met lokale materialen en tools, transitionele bijenkorven kunnen maken voor minder dan 3 euro per stuk. De kit bestaat uit 3 delen: een mal om de 'top bars' op maat te maken, een mal om de hoeken van 90 en 120° nauwkeurig te kunnen meten en een handleiding. Het resultaat is een bijenkast vervaardigd uit bamboe en een moddermengsel.

Bij een transitionele bijenkast zijn 2 maten van cruciaal belang. De top bars moeten exact 3.2 cm breed zijn, zodat de bijen aan elke topbar één raat bouwen. Als deze maat niet klopt, maakt het bijen volk de honingraten aan elkaar vast. Wanneer de imker de kast opendoet en er raten uithaalt ter inspectie, lukt dit maar moeizaam en worden de bijen agressief. Ook de hoek van 120° onderaan is belangrijk: als deze hoek teveel varieert, hangen de bijen hun raten vast aan de zijwanden van de kast.

De top bars die gemaakt worden met de Adis kit, bestaan uit bamboe (dat nu al gebruikt wordt om topbars te vervaardigen) en een modder mengsel. Een bamboe stok wordt in de mal gelegd en de mal wordt verder gevuld met modder. Onderaan blijft de bamboe vrij, hieraan bevestigen de bijen hun raat. Bovenaan zorgt de balk modder dat de top bars altijd exact even ver van elkaar liggen. In de mal zijn twee makeringen aangebracht, zodat de top bar ook als meetinstrument om de kast te maken dient. De mal bestaat uit gelasercut 6 mm multiplex. Deze wordt in België vervaardigd en wordt in flat package naar Ethiopië gebracht.

De hoekmal is eveneens gelasercut uit 6 mm multiplex. Hiermee kan de eindgebruiker zowel de hoeken van 120° als 90° controleren. In de mal zijn groeven voorzien zodat de mal met touw aan de bamboe stokken kan bevestigd worden tijdens het sjorren van het frame.

De handleiding werd gemaakt met veel aandacht voor de Ethiopische visuele cultuur zodat de eindgebruiker zich kan identificeren met de handelingen in de handleiding. Die visuele taal kenmerkt zich vooral door beperkt perspectief en een specifieke manier om Ethiopische gezichten weer te geven.

ADIS

ABSTRACT

Onderzoek

1. Cultuur

Mijn stage van 6 weken in centraal en noord-Ethiopië heeft gezorgd voor inzicht in de Ethiopische cultuur, zowel op vlak van bijenhouden als algemene cultuur. In het eindresultaat uit zich dit onder andere doordat de kast volledig door een vrouw kan gemaakt worden, omdat sommige vrouwen nu de traditionele manden voor hun man maken. Verder wordt er geen gebruik gemaakt van klassieke meetmethodes omdat de boeren dit niet tot hun beschikking hebben. Verder wordt met een mallensysteem gewerkt waarbij de mal op zich enkel waardevol wordt als ze gebruikt wordt voor het maken van bijenkasten. Wanneer met een grote mal zou gewerkt worden zou die op zichzelf al veel waard zijn en zou verkopen voor een boer op korte termijn voordeliger kunnen zijn.

In Ethiopië werden interviews afgenomen met zowel imkers als onderzoekers in de bijenteelt, geprototyped met een eerste vorm van mal en bezoeken gebracht aan verschillende imkers.

2. Materialen

De Adis bijenkast wordt volledig opgebouwd uit lokale materialen en met lokale technieken. De bamboe wordt momenteel ook gebruikt om bijenkasten te maken. De huizen in Ethiopïe worden gepleisterd met een modder mengsel dat ook voor deze kast gebruikt kan worden. Voordat de kast gepleisterd wordt, worden gedroogde bladeren tussen de bamboe stokken geweven om een betere hechting van de modder te bekomen. De huidige traditionele kasten worden ook gemaakt uit geweven bladeren.

3. Meten

De grootste remmer om nieuwe bijenkasten te maken is dat de boeren niet beschikken over meetmateriaal om de kasten binnen toleranties te bouwen. Een eerste denkpiste was om met geïndustrialiseerde wegwerp materialen zoals kroonkurken,… meetmateriaal te maken, maar dit bleek moeilijk omdat er zeer weinig geïndustrialiseerde materialen aanwezig zijn. Nu zijn 2 markeringen aangebracht in de mal, met deze 2 markeringen kunnen alle maten van de kast bepaald worden.

4. Weerbestendigheid

Omdat het leemmengsel op zich niet watervast is, moest er gezocht worden naar een low-tech waterproofing systeem. De Opuntia cactus die veel voorkomt in Ethiopië kan gebruikt worden om een waterproof mortel mee te maken. Er werd onderzocht welke manier om de het cactus sap te verwerken de meest geschikte is in dit project.

5. Stakeholders en co-creatie

Een belangrijk aspect in het onderzoek was na te gaan hoe je een product kan co-creeëren met stakeholders die zich meer dan 8000 km van de ontwerper bevinden, die in een andere cultuur leven en beide een andere taal spreken. Het belangrijste hier was een duidelijke visuele communicatie en testen waarbij de uitkomst nuttig was zowel voor de ontwerper als de eindgebruiker.

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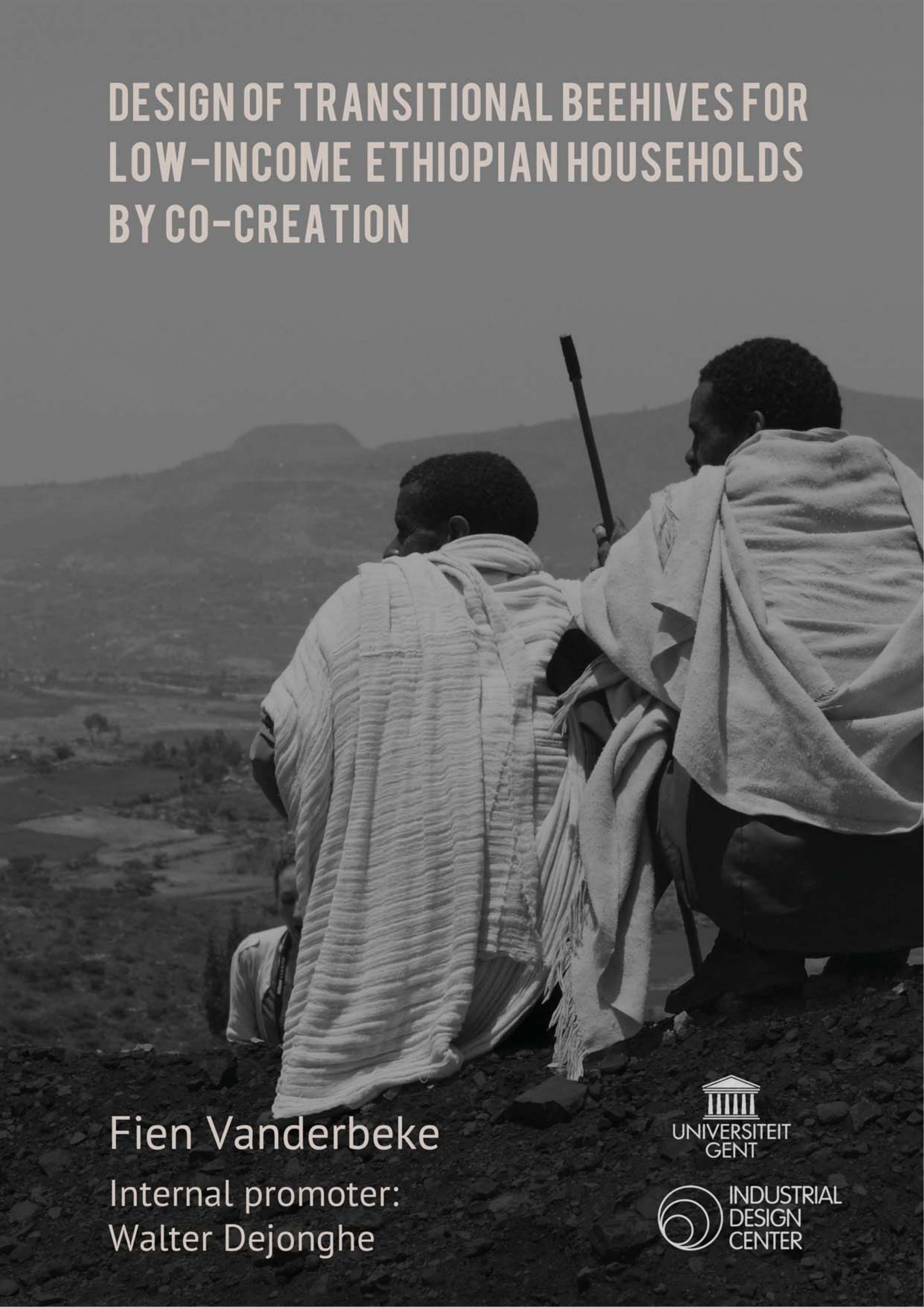

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NO MORE BEES,

NO MORE POLLINATION,

NO MORE PLANTS,

NO MORE ANIMALS,

NO MORE MAN.

-Albert Einstein

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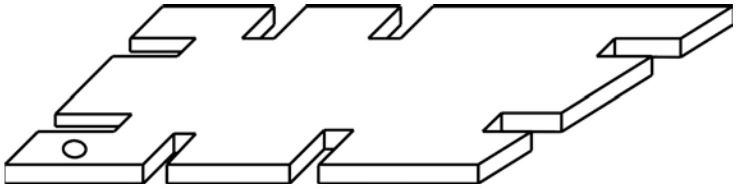
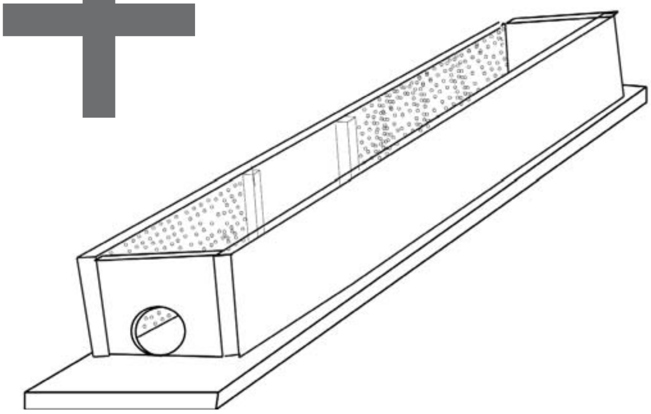
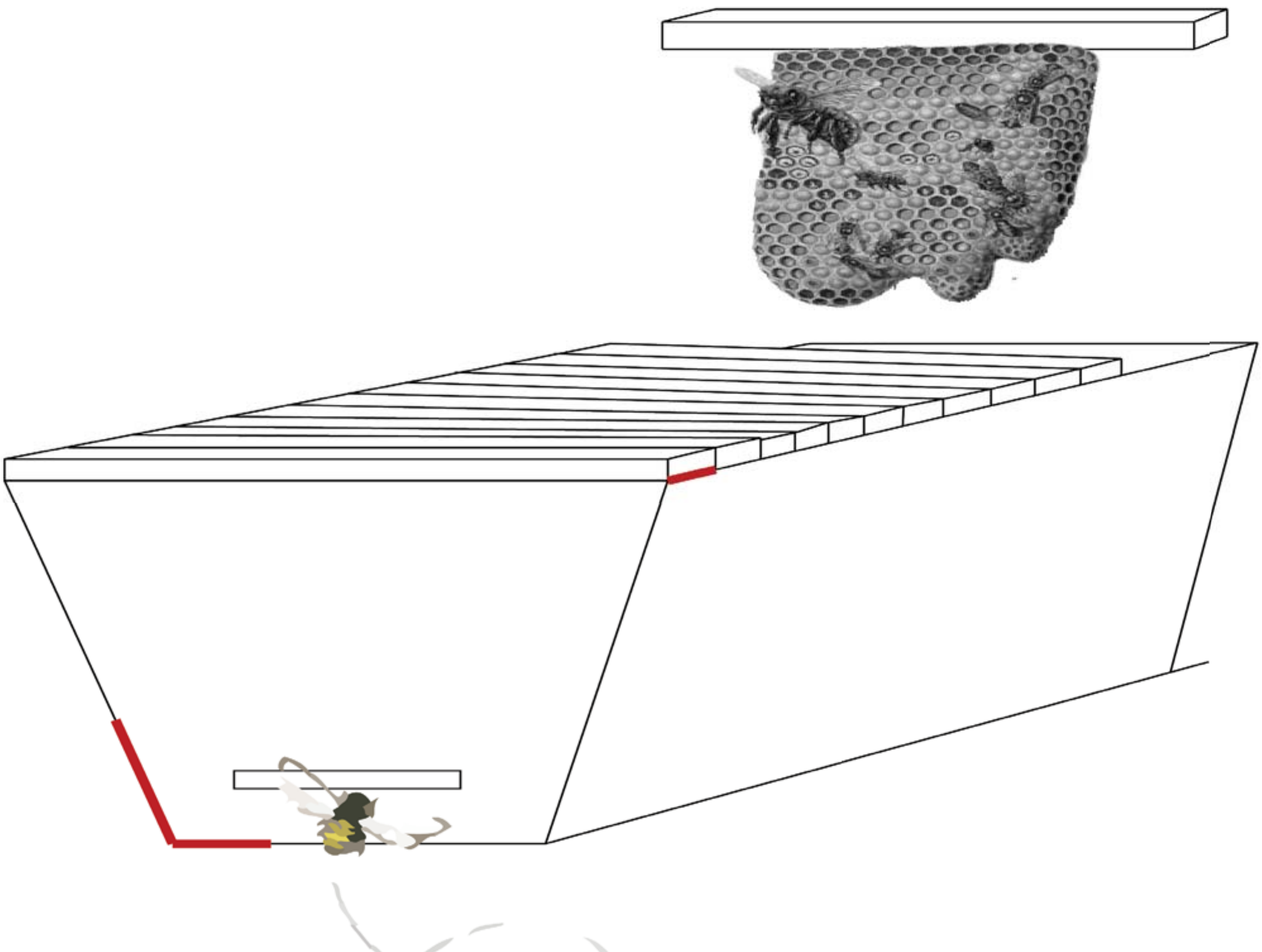
ADIS







This master thesis in industrial design describes the development and design of a beehive specifically for Ethiopian small scale farmers. This thesis is part of the Beeth programme (beekeeping Ethiopia), founded by professor Frans Jacobs from the University of Ghent.

The research question of this project was to design a transitional beehive that fits within the specific Ethiopian context and that is dimensionally stable.

The end result of this project is a kit that will be distributed to small scale farmers in rural villages during beekeeping training. This kit enables the Ethiopian farmers to manufacture their own hives without investments.

The kit consists of one mould, a calibre to control the angles during the production of the hive and a manual.
With the mould, farmers can make ‘top bars’: laths that lay on top of the hive on which the bees attach their combs. These top bars will at the same time serve as a measuring tool to construct the frame of the hive.

The key of this design is the context: all techniques and approaches that are used during the process emanate from the end-user: an Ethiopian small scale farmer.

CONTENT

WORD OF THANKS

This thesis has been an interesting and fascinating journey for me. The internship gave me the opportunity to go out of my comfort zone and to discover a whole new culture. The first step towards my thesis was set more than a year ago, when Oliver Dewolf helped me to pick a subject and helped my to arrange everything for my internship. I would like to thank him for this.
In Ethiopia I was welcomed warmely by Zewdu, Elsa, Mohammed and the other people at Holetta agriculural research centre, Mekelle University and Tigray Agricultural research centre. They helped me in any way possible: not only with research but with genaral advise, nice company,... They advised me and stayed enthousiastic troughout the year this project lasted.

I would like to say thank you to professor Frans Jacobs for the support and advice before, during and after my internship. Without him and the financial support of the Rotary of Wetteren, all of this would not have been possible.

After returning to Belgium, when the 'real design work' began, I could count on the support and guidance of my promoter Walter Dejonghe. He empathized with the difficulties of working in and for a different culture but remained critical about the choices I made. This thesis is different from most final project in industrial engineering as it is not about the development of an industrially made product for Western consumers. Walter understood en supported my choice to do the opposite: make a product that is simplified and low-tech as much as possible.

Last but not least I would like to thank my family and friends to keep on supporting me and to keep on listening to the endless repetition of stories starting with: "In Ethiopia,..."

For advice and guidance during my project I would like to say thank you to: Jan Detavernier, Hilde Geerling and the bothanical garden of Ghent University.

INTRODUCTION

The project

This thesis is part of the 'Beeth project' which stands for Beekeeping Ethiopia. This project focuses on beekeeping as a way to get out of poverty for small scale farmers in Ethiopia and was originated by professor Frans Jacobs from the university of Ghent and is supported by the Rotary of Wetteren.

The project operates on different levels: capacity building in educational and research institutes by organizing a four month beekeeping course in Belgium. The scientific research of the partners of the project is financially supported in the spirit of "sharing minds, changing lives". The alumni of this course are supported and encouraged by the project to organize farmers-trainings and spread their knowledge. This knowledge is passed on to students at universities and to local farmers. For these farmers, beekeeping can be a way out of lasting poverty.

The values

Core values of the project are: keeping it local. This means providing skills and materials to local farmers in order to support and extend their local production rather than contributing to the industrialization of beekeeping.
By doing so, beekeeping can contribute to a better livelihood for the poorest of the poor. Sharing knowledge in a sustainable system is another important aspect of the project. If a farmer can make and manage his own apiary by learning from fellow farmers and in his turn sharing his knowledge with his colleagues, this project can become a self-spreading, sustainable system.

The origin

The design question for this thesis was to develop a standardized hive suited for the specific context of small scale farmers in Ethiopia. This challenge was first proposed by professor Jacobs to the Howest industrial design centre and the research project 'design for impact' in particular. In 2012 students of the third bachelor industrial design engineering worked on this project for a semester. But it became clear that without knowledge of the Ethiopian context and culture, it is very hard to design for the local stakeholders. In preparation of this thesis I spent six weeks in Ethiopia in order to get familiar with the Ethiopian culture in general and the local beekeeping practice in particular. Six weeks was enough to give me a brief impression of both aspects but I am well aware that what I experienced in Ethiopia is only a quick glance of a very rich culture.

Internship

As mentioned, I stayed 6 weeks in Ethiopia during August-September 2013. Before I left for Ethiopia, I took a one week beekeeping course in Ghent.
The first two weeks I stayed in Holetta, a small village located 30 km from the capital Addis Ababa. In Holetta I was introduced to the Ethiopian way of beekeeping by Zewdu and the other employees of the Bee Research centre. I got to know both the technical and cultural aspect of beekeeping in Ethiopia and how new techniques and knowledge are introduced to farmers by extension workers. Together with the people from the research centre I made some early prototypes of a beehive.
After two weeks, I moved to Mekkelle, a big city in the Tygrai region in the North of Ethiopia. In Mekkelle I worked together with Mohammed from Mekkelle University. We did some prototyping and discovered that was still a long road ahead to end up with a suitable hive.
In the month I stayed in Mekkelle, I was invited on a field trip to Meychew, a village in the highlands. The beekeeper in Meychew learned me a lot about their experiences with beekeeping and the culture of beekeeping.

End product

The end product of this research is not a hive as such, but 'Adis', a tool for the farmers to build hives themselves.
This makes the farmers independent of research initiatives or NGO's. With one kit received at a training, a farmer can make an infinite number of hives and spread his knowledge to fellow farmers. The kit consists of a manual, a mould to build top bars and a mould to control if the angles of the frame of the hive are right.

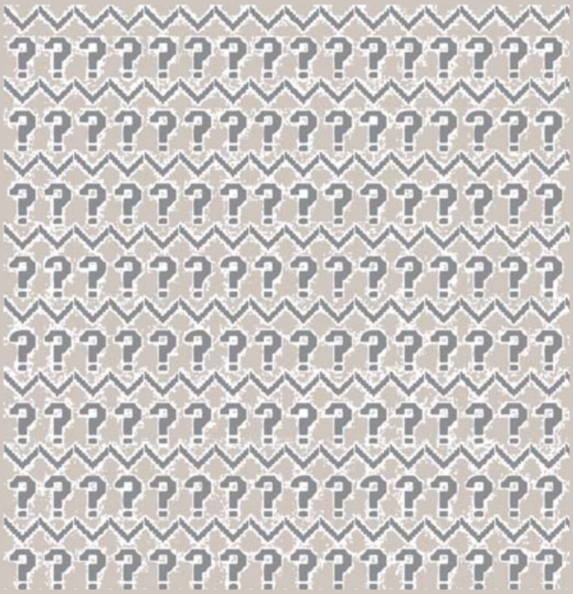
REASEARCH QUESTION

Involvement

Co-creation

Far-away stakeholders

Case study



bridging cultural differences

Visual communication

Adapting co-creation techniques

RESEARCH QUESTION

The aim of the research of my thesis is twofold: on the one hand there is the development of a beehive suited for the needs and demands of the local Ethiopian context. This serves as a case study for the development of a framework on how to develop products/services together with local, faraway stakeholders without physically being present in the context. In other words: how can a designer co-design a product with distant end-users.

Case study

The designed beehive has to overcome the current problems. Traditional hives have a low yield, while a modern hive has a yield up to 3 times of the yield of a traditional hive. But these hives have only recently been introduced to some model farmers. Most farmers do not know how to manufacture a modern hive unless they have been to an agriculture extension training.

Consequently the hive should be stand-alone, meaning that a farmer can teach it to another farmers after little or no training, with his own knowledge, skills, materials and tools.

The hives that are now manufactured in Ethiopia score low on preciseness. As will be elaborated later on, some of the hive's measurements have to be respected in order to guarantee easy bee management and comfort for the bee colony . At the moment, the locally manufactured hives do not respect these dimensions. The new hive should be constructed in a way that the tolerances are respected inherently. Every hive should have the same dimensions to guarantee interchangeability between hives. This makes it possible for the beekeeper to use the same material for all of his hives and thus reduces the cost of beekeeping. This also makes it possible to transfer a colony to another hive.

Another constraints in Ethiopia's apiculture is the cost of the raw materials to produce beehives. Ethiopia suffers from severe deforestation, wood is becoming a scarce good. The price for the raw materials of a beehives makes up for 75% [1] of the total price of a hive. So by avoiding the use of wood and looking for an material that is easy and cheap to obtain and process, the price of a beehive could be much less.

Donating beehives has proven not to be good solution in the past. The Ethiopian government gave away a lot [1] of modern beehives but most of them ended up as cupboard because the farmers didn't have proper training on how to use them. So this hive has to be made by farmers themselves, with their own skills and tools.

So the aim of the case study is to design a hive that going to be used by Ethiopian farmers in the long-term, in distant cooperation with them.

RESEARCH QUESTION

Framework

The big challenge in this project was that, as I had to attend school in Belgium, the hive had to be developed in Belgium and Ethiopia simultaneously in order to come to a good result.
The stakeholders (my contact persons and the end users) had to be involved in every stage of the process. Not only as test-persons but also in generating ideas, giving advice, ...
To make this work, the local context should be understood as thoroughly as possible and different ways to set up communication, to get feedback, to generate ideas over a big distance should be tested and evaluated.

First it should be mentioned that the ideal case is to work in the context you are designing for, as much as possible. But getting out of the context might be inspirational and confronting about the restraints of the project. In any case is prospecting the context and having good contact persons.

I would like to stress the importance of cultural aspects, even if they don't influence the design in a direct way.
A short example: [2]

These two wells are right next to each other. Strangely enough, only the hand dug well is in use nowadays. The reason for this is an complex land ownership system in Ethiopia. The person who digs the well is the owner of the water and can allow or deny access to the water [3]. The water pump donated by the government does not take this system into account and therefor the pump is abandoned.
So testing about acceptance and knowing about underlying reasons for acceptance or rejection is essential.

Another example in the same sector is the 'Playpump' [4], originally designed to make it fun for children to pump water. In reality however, the women provide water, not the children. The pump requires a lot of children playing voluntarily at the merry-go-round. But when playing becomes nescessary to pump up water, the line between play and hard work fades.

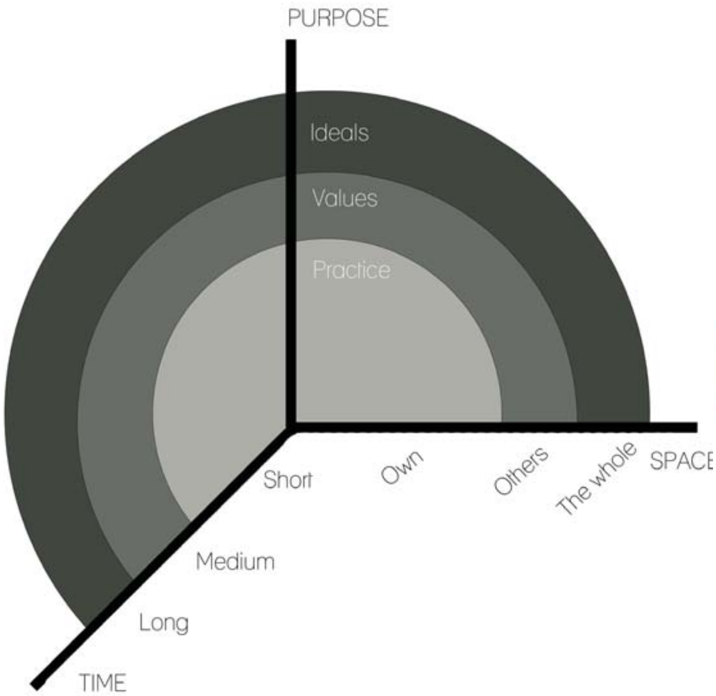
This thesis tries to give guidelines and tips on how to set up a project in an unknown cultural context and how to engage faraway stakeholders in the design process.

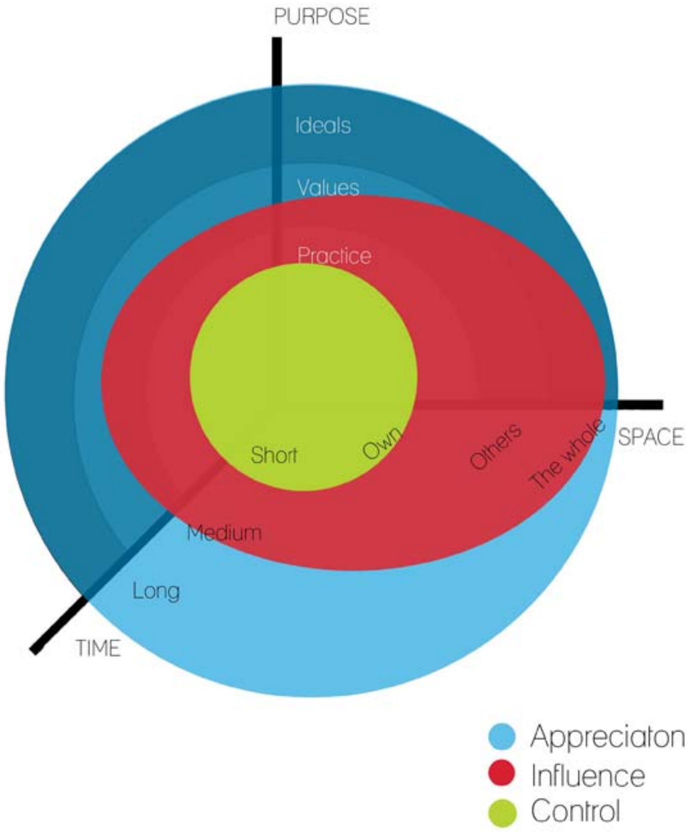
RESEARCH QUESTION

If we look at this project in the light of power and control as defined by William Smith [5], we can specify the range of control and influence.

Smith defines the total amount of power as the combination of 3 aspects: purpose, space and time. The highest level of power is reached when a project serves high ideals (purpose), serves a lot of people (space) for a long time.
In this project, the lives of many people can be influenced (1 million beekeepers in Ethiopia) and when the hive becomes a self-sustaining system, it can influence peoples live over a long time;

There are also 3 power relationships defined as control, influence and appreciation.
Control is when an actor has direct power over an outcome. In this project the control is very limited, I only have control over the tests that I do myself in Belgium.
Influence is when an actor co-produces an outcome by persuading other stakeholders. For this project the influence is (and has to be) rather extensive and defines the relationship between me and the intermediaries.
The third power relationship is appreciation, meaning that the actor understands the effects on which he has no power or influence. In this case, appreciation is the power relationship between me and the end-user: I cannot communicate directly with them but I can try to understand the outcome of tests.





PROJECT FLOW

Internship:
experimenting with a first version of a mould
interviewing beekeepers
participating in beekeeping activities

Stage 1:
identifying the constraints and opportunities in this project
experimenting with ways to define the dimensions of the hive without measuring with a ruler
experimenting with loam as a building material

Stage 2:
elaborate the idea to measure with top bars
experimenting with visual communication towards distant stakeholders

Stage 3:
test the idea to measure with top bars
test visual communication towards distant stakeholders
testing the insulation values of different hives

Stage 4:
finalise the top bar moulds
building actual hive
making manual to produce the hive

CONTEXT

Limited mobility

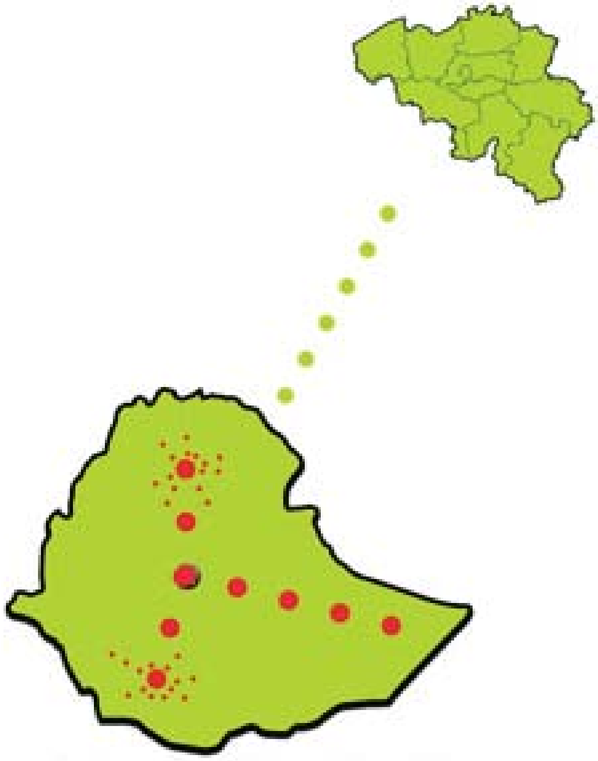
Small scale beekeepers

Indigenous knowledge

Local materials

Technical support

Ethiopia in general



Ethiopia is a country located in the horn of Africa. With over 82 million inhabitants, it has the second largest population of Africa.
Ethiopia is the only African country that was never overruled by a Western country during the colonization period. Consequently, Ethiopia has a variety of unique languages and ethnic groups, a unique religion (the Ethiopian Orthodox Church) and unique food that can only be found in Ethiopia.

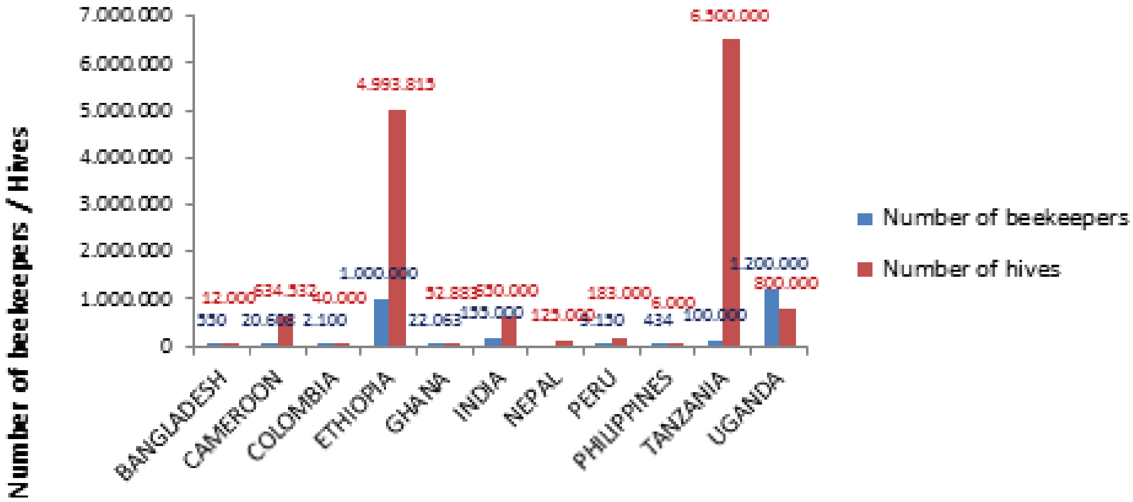
For many Europeans, the name Ethiopia is still associated with the country of the great famine in 1983-1985. They remember starving children, food droppings and Live Aid [6]. But Ethiopia is so much more. If you visit Ethiopia now, you find a country with an overwhelming nature, history and culture. Korem, the place where the documentary about the great famine was shot, is now (to Ethiopian standards) a prosperous community.

Nevertheless, today Ethiopia is still one of the poorest nations in the world. The Ethiopian population is growing very fast, faster than the agricultural gross domestic product of the county. So the living standards in rural areas are decreasing. In the Human Development Index [7] from the United Nations, Ethiopia is listed as the 173th country out of 208 countries. This ranking takes education, income, live expectancy,... into account
The average income in Ethiopia is about 20 euros (or 500 birr) a month, this makes that the average Ethiopian makes less that 1 euro a day to live off [8]. The country has the ambitious plan to become independent of external food-aid in 2015.

State of beekeeping in Ethiopia

Ethiopia has a long tradition of beekeeping. In ancient Egyptian hieroglyphs, references are made to Abyssinia (the old name for Ethiopia) as a source of honey and beeswax.[9]

This tradition remains intertwined with the Ethiopian culture until now. Ethiopia is the second largest honey producer of Africa, after Tanzania. Globally, Ethiopia is the tenth largest honey producer [10]. About one million Ethiopians are beekeepers. Most of them (94%) still uses traditional beehives.[1] Every year Ethiopia produces about 50.000 tons of honey, from which 98% is used for the Ethiopian market [1].
This annual production is only at a mere 10% of the full production potential [1].



Most of the beekeepers in Ethiopia are backyard beekeepers. This term has several connotations: first of all, the literal meaning: the hives are placed next to the house. Second connotation is the small scale of the beekeeping. There is almost no commercialization of beekeeping activities on a large scale (hence the low export quantities).
Most beekeepers sell their honey on the local market or to tej-brewers. Tej is a strong alcoholic beverage, a sort of mead. 80% of the Ethiopian honey is used for tej production. [1]

Comparison of beekeeping practice in Belgium and Ethiopia

In Belgium there are almost no professional beekeepers, beekeeping is mainly an enjoyable leisure activity. In Ethiopia it is a necessary complement to the farming income. Most beekeepers practice beekeeping as a side-activity to crop cultivation and cattle herding.
In tropical regions hives can only be opened at night because the bees are too aggressive during the daytime. Even at dusk or dawn a beekeeper has to be careful. Moreover, most beekeepers don't have access to smokers to tranquillize their bees and don't own proper protective clothes. The farmers use their charcoal stove both for cooking and to make the smoke to tranquillize the bees. The Belgian beeraces are very calm, only a minimum of protective clothing is needed.
In Belgium there is a regulation that an apiary site has to be at least 20 meters from the neighbours back door [10] while in Ethiopia, most apiary sites are next to the house of the beekeeper.
The used hive types are also different.
Another remarkable aspect of Ethiopian beekeeping is the marketing of honey. Although three different colours are different and the white honey is generally considered as the best, no marketing efforts are done. In Belgium, honey is nicely packed and often marketed as a healthy product of nature. In Ethiopia honey is stored in large barrels and the customers have to bring their own packaging to the store.




CONTEXT



Importance of beekeeping

Beekeeping is an excellent 'poverty alleviator'. A farmer can with a 'small' investment start beekeeping and by this create an additional income. To start with beekeeping a farmer needs to invest in at least one beehive and one colony. The minimum budget is the budget for 2 colonies (each 1000 birr, 40 euros), and two hives (depends on the hive type, see 'Benchmarks'). If a beekeeper can catch a swarming colony and keep it in a traditional hive, the initial investment is almost zero.
The rest of the material needed depends on the type of hive and the accompanying bee management method. Protective clothes are rather scarce, a lot of beekeepers use their shawl to protect themselves from bee stings.

In comparison, let's look closer at the startup of crop production: land is needed, seeds, fertilizers and tools need to be bought, and in an ideal case an oxen needs to be bought and maintained. The start-up costs are very high and often young families are landless.

In contrast to cultivating cropland or herding cattle, beekeeping is not a full time activity. Most of the time the bees need to be left alone. So beekeeping is an agricultural activity that is easily combined with other income generating activities such as crop cultivation, cattle herding, trading,…
There is no land needed for beekeeping, as it can be practiced in the direct surrounding of the house or in an exclosure. (a land area where farming activities are forbidden to restore the land from erosion)

The added value is broader than just income generating. In contrast to for example ploughing, there is no general taboo on women as beekeepers. So female headed households (mainly widows or divorcees) can also profit from knowledge about beekeeping. This is a theory because in practice, mostly men are in control of beekeeping.

Another positive effect of beekeeping is the higher pollination of certain crops [11]. This is an indirect advantage, but is not yet emphasized at farmers trainings.

Although Ethiopia is one of the biggest honey producing countries in the world, the production system has some weak links. First of all: most farmers hold on to traditional methods which results in poor quality and low quantities of honey per hive. This is partially due to lack of access to proper extension/education and lack of access to good materials. Also the distribution has some gaps: most farmers sell their honey on the local market in the village or sell it to middlemen. The middlemen often adult the honey and sell it for a high price. [1]

Interviews

During my stay in Ethiopia, I conducted some interviews with local beekeepers. Each one of the beekeepers was owner of at least 2 modern hives and a number of traditional hives. The traditional hive provided wax to make wax foundation sheets for the modern hives. All the beekeepers I interviewed have had training from extension workers. One beekeepers told that his modern hives weren't occupied because he could not do it alone. None of the farmers used top bar beehives.
The Kenyan top bar beehive was only recently introduced in the area around Meychew to three model farmers as part of a research/extension activity by a master student from Mekelle university.
The beekeepers stated that they didn't know how to make the top bar hives and didn't have measuring tools to construct them. But all of them where interested to try it, if someone provided the knowledge.
An important about with these interviews is that all these farmers can be considered as model farmers, as all had knowledge and access to new technology. It was hard to get in contact with traditional beekeepers.

Conclusion:
I will elaborate the aspect of production and development of a hive type based on the shape and measurements of a transitional beehive such as the Kenyan top bar beehive. This hive type provides both wax and honey and can be constructed by farmers. It gives a beekeeper a possibility to open the hive and check on the bees, in contrast to the traditional beehive. And it has a more intuitive way of bee management than the modern hive.

BENCHMARKS

Eco-hive

Concrete hive

Modern box hive

Topbar hive

Traditional hive

Eco-hive

Beekeepers are generally known for their creativity in hive designs. A lot of adaptations to classic designs have been invented. I looked at different hive types to see how they handled common problems such as ventilation and isolation.

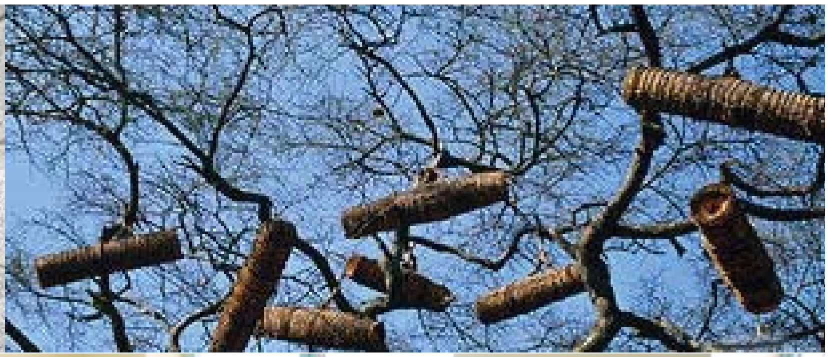
A Warré hive [12], also known as the eco-hive, has a special compartmented roof with natural materials that serve as isolation and let vapour escape. The ventilation is regulated by a mesh on top of the top bars. The bees fill or empty the voids of the mesh to in- or decrease ventilation. These are small interventions make it easier for the bees to organise themselves, which causes less aggressive bees.
The concept of this roof was translated to Ethiopian materials and techniques to make the roof for the Adis hives. In the cover of Adis hives, a jute bag is used instead of the mesh, allowing the bees to regulate the ventilation inside the hive. The bag is filled with natural materials like hay and dried cacti leaves that serve as a ventilation buffer. The cover is made waterproof by a plastic bag in combination with cacti leaves waterproofing (see Tests section).

Another hive that was inspiring, is a hive made of concrete [13]. These hives are sometimes made in developing countries. In this example, the ground is used as the mould for the concrete. In the Adis hive the soil is not the mould but one of the main construction materials.

Currently used hive types in Ethiopia

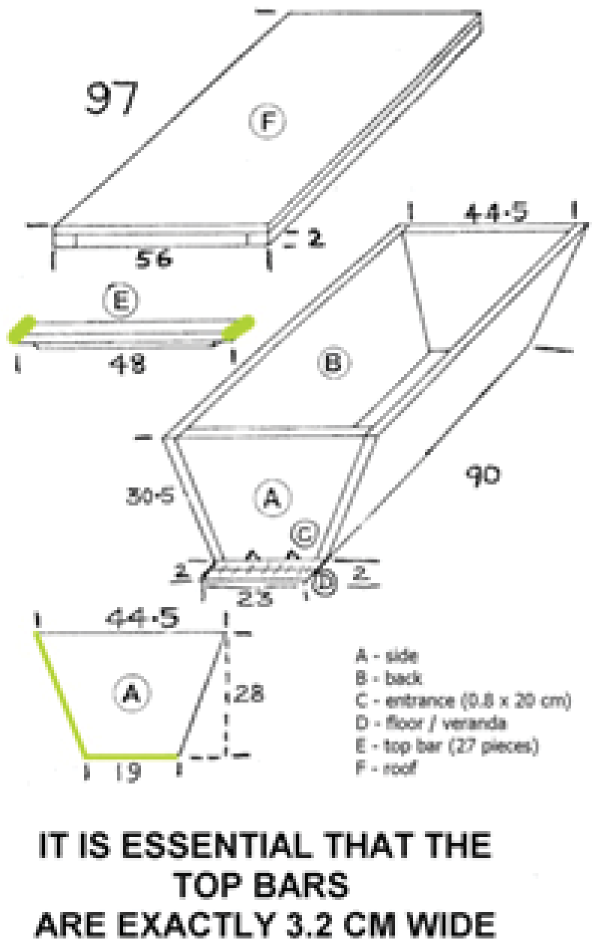
Traditional hives

As said before, most of the hives in Ethiopia are traditional hives. They are cylindrical structures made of cow dung and mud and sticks or a weaved structure. Beekeepers hang them in a tree and wait until a bee colony occupies it. The bees build their own combs in these hives. The honey and wax is harvested by climbing in the tree and destroying the combs. This makes the (already aggressive African) bees very aggressive and chases them away. After every harvest a new colony has to occupy the hive. A beekeeper can never be sure if it is the right time to harvest because he cannot get access to the hive unless he destroys the combs. Impecunious beekeepers don't have money to buy smokers to tranquillize the bees, so harvesting honey becomes a dangerous and painful job. The honey that is obtained from these hives is crude honey (the honey is still in the combs). The honey can be separated from the wax by kneading it, which often results in honey mixed with pollen and dead bees. As a result of this, the honey from traditional hives is sold at a lower price because it needs to be purified.



Transitional or Kenyan Top Bar hives

As a transition between traditional and modern beekeeping there is a second hive type: the Kenyan top bar hives. This kind of hive is originally designed by Pam Gregory [14] and is shaped like a trapezoid. Most of the transitional hives are made of wood. Recently the KTB has been introduced to Ethiopian farmers by extension workers who made a new version of it: a hive made of wood sticks and mud.
On top of the trapezoid hive, wooden bars with a width of 3.2 cm are placed. The bees will construct a comb on each of these bars. The bars can be taken out separately to check them or to harvest honey. A colony can be held in the same hive for several harvests because this is a nondestructive form of bee management.
The KTB produces a great yield of both honey and wax. As wax is scarce and thus expensive in Ethiopia, this hive is ideal for poorer farmers who don't have the possibility to invest in modern beekeeping. The main problem with this hive is that it is not standardized which causes several problems that will be elaborated later on.



Modern Box Hives

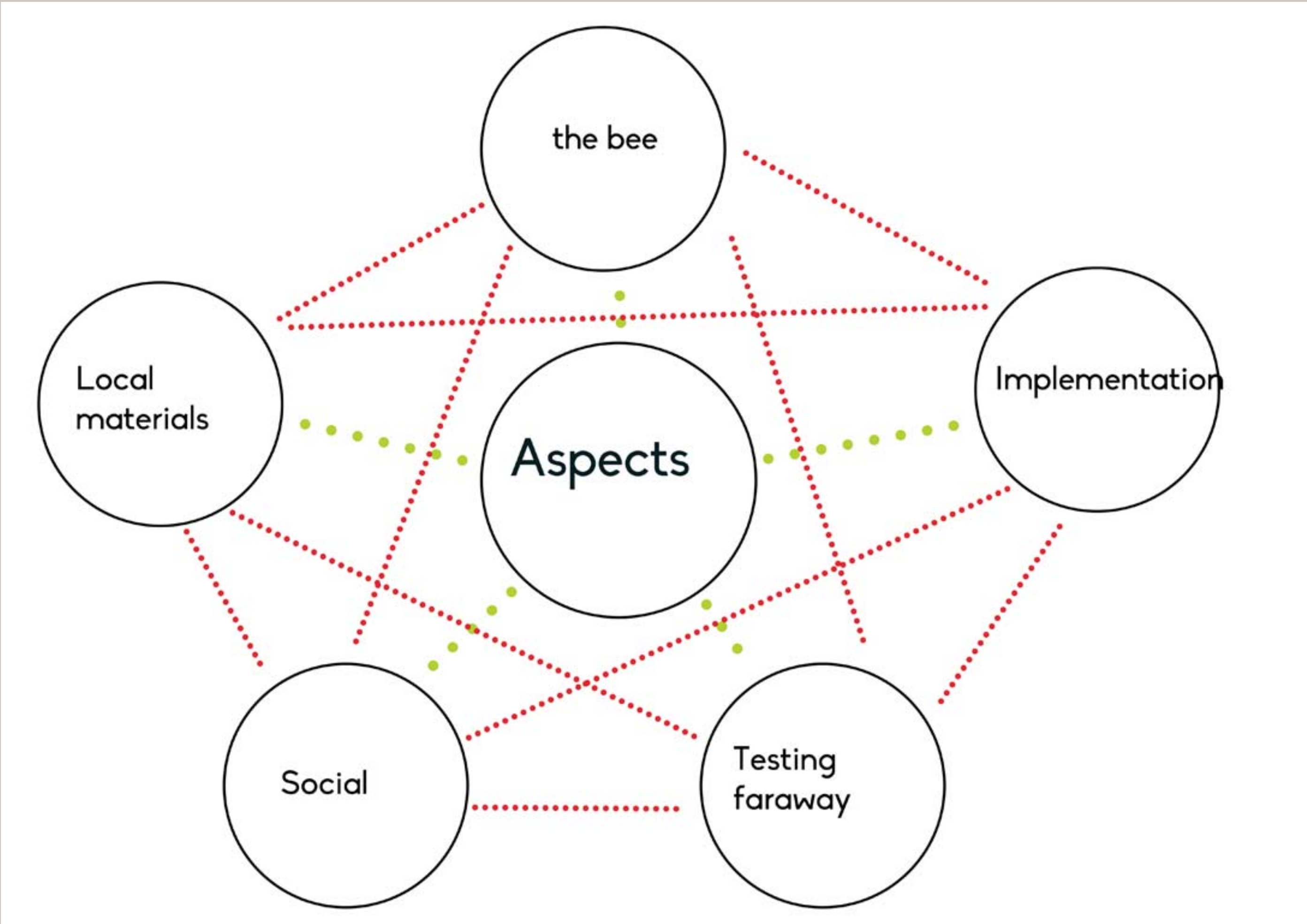
The modern box hive is the hive type that is used by Belgian beekeepers (the Simplex hive). Several wooden boxes are placed on top of each other. Several frames are positioned at regular spaces inside the boxes. Onto the frames, a wax sheet is attached. This type of hive has a high honey yield but does not has the possibility to harvest wax. The honey is easier to extract because of the frames. The frames are strong enough to put them in the extractor that spins them around to separate the honey from the combs. As a result of that, the honey is purer than the honey from a transitional or traditional hive. This in the case where the farmers have access to a honey extractor. This type is expensive because a lot of wood is needed to construct it. Farmers are not able to make the modern hives themselves because they don't posses the necessary construction and measuring tools. The box hives are generally sold on the market for 1000 birr each (40 euro).

Price comparison of hive types

Hive type	Unit price (ETB) [15]
Modern	897
Transitional	436
Traditional	70

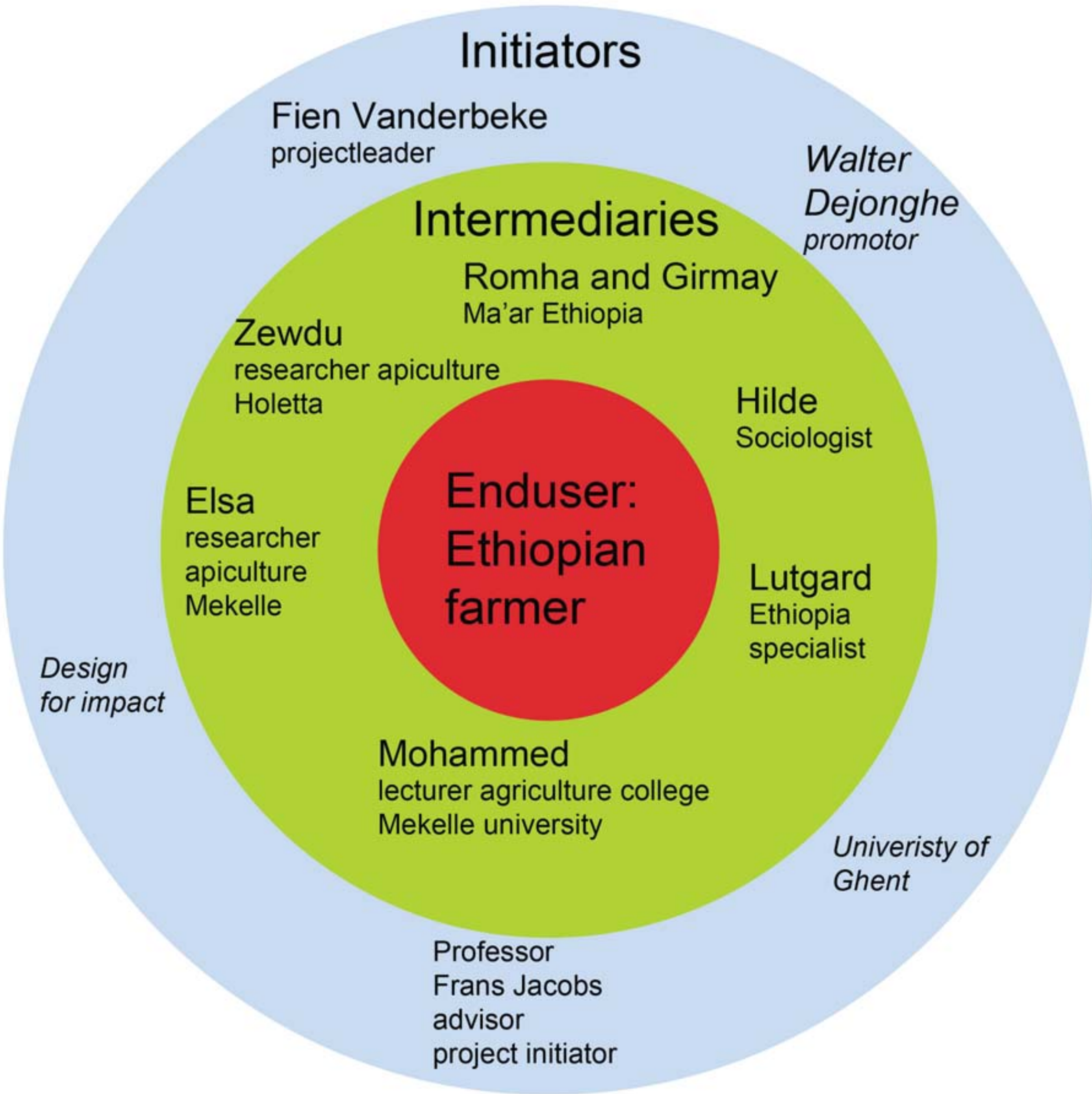
The goal of this project was to avoid costly materials and to end up with a nearly free hive type. This means concrete: a unit cost of less than 100 birr per hive. The Adis hive costs maximum about 75 birr per hive, the price is lower when a farmer has bamboo plants on his property for example.

ASPECTS OF THE RESEARCH



Social

To describe the social context of this entire project, it is necessary to identify all stakeholders involved. The stakeholders include the designer, the end-user and his family, the intermediaries between the designer and the end-user.
Each of this stakeholders has his or her unique cultural and personal background that has to be kept in mind during all aspects of the development of the beehive. This is one of the hardest parts of creating a fitting design-strategy because to a Western-minded designer it is often not clear why certain things work or don't work. This makes the intermediary persons so special: in this case-study the intermediaries are Ethiopians who work in research centres or at universities. They share the cultural background with the end-user but have often studied in Western countries so that they can empathize with a Western point of view.

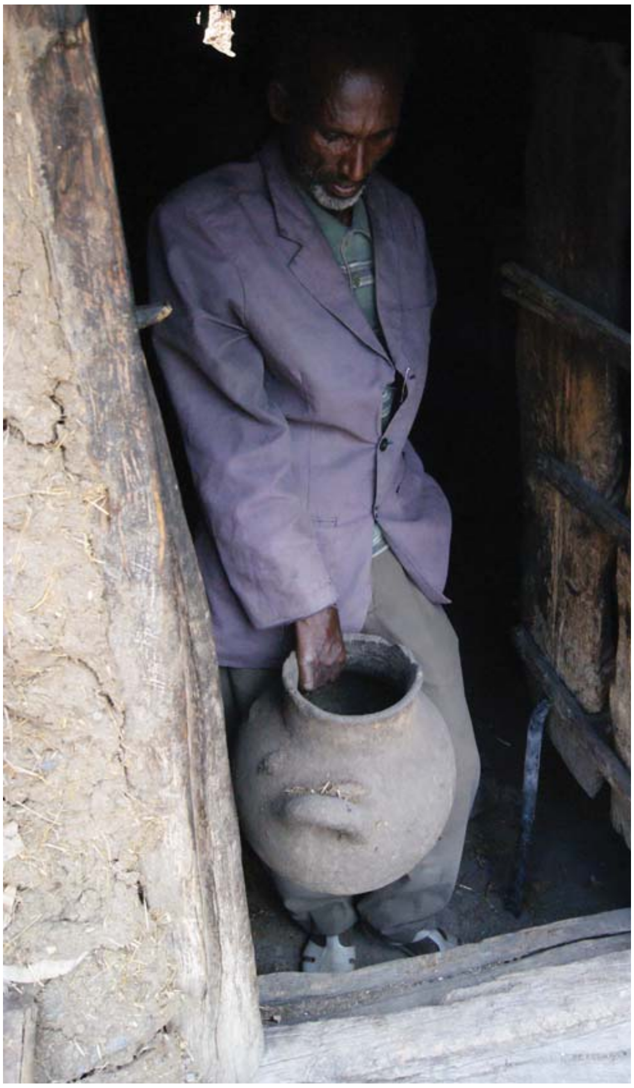


Secondly, there has to be a fitting motivation-technique for the intermediaries to involve them in all stages of the design process. Motivation makes people move to do something [16]. According to Richard Ryan two types of motivation exist: intrinsic and extrinsic motivation. Intrinsic motivation can be explained as motivation from within. People do something because they think it is enjoying, not because of the outcome. This type of motivation can either be stimulated or destroyed by external influences [16]. Most important factors for stimulation of intrinsic motivation are the feeling of autonomy and competence. So an activity that is on the right level of competence for someone and he or she has a feeling that he or she has some degree of decision making in the process, will probably become more even more motivated than initially.

The most motivational factor in the testing phase was goal setting: tests should have a clear and useful goal. Useful in this context means that the outcome of the test is not only valuable as a result for the designer but also for the testing person. For example: when testing the reaction of materials on a tropic environment, it would be easy to ask: can you gather loam, wood, water and hair, mix them together and let it dry. The chance the test person will carry out this test is very low. But if you instead give the test person the opportunity to build a functional hive with this material, his motivation will increase enormously.

To be consistent in decision making during the design process, a goal directed persona of the end-user and intermediary was described [17]. This kind of persona focuses on the person in a specific context, here respectively the beekeeping and work at the research centre.
This prove to be a useful tool to make consistent decisions.

The end-user



The end-user defines if the project is successful or not.
In this case study, the development of a transitional beehive suited for the Ethiopian context, the end-user is a poor farmer that is or becomes a beekeeper. The fact that he has access to limited resources makes that he is precautious regarding to introducing and testing new technologies.[1] When his yield with this new technology fails, he does not have honey to sell and he loses a colony and his investment money. The new hive should therefore be introduced to innovative farmers (this can be accompished through the Ma'ar project, a group of innovative farmers around Mekkelle), once they can prove to other farmers that this new system works, the system will be adopted by them too.
Beekeeping is still mainly a male activity. In the research centres in Ethiopia women had the opportunity to join the courses, but from what I observed, all participants were male. This strokes with the findings of Clare Bishop-Sambrook [18] who interviewed Ethiopian farmers on the access and control of recourses in Oromia, Ethiopia. They stated that all control and access of beehives was exclusively reserved for men. On the other hand I met a Tigray woman that had made the traditional beehives her husband used.
So the hive should be preferably made in a way that it is possible for women to make them, keeping in mind that it will be mainly made by men, except for women that have a certain kind of autonomy from their husband.

THIS IS HAILE

has a wife and five children

He lives in Maychew,
a rural village in Tigray,
Northern Ethiopia

45 years old

learned beekeeping skills
from his father

Haile is a backyard beekeeper

is illiterate

he is risk averse because of his low income

he built his own house

earns 25 euro a month

The intermediaries

In this particular case study the connection between the designer and the end-user. In this case they are a crucial part of the project. As most beekeepers live in small villages in remote areas and don't have internet access, it is impossible for me to communicate directly with the end-user. The intermediary persons know a lot of beekeepers, as they give training to them or do research together with them. They know the language and have a thorough insight in all aspects of beekeeping and beekeepers.

Crucial points in setting up a working network with the intermediaries are the way of communicating and motivating them to cooperate on every level.
Different ways of communicating were considered and tested:

- Sending physical instructions/materials/test set-ups
- Communicating through a blog
- Personal communication by email

The Ethiopian society is an rather individualistic society [19] which makes it preferably to communicate by email because this is personal and direct.

The initiators

The people who take the initiative should always keep in mind that they are working for people with a different point of view on the situation. Everything should be in function of the end-user.

THIS IS ELSA

Elsa still lives at home with her parents, brothers and sister

she recently graduated from Mekelle University and works now in the agricultural research centre

Elsa often travels to the countryside for fieldwork

She learned her beekeeping skills during a four month course in Belgium

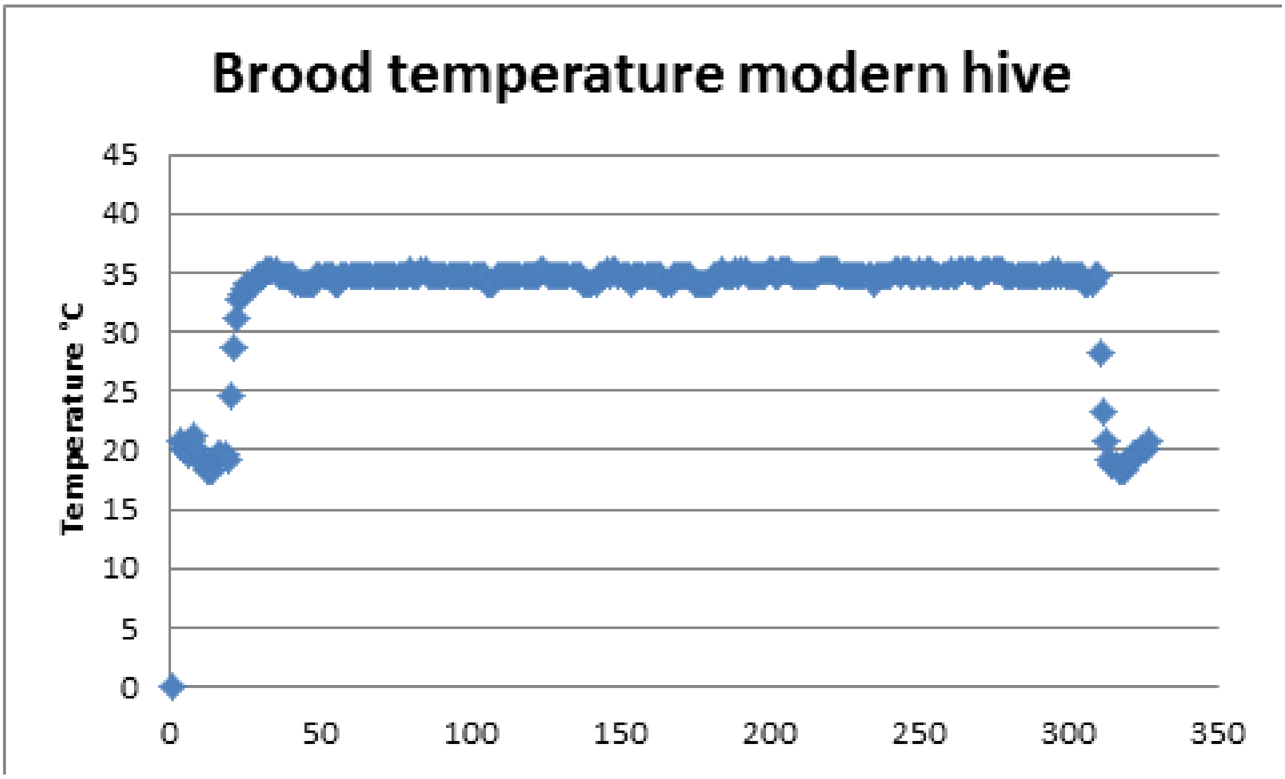
To get budget for research projects, Elsa has to do applications and fill in forms

She loves experimenting and learning new skills

She is one of the only female beekeepers

The bee and technical consequences.

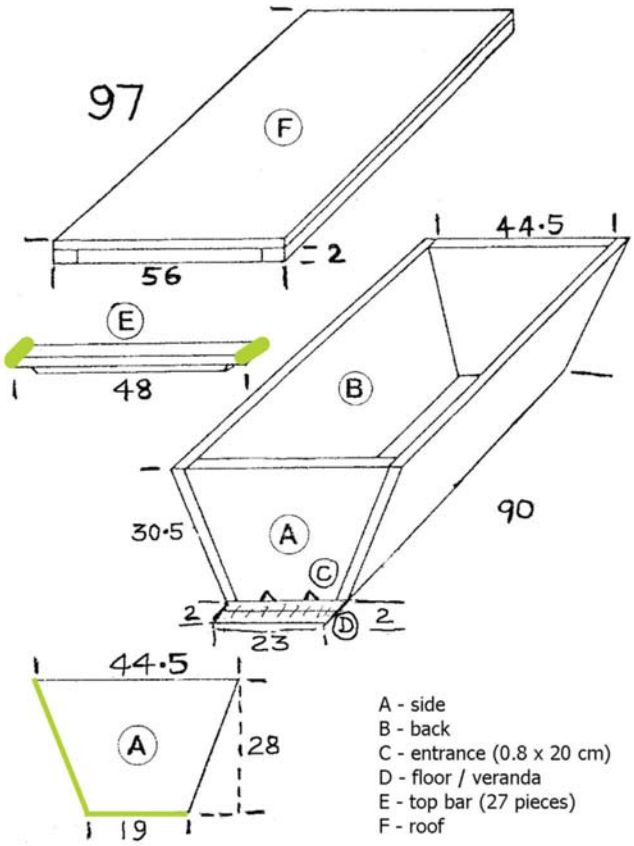
A beehive has to meet some minimum requirements in order to guarantee a good living environment for the bees and to give the beekeeper the possibility to perform proper bee management. First of all, the material of which the hive is made of, should insulate properly. There also needs to be a 'humidity and temperature regulation'. Bees are a super-organism and work together with the whole colony to regulate the temperature in the hive. According to my temperature measurements in Ethiopia, the bees keep a constant temperature of 35 °C in the breeding nest. (see 'test' section) A hive should be made in a way that makes it easy for the bees to control the temperature, because the more effort they have to do to keep the temperature invariable, the less honey they can produce.



There is no material restriction to produce the hives (for the bees) but one should be precautious with volatile substances such as alcohol and paint, because bees are very sensitive to their smell.

In respect to bee management, the hive has to meet some standards. First of all, it is not advantageous for the beekeeper if the combs are attached to the sides of the hive. This would make it a lot more difficult to harvest the honey, as the combs cannot simple be lifted out. Therefore, the spacing between the walls of the hive and the top bar should be between 4 and 7 mm. Bees use propolis to fill cavities smaller than 4 mm and build combs in cavities bigger than 7 mm.
Secondly, the spacing between the centres of the top bars should be constant at 32 mm. When this distance is respected, the bees will build one separate comb on each top bar that is not attached to the others.
All hives should have the same measurements so that the beekeepers can transfer colonies or place a queen excluder (a wire grid to prevent the queen bee of laying eggs in the honey chamber) in the hive.

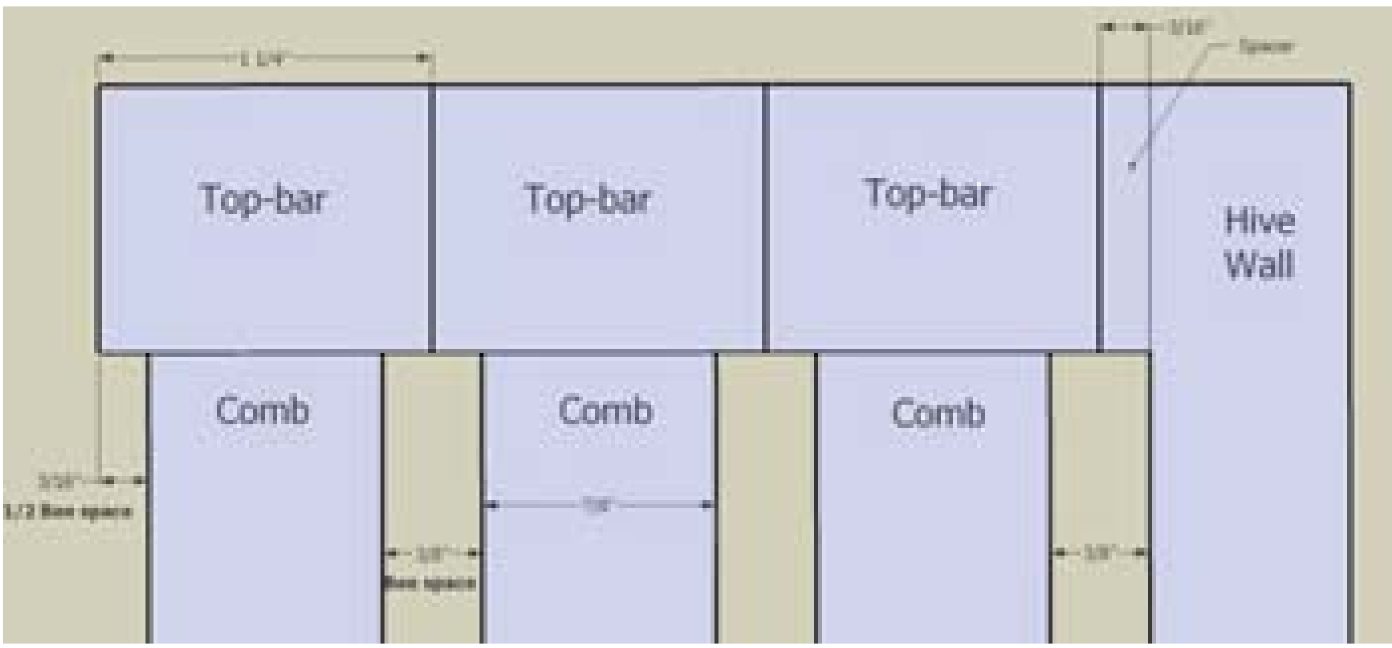
TECHNICAL ASPECT



The key dimensions to guarantee a flourishing colony are marked green on the figure.

First of all there is the width of the top bars: this should be exactly 3.2 cm wide. If they are to smaller, the combs will be too close for the bees to easily fit between them. They will seal the gap between the top bars with propolis. This means a lower honey yield. When the top bars are wider he bees will attach both combs to each other with wax. This causes a big disturbance for the bees when opening the hive or harvesting the honey.

The same goes for the angle of the sides: this should be exactly 120°. If this angle is bigger or smaller, the bees will attach their combs to the sides.



In Ethiopia, there are five main bee races identified so far. [20] The apis mellifera scutellata, often referred to as the killer bee, is known for his extreme aggressiveness and group attacks. The other races are also a lot more aggressive than the races used in apiary in Belgium. If possible the hive should be designed so that the disturbance of the bees by the beekeeper can be kept to a minimum.

Table 2 Climatological, vegetation and physiographical regions of the five morphoclusters of Ethiopian Honeybees. A.M refers to *Apis melifera*[33]

Bee Race	*A.m jemenitica*	*A.m scutellata*	*A.m bandasii*	*A.m. monticola*	*A.m woyi-gambella*
Mean temperature	20-25°C 25-30° C 18-20°C	18-20°C	16-18°C	16-18°C	20-25°C 18-20°C 25-30°C
Vegetation	Tropical wood land and thorny bush, Semi desert steppe, Grass land	Grass land Tropical wood land and thorny bush, forest	Grass land	Grass land, Altimontane scrub steppe	Tropical wood land and thorny bush

Materials

Common materials to build hives in Ethiopia are wood (mainly for the modern hives), bamboo and eucalyptus sticks (to construct the frame of transitional hives), mud and cow dung (to plaster the transitional and traditional hives), leaves (to weave a traditional hive), clay (to construct traditional hives and in one experimental case also a modern hive), straw (to enforce the mud and prevent it from cracking).

Using these common materials in the new hive design has a lot of advantages: people have the skills to process these materials. Most of the materials listed are cheap, except for the wood. The materials have proven to be appropriate for hive making.
But each material has his disadvantages too. For example: the bamboo sticks have an irregular shape, which makes it difficult to construct a hive within tolerances.

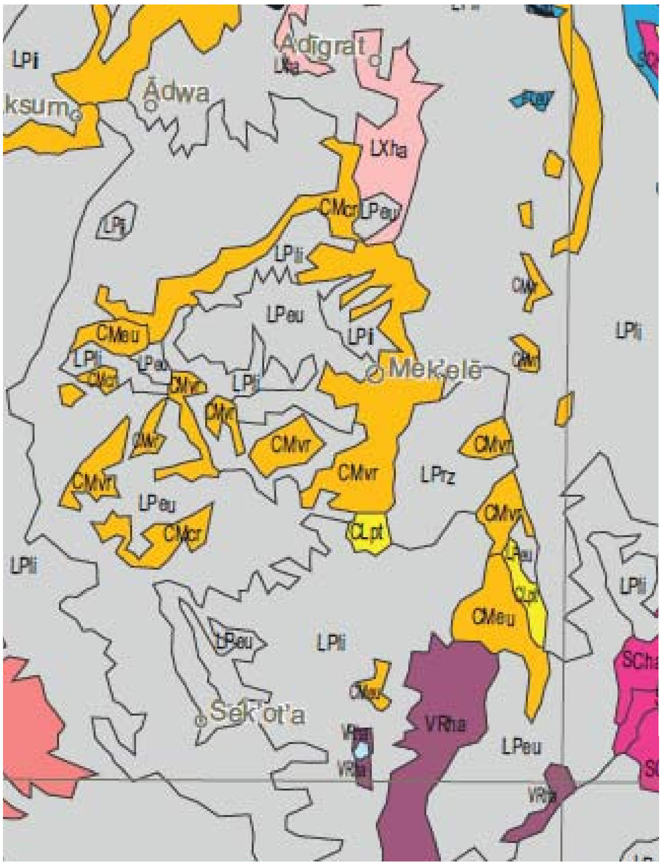
MATERIAL ASPECT

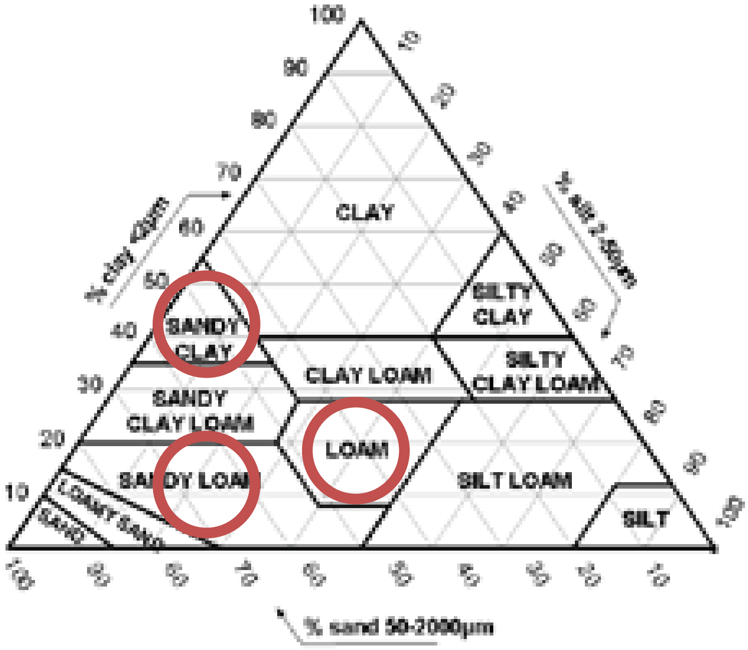
During my stay in Ethiopia I listed common materials that could be of any use to construct a hive. The materials listed do not only serve as a building material for the hive, but some of them can be used to measure distances or build a mould.

- Mud
- Cow dung
- Corrugated iron
- Bamboo
- Sticks
- Grass
- Bottle caps
- Tires
- Jerrycan
- Banana tree leaves
- Fabrics
- Crowns
- Plastic bags
- Animal skin
- Animal bones
- Clay
- Water bottles

Back in Belgium some material tests were done to work out how suited the listed materials where to build transitional hives.

When working in the context of a developing country, you should not only be aware of the material constraints of the country you are working in but also of the reverse material constraints. The students who worked on the hive during the first phase of the project proposed among others a hive made of multiplex. This is a very common material in Belgium but it is not to be found in Ethiopia. The reverse material constraint appears when we look at the abundant materials in Ethiopia, listed above. A lot of prototypes in this project were built with bamboo with a cross section of 2.5-3 cm. This is easy to find in Ethiopia, as bamboo grows there. Here in Belgium, however it was a lot harder to find bamboo with the right measurements.





A main material used in the end product is loam. This loam was purchased in Belgium, so before the tests were carried out, it had to be ascertained that the loam had enough in common with the Ethiopian soils. The figure above shows the soil map of the Mekelle region [21]. Main soil type are Leptosoils, the grey areas. These are thin soils on bedrock. These areas are not well suited for crop cultivation. The yellow areas are well developed soils, very well suited for agricultural activities. A Cambisol consists of sandy loam or finer particle sizes. It contains at least 8 mass percent clay [22]

This soil analysis alone gives a rough view of the region's soils. Soil samples of the region examined by a geology master student show that the soil is mainly sandy clay and sandy loam soil. These soil types are marked respectively red and yellow on the soil texture triangle. The purchased loam is loam used for fishing bait. The composition of the loam is not constant and is not determined by the company. But the fact that all these soils are in the same region of the soil diagram confirms that loam is a suited substitute for 'the real soil' in Ethiopia to perform tests with.

IMPLEMENTATION ASPECT

This project can only succeed if it is implemented in a suitable way to the farmers.
I don't have any control over the implementation, the only way I can use the implementation is to just check the context of the implementation with the wishes and demands of the design of the hive.

With the support of the Vlir-UOS program [23], 24 Ethiopian researchers came to Belgium over the years for an intensive beekeeping course of four months about tropical beekeeping. They will become the Ethiopian ambassadors of the Beeth-project.
Spread all over the country, they will organize small scale training sessions in rural villages about beekeeping and hive making. In 5 days they will demonstrate, in a hands-on workshop, how to build hives and how to manage the bees in those hives. 10 Farmers/beekeepers will participate in each workshop, and in the first year of the program 48 courses will be given. After the course, every farmer becomes the mentor of 10 more beekeepers in his village. In total, 4800 beekeepers will be reached in the first year. This means 4800 beekeepers that increase their living standard with at least 50%.
The farmers receive a per diem by participating in the course and are selected by the ambassadors to avoid that the same beekeepers participate in the course over and over again. [24]
Now, beekeepers that go to training programs are often selected by the government or the head of the village and only certain beekeepers have a chance on participating in education. [19]

Until now, all beekeeping education was organised in the local research centres. This implies that only farmers that live close by or farmers that are wealthy enough to leave their farm for a few days could take part in this education. With this program less mobile farmers can be reached too.

Each farmer taking part in the beekeeping education gets an Adis kit (top bar mould, angle mould and manual) to make hives at home. The beekeeper himself gets an ambassador of the project in his village after the project in order to spread the knowledge.
The outcome of each course is inspected by local Rotary clubs. The entire project is funded by Rotary Wetteren.

DISTANCE ASPECT

The aim of this project is to cooperate with Ethiopian stakeholders in order to develop a new transitional beehive in all phases of the design process.

The four stages of the design process according to the Innowiz design-methodology [25] are problem definition, idea generation, idea selection and idea communication. This is not a linear process but an iterative process that has to be run through for every subproblem. The more testing and idea generation is done, the more questions and specific problems will rise. Each of them has to solved and incorporated in the final design by running through the four stages of the design process.

Every stakeholder in the project has his own reality and context that makes up 'his world'. Every test, every aspect of the design process should be designed to fit in the particular reality of this stakeholder.

For example, if you want to test with your stakeholders if the system with the top bar mould works, you should adapt the test for the intermediaries or the end-user. This means: working with available materials and knowledge, giving instructions that fit in the world of the (illiterate) end-user, …
Very important when testing is that the result of a test is directly usable for the test person and that he or she can determine for themselves if the test succeeded or not. (see 'Tests' section)
To determine the opportunities and restrictions when setting up a test, a goal directed persona [17] can be of use. Another way to empathize with the different world view of the stakeholders is to list restrictions and note how you can bend them into possibilities. (Table 2)

DISTANCE ASPECT

Aspects of the context	Researcher	Farmer	Initiator	- to +
Space	+	-	+	
	labo	Small house	workshop	Not much space needed to
	multiple apiary sites	backyard beekeeping	space at home	make and store hive
Tools	+	-	+/-	
	beekeeping material	selfmade beekeeping tools	Lots of tools	No tools or very common
	access to market	access to village market	No access to same tools as stakeholders	(farming) tools needed to make
	wood lab	farming equipment		hive
Materials	+	+/-	+/-	
	access to market	natural materials	access to various materials	free/ very cheap/ waste material
	leftovers from building other hives		no access to same materials as stakeholders	mimic material' that is available in Belgium
Budget	?	-	+	
	long procedures	less than 1 Ha farmland	Sponsoring project	free/ very cheap/ waste material
	depends on project	Seasonal food shortage		
Help	+	-	+/-	
	Students	Poor people give their labour		Possible to make it alone
	bee technicians	in food for work programmes		
Technical knowledge	+	?	+	
	have had training	Depends on training or not	beekeeping training + technical education	Fool proof, no technical skills needed
Time	?	?	+	
	give training	Farming (depends on season)		No constant attention needed
	do research	Herding		Synchronised with beekeeping activities
	field trips	Household tasks		Flexible timing
Direct contact with the project	+	-	+	
	know everyone personally	don't know the initiators of project	Knows most stakeholders	
	communicate with all stakeholders	don't know the researchers personally	coordinates the project	
Own investment	-	+	-	
	money from university or project	have to buy materials	Sponsoring	
Communication	+	-	+/-	
	know all stakeholders	don't know all stakeholders	Internet access, camera, English	Communication without words
	internet access	little internet access, no camera	No direct communication with end user	trough researchers
	speak English	local languages (Tigrinya, Amharic,...)		
Results are useful for stakeholder	?	?	+	
				Close goals
	depends on test	depends on test		Tests should be useful for every stakeholder
Reward	?	?	+	
Feedback	+	-	+	

REQUIREMENTS

no use of wood

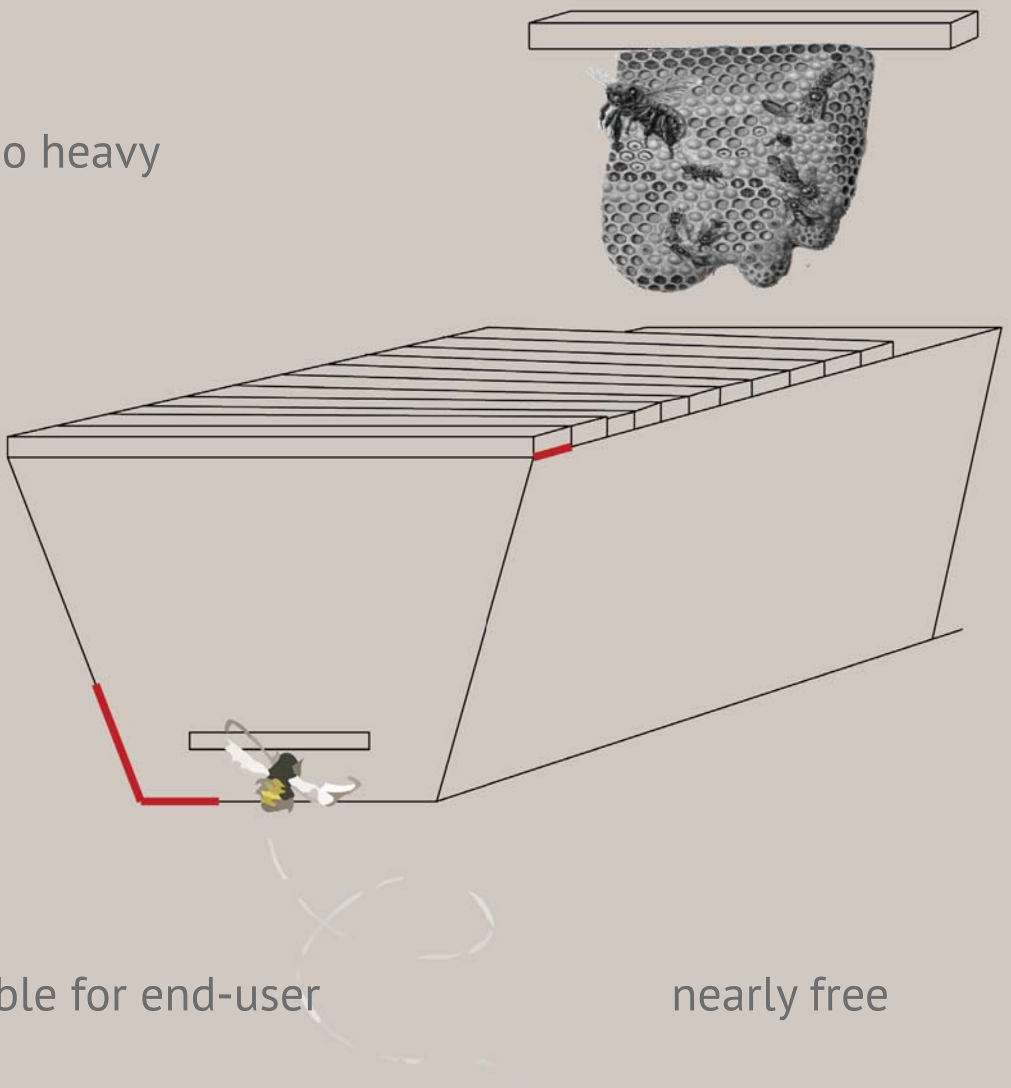
waterproof

dimensionally stable

strong

not too light

not too heavy



acceptable for end-user

nearly free

use of local materials

use of local techniques

To summarize all needs, demands and wishes that already have been identified for the hive and how all these aspect can be validated, a validation matrix was developed during the first semester. The second semester was used to test and verify as much of this requirements as possible to make Adis a suitable hive. All short time tests were preformed and the accompanying requirements were met in the final product. A year is too short to perform tests about long-time behaviour of the end-user. Therefore, only the tests on the short-term were performed. This includes: budget, availability of materials and tools, required knowledge, first time construction,... This does not include yield rates and the preferability of the transitional hives above the traditonal beekeeping methods.

Tests / Requirements and wishes	Aspect	Number of combs that can be harvested	Beepopulation survives	The bees have to build their own combs	Temperature measurements in empty hives	Humidity measurements in empty hive	Hives are made in suitable material	participant can make the hive in the right material	# refunds for materials to intermediaries	# birr per hive	Hive can be carried by one person	Empty hive is not blown away during windy period	Mould can be placed inside new hive
-The hive has a reasonable yield	Bees	High											
Bees can live in the hive	Bees		High										
The hive provides enough temperature insulation	Bees / material / production				Medium								
The hive provides enough humidity regulation	Bees / material / production					Medium							
The hive produces wax and honey	Production			High									
-Material is available	Materials						High	High					
The material is cheap	Materials/social								High	High			
-The hive is not too heavy	Materials / production										High		
-The hive is not too light	Materials / production											High	
-The hive is within tolerances	Production												Medium
quality controle on the hive is possible	Production												
The production of the hive is fool proof	production												
Hive is produced correctly	Production / social												
-Production is repeatable	Production/ social												
-The beekeeper can check the hive	Production												
-not time consuming to make	Production / material												
-Strong	Production / materials												
-Can stand outdoor weather conditions	Production / materials												
-The hive is suited for nightwork	Production / materials												
-Hive can be made by one person	Production / materials												
-Only available tools needed to construct the hive	Production / social												
-no preliminary knowledge needed	Production / social												
-no measuring equipment needed	Production / social												
-Is preferred over traditional hive	Social												
-can be made by a woman	Social / production/ material												
-Mould does not get lost	Social/ production												
-Easy to maintain	Social/material/ production												
Dimensie		#	Yes/no	Yes/No	Δ% inside/outside	Δ°C inside/outside		Yes/no	# birr	# birr	Yes/no	Yes/no	Yes/no and Δcm
streefwaarde		half of #	Yes	Yes	Same as eco hive	Same as eco hive		Yes	0	<150	Yes	NO	Yes, Δ < 4cm
Benchmark 1		No	Yes	Yes	?	?		Yes		70	Yes	?	/
Benchmark 2		Yes	Yes	Yes	?	?		YES		400	Yes	NO	?

Tests / Requirements and wishes	Aspect	The variance between 2 hives made by same person	Visual feedback on mould	# hives within tolerance	manual with ethiopian photos	combs are attached to walls	Opening	Uncomplete tests due to lack of time	Weight it can carry for one month	No signs of wear after a moth outside	# persons needed for lighting	# beestings	Farmer can produce all beemanagement with light of one cellphone
-The hive has a reasonable yield	Bees												
Bees can live in the hive	Bees												
The hive provides enough temperature insulation	Bees / material / production												
The hive provides enough humidity regulation	Bees / material / production												
The hive produces wax and honey	Production			High									
-Material is available	Materials												
The material is cheap	Materials/social												
-The hive is not too heavy	Materials / production												
-The hive is not too light	Materials / production												
-The hive is within tolerances	Production	Medium	Medium										
quality controle on the hive is possible	Production		High										
The production of the hive is fool proof	production	Medium				Medium							
Hive is produced correctly	Production / social				Medium								
-Production is repeatable	Production/ social	High											
-The beekeeper can check the hive	Production					High	High						
-not time consuming to make	Production / material							Medium					
-Strong	Production / materials								High				
-Can stand outdoor weather conditions	Production / materials									Medium			
-The hive is suited for nightwork	Production / materials										Medium	Medium	Medium
-Hive can be made by one person	Production / materials												
-Only available tools needed to construct the hive	Production / social												
-no preliminary knowledge needed	Production / social												
-no measuring equipment needed	Production / social												
-Is preferred over traditional hive	Social												
-can be made by a woman	Social / production/ material												
-Mould does not get lost	Social/ production												
-Easy to maintain	Social/material/ production						Medium				Medium		
Dimensie		Δcm	Yes/no	Yes/no		#	Yes/no	%	KG	Yes/NO	#	#	Yes/no
streefwaarde		Yes, Δ < 4cm	Yes	Yes		0	Yes	10	>25	NO	0	=< other hives	yes
Benchmark 1				Yes		?	No	?	10	NO	?		?
Benchmark 2				Yes		?	Yes	?	>25	NO	?		?

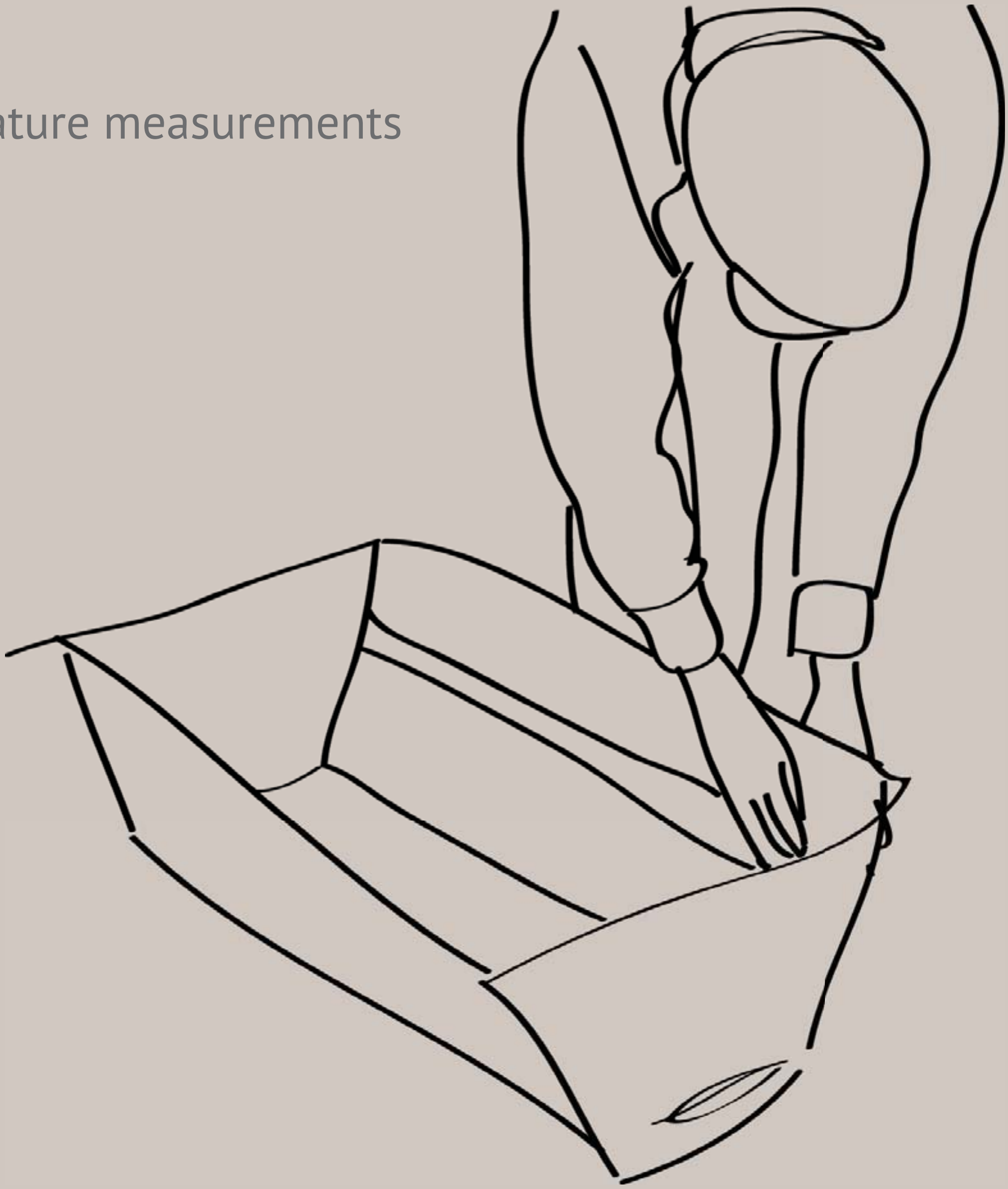
Tests / Requirements and wishes	Aspect	Hive produced by one person meets the requirements	Production only requires tools listed by Bishop-Sambrook	Request for extra tools	Farmer understand the production after one training	Hive is within tolerances without rulers...	Hives are made spontaneously	Hive is still in use after the first yield	Number of traditional hives decreases	Uses skills and tools listed by Bishop-Sambrook	4 weeks after the test, the person still has the mould	Benchmark: traditional	Benchmark 2: transistional, bamboo+ mud
-The hive has a reasonable yield	Bees											Not ok	OK
Bees can live in the hive	Bees											OK	OK
The hive provides enough temperature insulation	Bees / material / production											?	?
The hive provides enough humidity regulation	Bees / material / production											?	?
The hive produces wax and honey	Production											OK	OK
-Material is available	Materials											OK	OK
The material is cheap	Materials/social											ok	+- ok
-The hive is not too heavy	Materials / production											OK	OK
-The hive is not too light	Materials / production											OK	OK
-The hive is within tolerances	Production												Not ok
quality controle on the hive is possible	Production											Not ok	Not ok
The production of the hive is fool proof	production											OK	Not ok
Hive is produced correctly	Production / social					Medium							
-Production is repeatable	Production/ social											Not ok	Not ok
-The beekeeper can check the hive	Production											Not ok	OK
-not time consuming to make	Production / material											?	?
-Strong	Production / materials											OK	OK
-Can stand outdoor weather conditions	Production / materials											+/- ok	+/- ok
-The hive is suited for nightwork	Production / materials												
-Hive can be made by one person	Production / materials	Medium										OK	OK?
-Only available tools needed to construct the hive	Production / social		Medium	Medium								OK	OK
-no preliminary knowledge needed	Production / social				High							OK	Not ok
-no measuring equipment needed	Production / social					High						OK	Not ok
-Is preferred over traditional hive	Social						High	Medium	Low				?
-can be made by a woman	Social / production/ material									Medium		Ok	Not ok
-Mould does not get lost	Social/ production										Medium		
-Easy to maintain	Social/material/ production											Not ok	?
Dimensie		Yes/no	Yes/no	#	%	%	% participants	%	#/farmer	Yes/no	Yes/no		
streefwaarde		Yes	Yes	0	80	80	20	70	=>1	Yes	Yes		
Benchmark 1		?	YES		/	/	100	?		Yes			
Benchmark 2		?	NO		?	/	?	?		NO			

TESTS

Moulds

Materials

Temperature measurements



Waterproofing

Manuals

First test with mould to make beehives

Before I departed for my stay in Ethiopia, i tested the first version of a mould to make top bar hives. The idea originated from one of the ideas developed by the third bachelor students. The dimensions of this mould where the same as Pam Gregory's transitional hive [14]. The mould consisted of aluminium sheets kept together with tape.
An aluminium mould was covered with paper pulp and wallpaper paste. During the drying process, the hive lost his shape and loosened from the mould. It was very hard to dry as the aluminium does not absorb any moisture. So even before it was dry, the mould was taken out of the structure, so that it could dry entirely. When dry, the hive was deformed and had some holes in it. It was strong enough to carry some wooden bars. It was, as predicted, very sensitive to moisture. After a rain shower it collapsed entirely.

The mould has proven to be useful but needs a lot of adaptations to really work. It is very hard to lift the mould out. The mould does not allow proper drying.

1. Hive mould test in Ethiopia

The same hive was tested and adapted in Ethiopia. Holes were drilled in the sides to allow proper drying and the structure was reinforced with sticks.
The mould was still not strong enough and bend over the heavy weight of the mud.
Aluminium sheet metal and duct tape are rare in Ethiopia, most participants had never seen it before. The mould was also to big to transport and difficult to assemble precisely. The mould was not releasing itself, it was hard to separate the mould and hive.

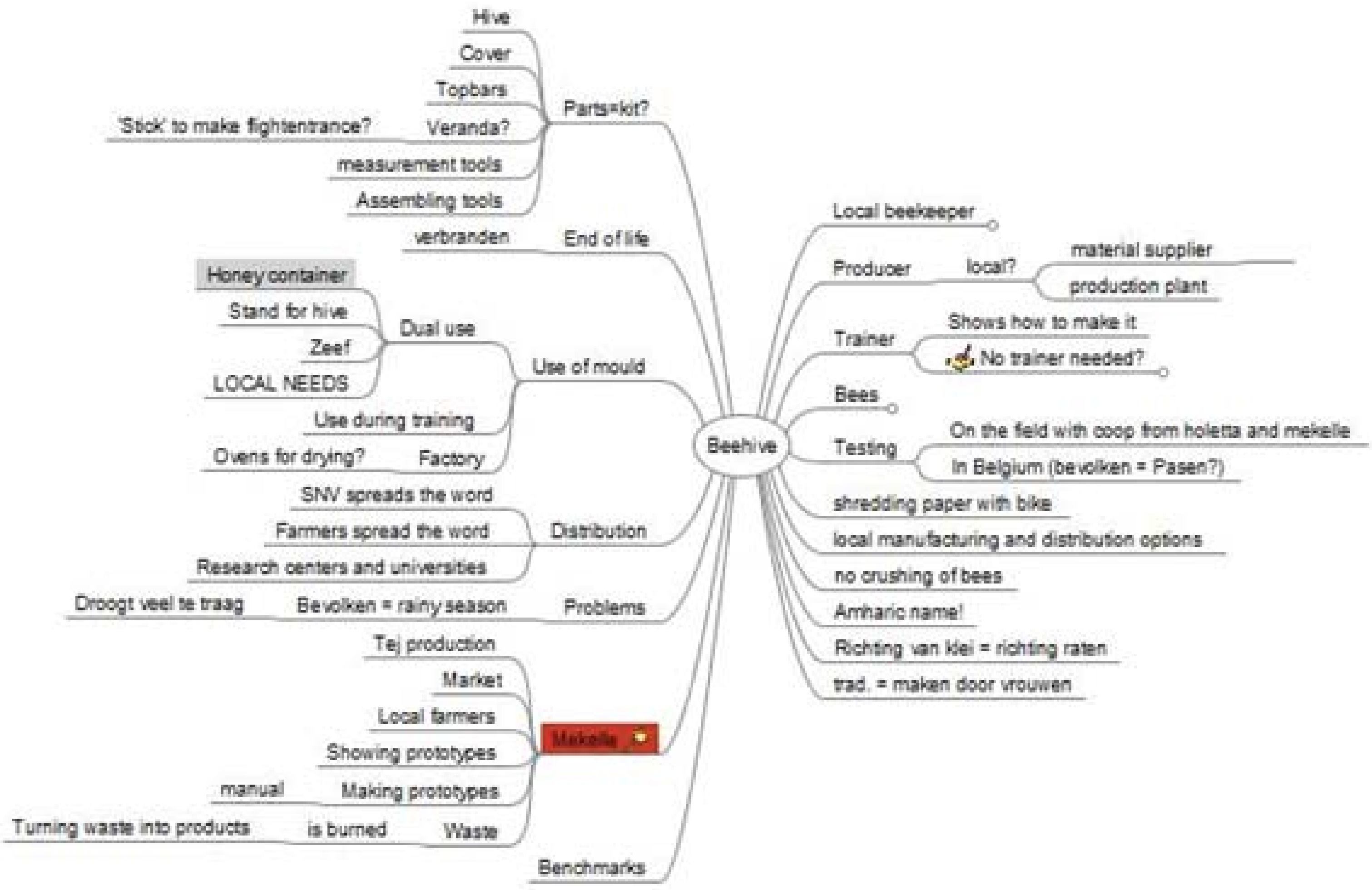
The major positive aspect of the hive was the easy to build the hive itself. I made several hives together with people from university, a research centre and the cleaning ladies at the research centre. Everyone enjoyed making it and a single sentence was enough to communicate how the hive had to be built. Another advantage is that different materials can be used on the mould.

This test was a co-discovery experience: the employees of the research centre discovered the mould together with me. This was a good way to identify the advantages and disadvantages of the mould and to develop new lines of thought such as a mould to make panels with a mould and mount them afterwards.

4. Mud hive with mould

With the same kind of mould as the one from the first test, a hive out of reinforced mud was constructed in Holetta. The aim of this test was to see if the local materials and techniques could be directly applied to the transitional hive.
The mud cracked and the hive was too heavy to transport. The mould broke under the weight of the mud.
The mud itself is a great material because it is free and easy to process, but it has low insulating capacities and it is very heavy.

2. Ideas after working with the mould



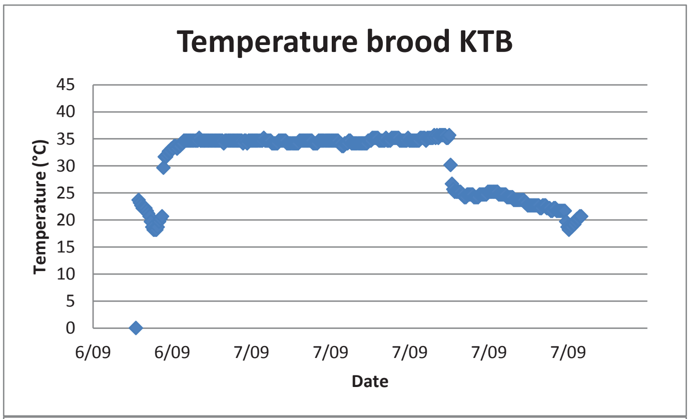
Comparison of the used hives

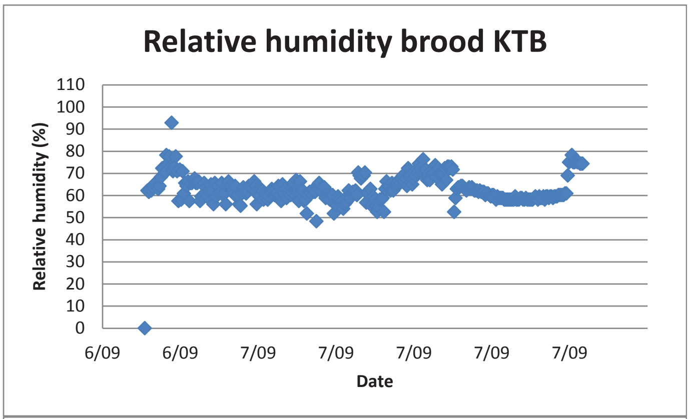
To compare the dynamics inside populated hives, the temperature and humidity were recorded in several hive types during a few days. The recording was done with iButtons [26], rugged sensors that record both temperature and humidity data. Several sensors were installed inside the hives. They were mounted into the combs and protected with a wire mesh to prevent the bees from propolizing the sensors. The sensors were installed in the honey chamber, the breeding nest, the pollen belt and at the entrance of the hive.
From Western bee races it is known that the colony maintains ideally a constant temperature of 35° C in the breeding nest so that the breed can develop to the fullest [27]. From the temperature data obtained in this test, we can state that the races that occur in Ethiopia [20] maintain this same temperature. From what is observed, it appears that in a traditional hive larger temperature variations occur. This means it is harder for the bees to keep the temperature constant.

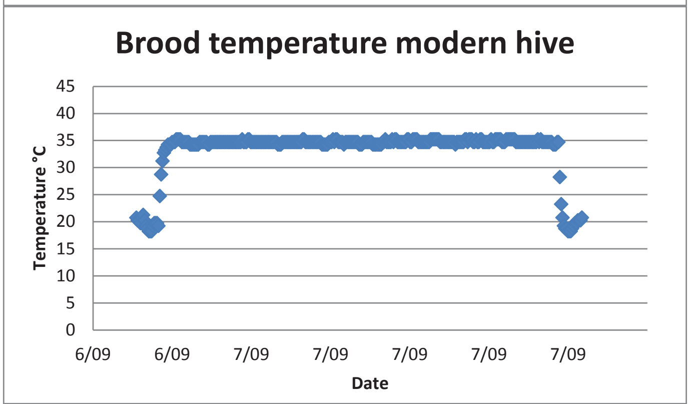
Out of this results it is not possible to draw conclusions about insulation and yield rate of the specified hive types. The temperature was measured, not the effort and activity of the colony to maintain the temperature in the breeding nest. For this assumption to be conclusive further measurements should be carried out that take the activities of the bee colonies in account, such as permanent observation in combination with temperature measurements.

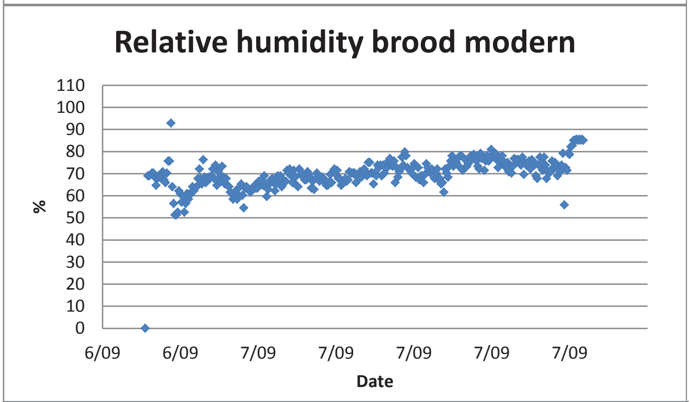


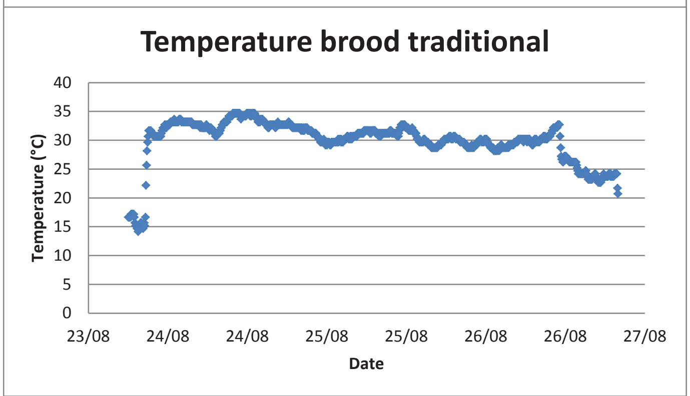
TESTING CYCLE 1: ETHIOPIA

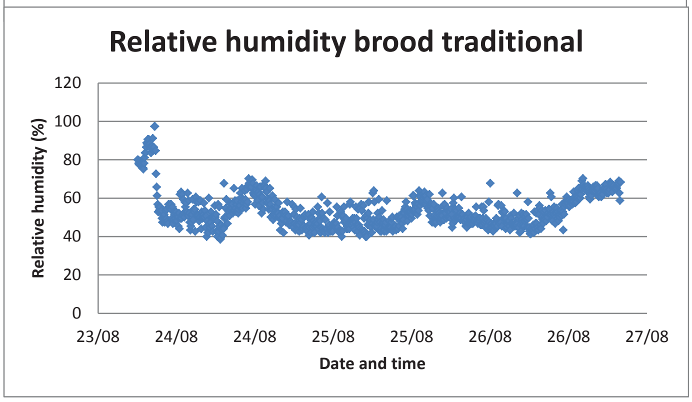












Type	Mean brood temperature (°C)	Mean brood humidity (%)
Traditional	31,21	50,83
Top bar	36,11	56,52
Modern	34,71	69,93

Western bee races keep their brood between 32 and 36°C, but ideally at 35°C. For the Ethiopian bee races we see a lot of variation in the traditional hive and a mean temperature of 31°C. The top bar hive scores better: there is less variation and the mean temperature is 36°C. The modern hive gives the best results: a mean temperature of 35°C and almost no variation.

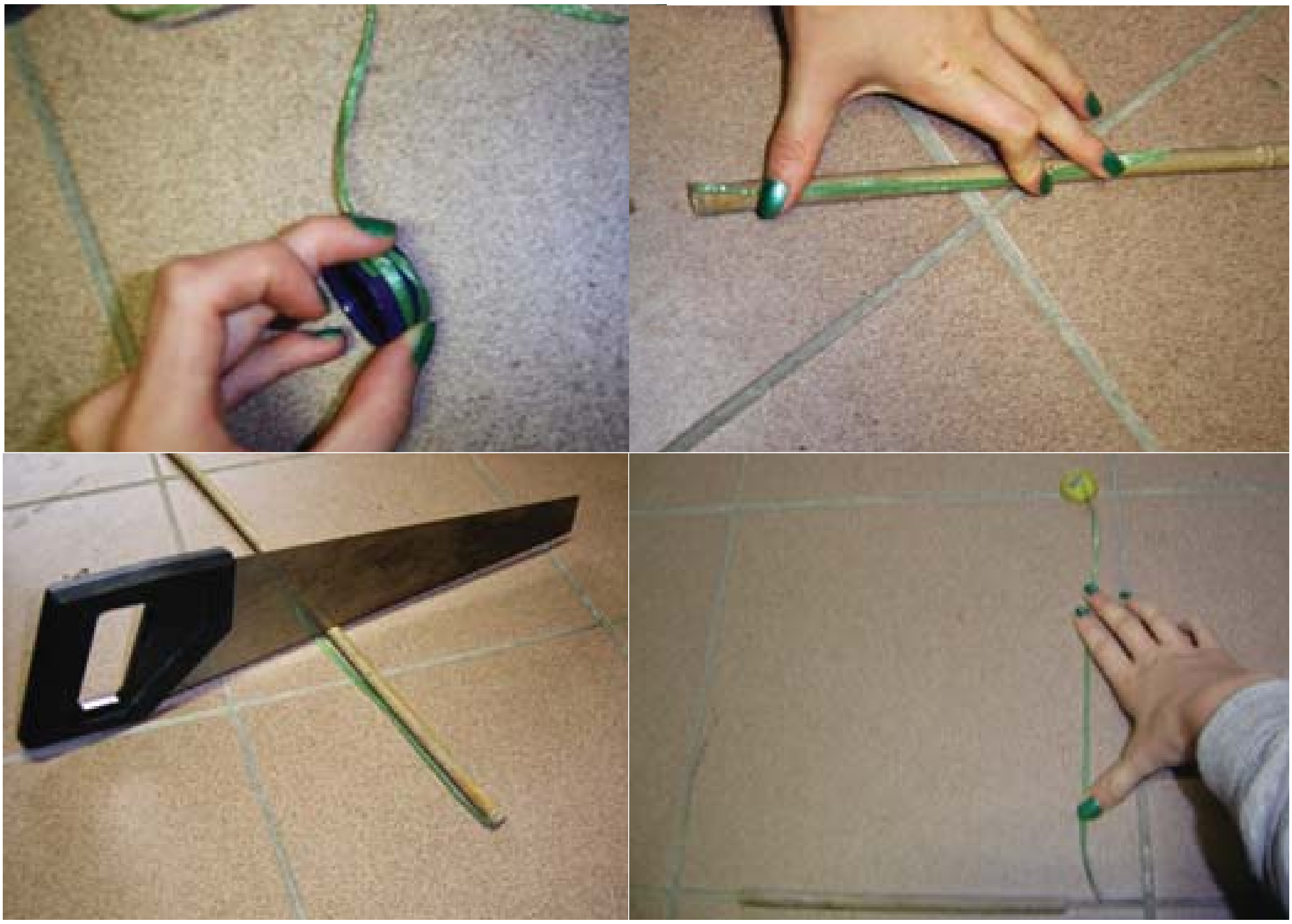
3. Measuring equipment

During the interviews it became clear that one of the main constraints of the introduction of the top bar beehive was the lack of measuring equipment.
The idea behind this test was that is possible to measure all elements of the hive with common standardized, industrial products instead of with measuring equipment such as rulers, protractors,... Using this elements, no large mould is needed.

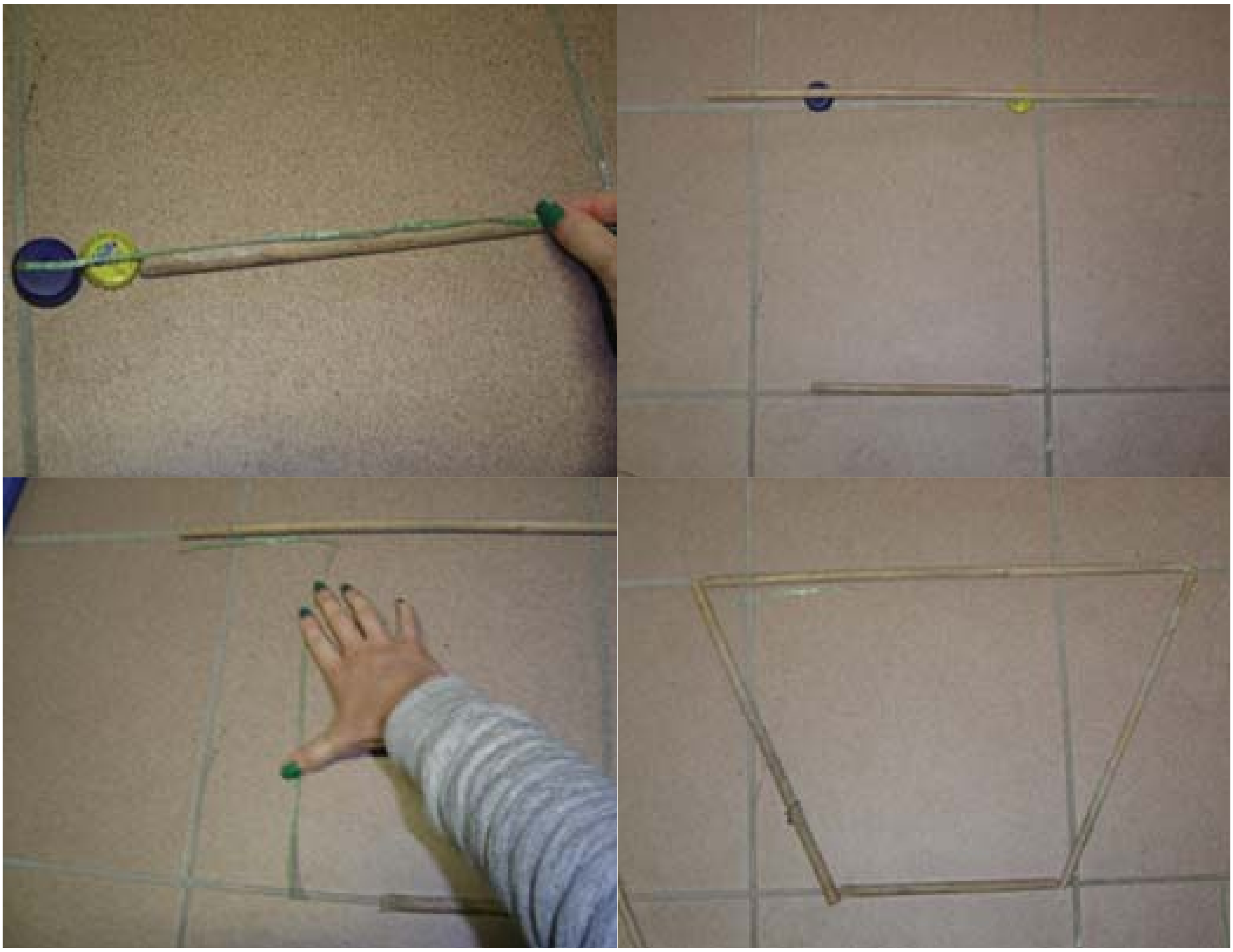
First of all I made a list of those common standardized, industrial products that can be found everywhere in Ethiopia. It ended up to be a short list.

- Bottle caps
- Car tires
- Crowns
- Jerry cans
- Corrugated iron

Then all the hive dimensions were defined a function of those materials listed above.



TESTING CYCLE 2: MEASURING

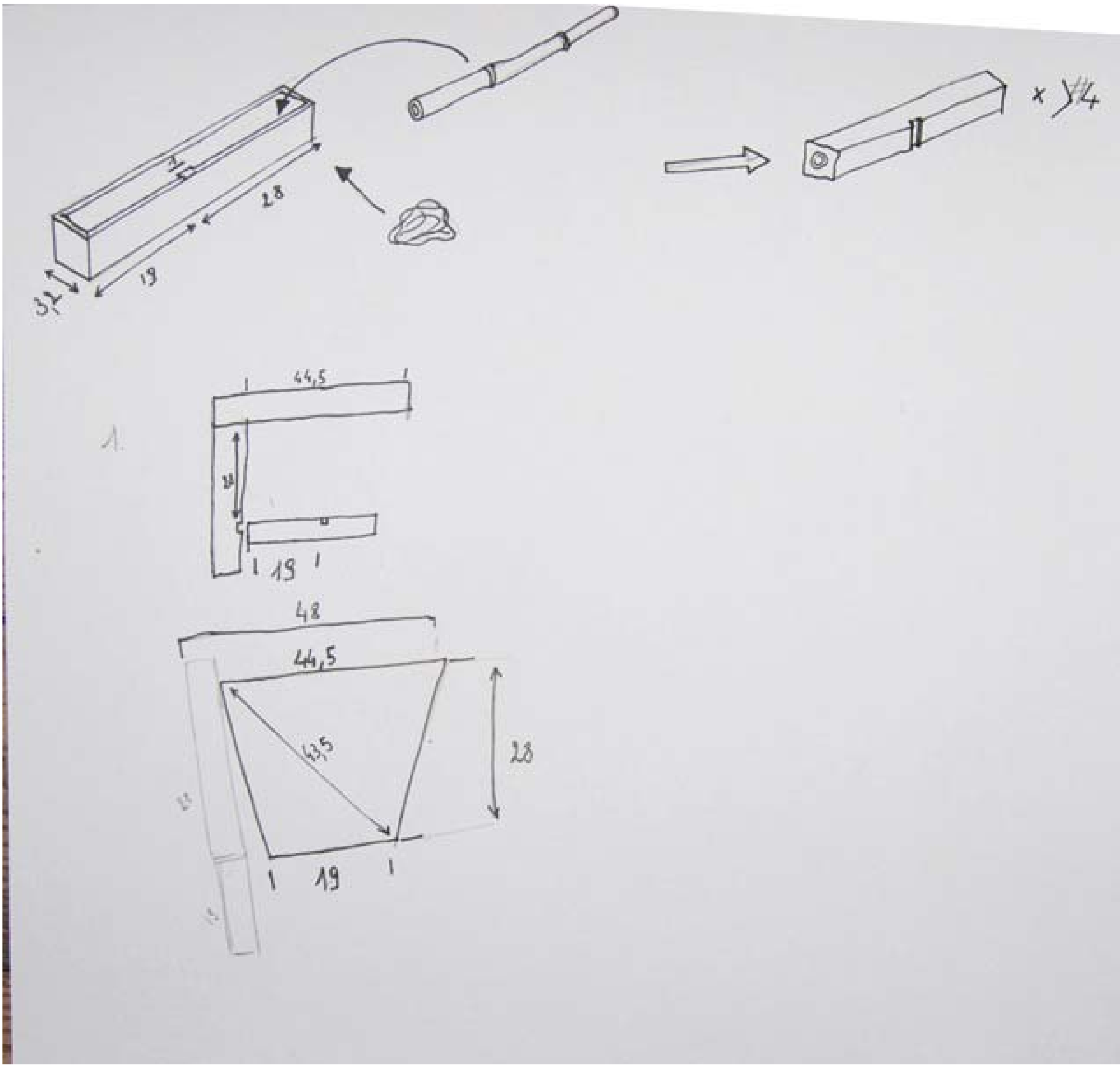


The procedure was as follows: first the length of the bottom side was determined by winding a cord around a bottle cap 3 times. This length was marked on the cord and transferred on the bamboo stick, which was sawn later. This method was applied for all dimensions of the front panel of the transitional hive.

After the test it appeared that it was very hard to measure precisely. The fact that you have to count how many times you wind the cord around the bottle cap is also a bit confusing and hard to remember. This test was not carried out in Ethiopia because it did not have added value for the Ethiopian stakeholders. The result of this test could not be used, to they were not motivated to participate.

4. Measuring top bars

After looking to the dimensions of the top bar beehive again, it became clear that most of the dimensions could be approached by dividing the dimensions of the actual top bar into 2 sections.
By providing a small mould to make the top bars, a farmer could not only make top bars but these top bars would turn into measuring devices to construct the hive.



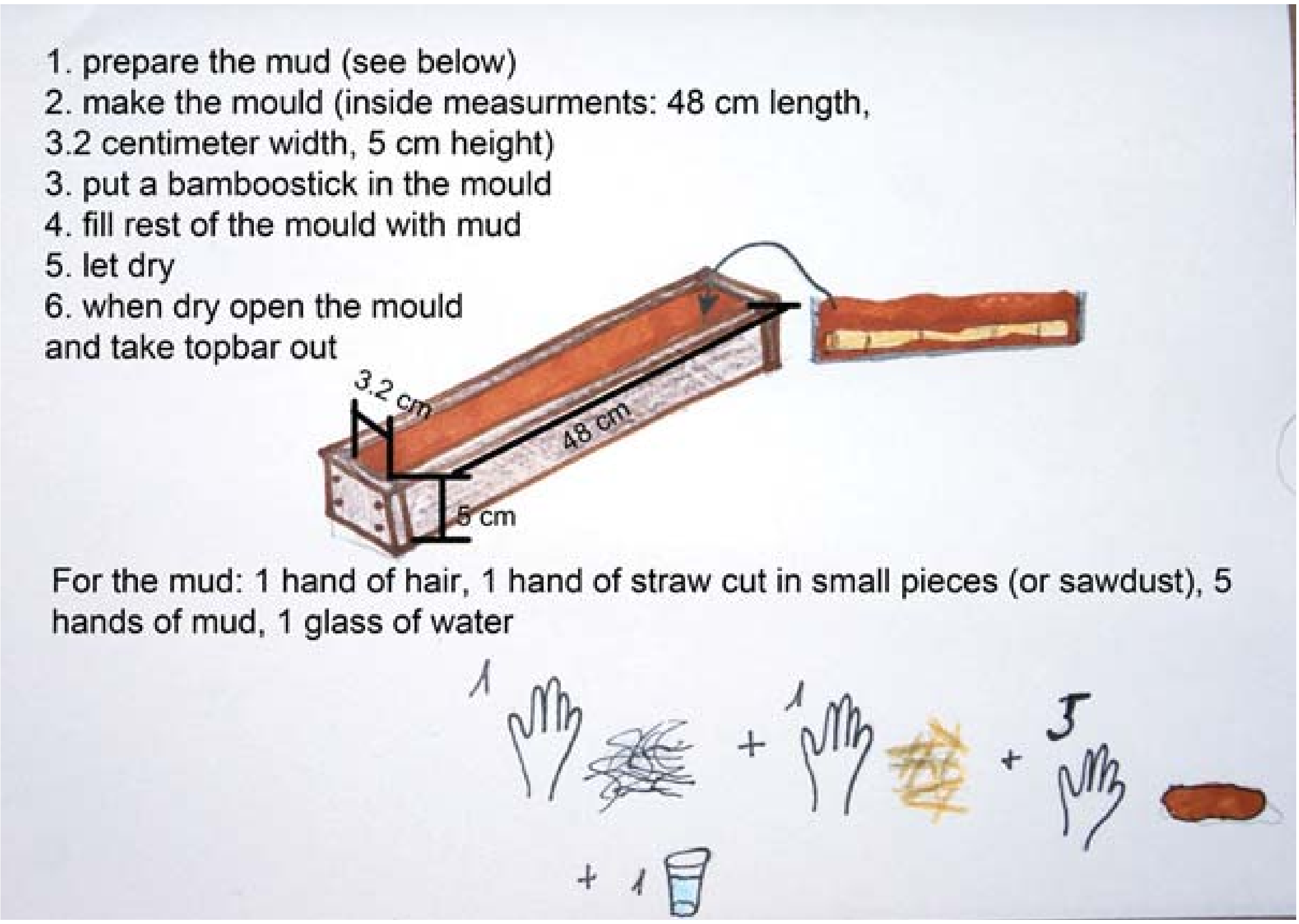
TESTING CYCLE 2: MEASURING

So by making a mould for the top bars with an engraving of 1 cm, the top bar itself becomes measuring equipment for the hive.

Now most top bars are bamboo sticks. The advantages of the bamboo are the strength, the abundance and the low cost. The big disadvantage is that, as bamboo is a natural material, the top bars aren't straight so there are gaps between them and it is sometimes hard to fit them in the hive. Without measuring equipment a farmer never knows if his bamboo top bars are 3.2 cm.

The idea behind the mould to construct the top bars and the measuring equipment at once, is to keep the bamboo as the core of the top bar. This core is covered with mud so that it takes the shape of the mould. This 'covered' top bar serves as measuring equipment and actual top bar so the measuring equipment becomes part of the hive.

As the material that is accessible for the bees to build the combs on, is still bamboo, the bees will be able to build combs on it.
The mud does not cause any trouble either, as this is already used in traditional hives.



As mentioned before, locally made box hives score low on preciseness. Because of this reason, it was not able to reproduce these moulds in Ethiopia as they have to be very precise. Another problem with this test were the hierarchic culture and budget restrictions. The intermediaries had to go through a long procedure to get budget to reproduce these small moulds. Therefore, this test was not performed in Ethiopia.

To test which materials and material thicknesses are best suited for the top bar moulds, six different moulds were laser cut and filled with bamboo and mud mixture. The types from left to right: mdf 6mm (number 1 and 2), multiplex 9 mm (number 3 and 4) and hardboard (number 5 and 6). Each type had two versions: one with a cutout for the bamboo stick in the bottom and a draft and one without.
Each of these moulds were filled with a bamboo stick and loam-hair-wood mixture. After 4 days the moulds were removed and the top bars were examined.

The 6 mm MDF gave good results: the material was strong enough, the markers left good imprints and it was easy to remove the mold.

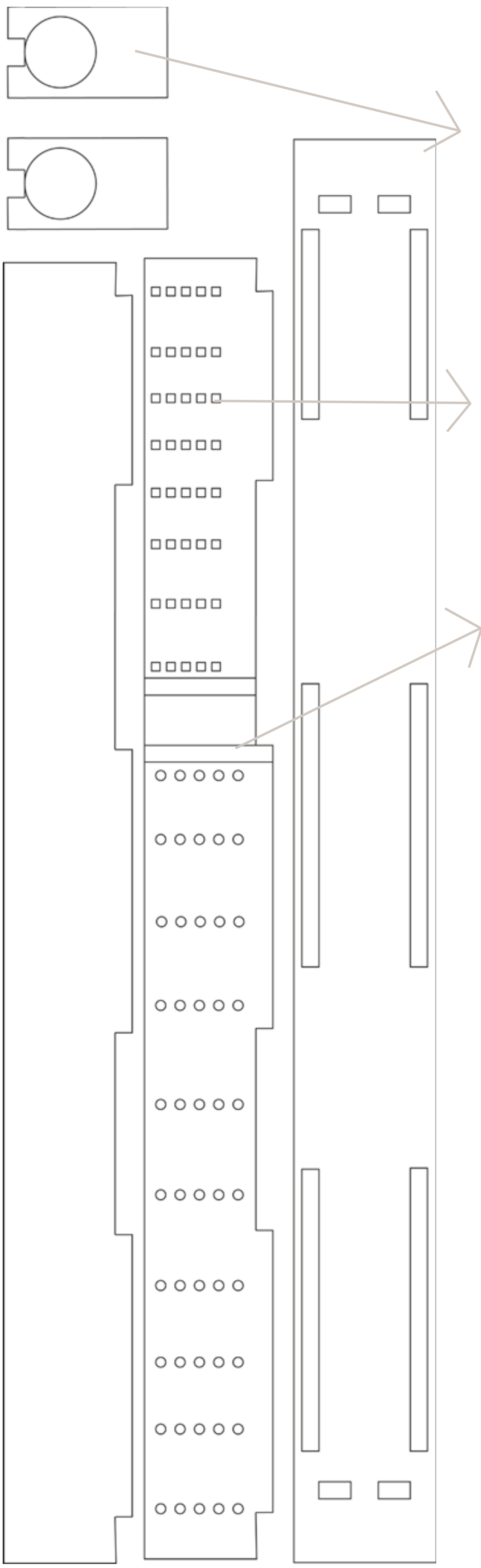
The 9 mm multiplex gave equally good results but the material was to thick for proper laser cutting.

The hardboard did not give good results. The material was to weak and not water resistant. The marks were to thin and did not leave clear imprints.

General conclusions:

The cutout and draft did not have an effect: the mould was easy to release without draft as well. The bamboo was unable to sink in the cutout because the cutout could not be made large enough.

A 6mm water resistant material is ideal for these moulds.



A new version of the mould, to overcome the difficulties of the previous ones, was lasered according to this drawing.

In the small sides holes were provided to stick the bamboo through. These holes are an indicator for the appropriate bamboo thickness and hold the sticks in place.

The small cavities in the long sides make sure that the mud mixture at the bottom dries too. The cavities have a square and round shape. The difference is an indicator for the short and long side of the top bar and can be used in the manual to highlight the difference.

In the long side, the engravings mark where to place the markers (the markers are formed by the pieces that are cutout of the bottom)

TESTING CYCLE 2: MEASURING

	Top bar 1			Top bar 2		
	1	32		1	32,4	
	2	31,9		2	32,3	
	3	31,2		3	32	
	4	31,6		4	32,1	
	5	31,6		5	32,1	
	6	31,5		6	32,2	
	7	31,5		7	31,9	
	8	31,2		8	31,8	
	9	31,5		9	32,1	
	10	31,7		10	32,2	
Mean:		31,57			32,11	31,84

Two random top bars were measured at 10 different points in the length. They had to be 32 mm width. As shown in the table above the maximum deviation is 0.8 mm. In general the deviations are less than half a millimetre, so we can conclude that these moulds are good to produce top bars within tolerance.

Next step to make the top bars dimensionally stable is to produce a lot of top bars in different conditions (different curing times, different mud mixtures, different drying temperatures and humidities). By measuring these top bars, the extreme acceptable values to produce top bars within tolerance can be found. These values are important when describing the process in the manual.

TESTING CYCLE 2: MEASURING

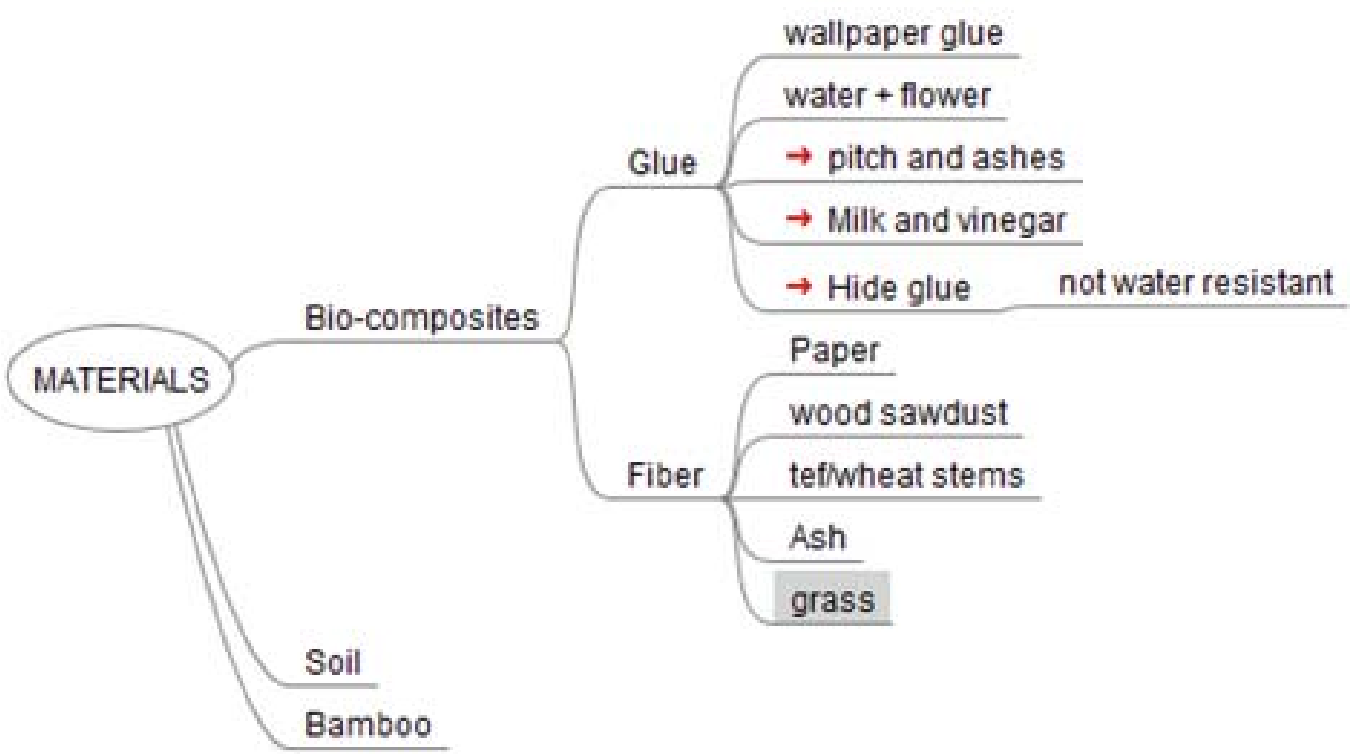
Five different curing durations and two different mud mixtures were used to make topbars with the mould. Each top bar was measured on ten different points to see if the tolerances were maintained if the drying time and the exact mud mixture was not respected.

Drying time	24 u	36 u	48 u		72 u
Mixture	A	B	A	B	B
Measurments	mm	mm	mm	mm	mm
1	32,7	31,6	31,6	32,6	33
2	31,5	31,7	31,6	32	32,8
3	31,2	30,9	31	32,1	32,8
4	31,2	32,4	31	31,3	32
5	32,8	31,2	30	31,2	32,1
6	32,6	31,2	31	32,3	32
7	33	31,4	30,6	30,7	32
8	32,9	31	31,3	31	31,9
9	32,6	31,9	32,3	31,4	32
10	32,1	31,9	31,7	31,7	32
Gemiddeld	32,26	31,52	31,21	31,63	32,26
St. Dev	0,709	0,469	0,642	0,611	0,425

Conclusion:

The curing time of the mud mixture does not affect the tolerances largely. However, the curing time is important for the strength of the top bar. Releasing the top bar from the mould too early causes fragile top bars that will break in no time. The marks are visible regardless of the drying time.
The moulds do not wear after multiple uses. In the worst case, a bit of mud sticks to the mould (when the top bar is taken out too early). This can be washed of with water and does not cause any deformations.

2. Brainstorm materials



After the listing of common materials in Ethiopia, I looked at free natural or waste materials. A promising line of thought were the bio-composites formed with hide glue or pich and ashes and reinforcing fibres such as hay or ashes.

Glue made out of pich was not further examined because it is hard to obtain and rather scarce. For one hive, a large amout of glue would be needed, which is not feasible with pitch, not in Belgium nor Ethiopia.

3. Mud reinforcement

When using a mixture of only loam and water, the risk of cracks in the surface is high. To prevent the hive from cracking, fill materials are added to the loam mixture [28]. Other factors to reduce cracking are humidity, temperature and composition of the loam soil. These factors are almost impossible to control in a low-tech environment. Fill materials can be: wood chips, straw, hair, …
To become familiar with the difference the filling materials make, 3 'top bars' were made with different loam mixtures. One with only loam, one reinforced with human hair, one reinforced with hair and wood flakes (to get a better insulation).
The third top bar, with the wood and hair, showed no cracks, in contrast to the other two.

6. Hide glue

During the test with the mould in Ethiopia, we actually used a biocomposite by using paper and wallpaper paste (which could easily be replaced by glue made of wheat flour and hot water).
As the paper paste did not give satisfying results and because wheat flour is a primary food source for the poorest of the poor, the combination of paper and wheat paste is not feasible. Besides, waste paper is not collected but burned. In small rural villages only a very limited amount of paper is available, not merely enough to make hives with.
Looking at other bio-composites that could be made with materials available in Ethiopia, reinforced hide glue comes forward. Glue made out of animal skin [29] was a promising material as hides are waste material and come free with the purchase of slaughtered animals. Again there were three top bars made, one with only the glue, one reinforced with hair and one reinforced with hair and wood.

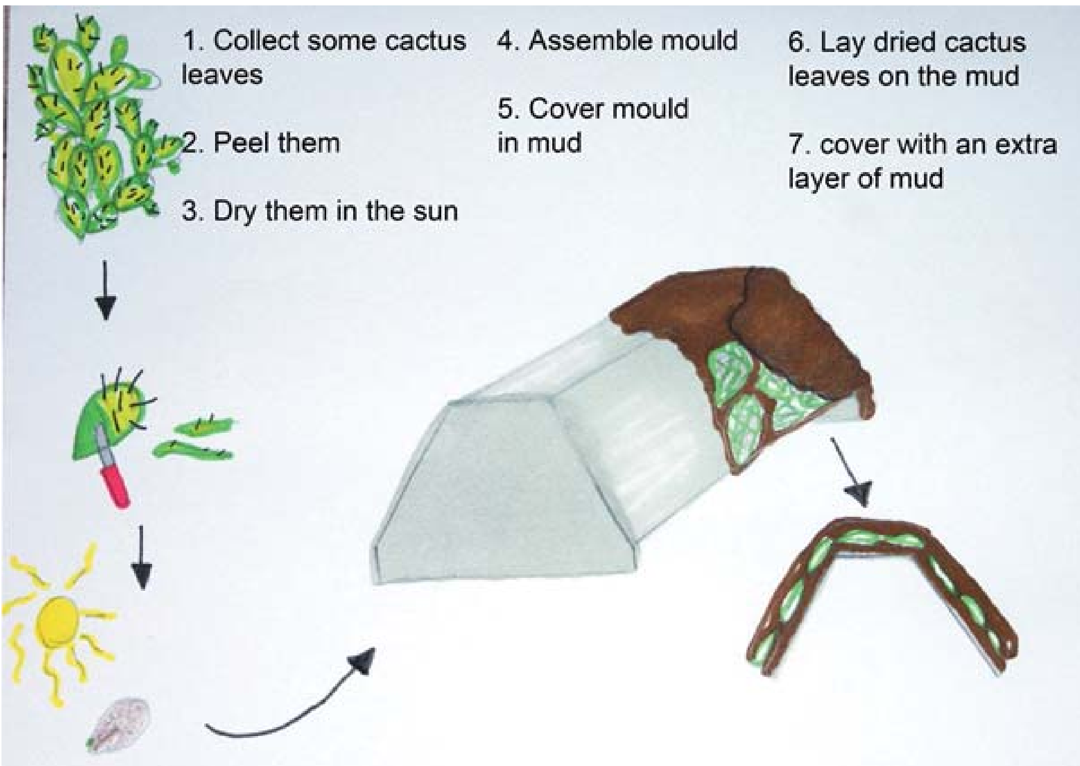
The result was not as hoped: the reinforced top bars didn't cure entirely and after a while they started to mould. On top of that, the glue is soluble in water, so the hive would not last long.

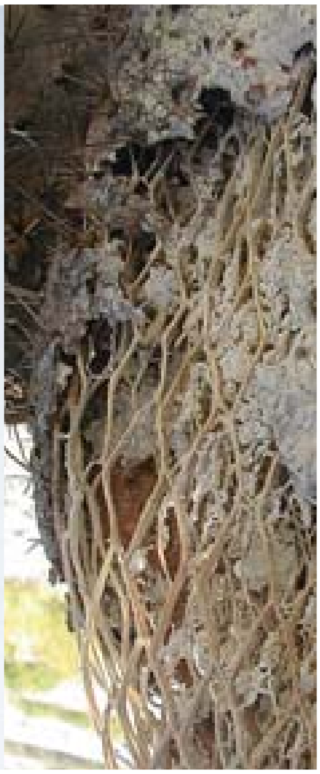
After this test, to focus returned to the mud-mixtures, combined with bamboo, as they are both easy to obtain and to work with.

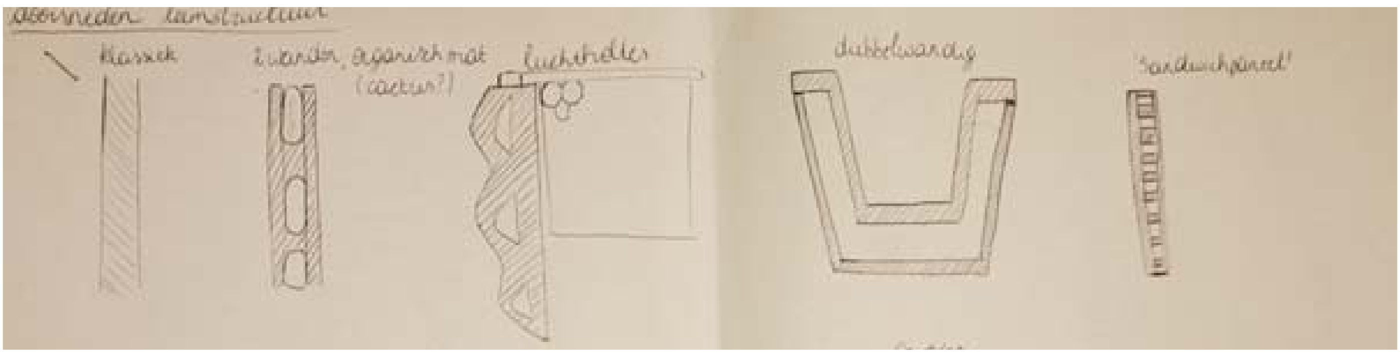
Mud with cactus

On the livelihood conference in Mekkele, A. Gebrekidan presented a paper about water filtration with dried cactus leaves. This cactus, the Opuntia species, grows especially in the Northern parts of Ethiopia. The fruits (called 'Beles') are eaten as a snack during dry season and the leaves are used as animal fodder. [30]

To make the hives more insulating and make them lighter, the dried cactus leaves could be inserted in the structure of the hive walls.
To make this work, there should be experimented with different wall structures. In the final Adis hive, the cactus leaves are not used in the wall structure. The frame is built with bamboo stick, which are light on their own and then plastered with mud. This prove to be insulating and light enough.







Testing of insulation qualities

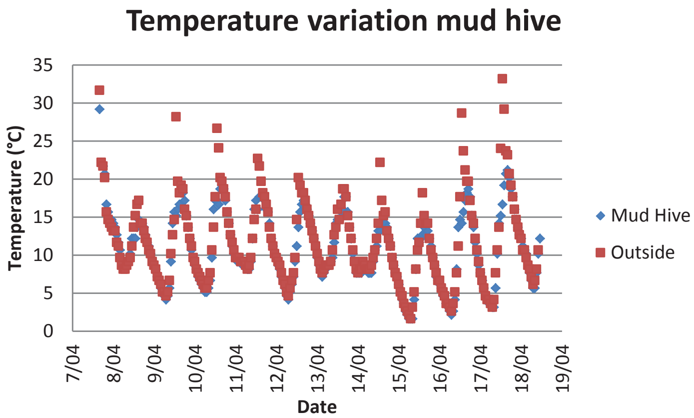
To compare the thermal insulation qualities of different hive types, unoccupied hives were installed on a south faced bee stand. They were left outside for 10 days with sensors to record temperature and humidity data. At the stand, a sensor was attached to record the outside temperature and humidity. Two 'beehives', two wooden top bar hives, three modern hives, three Kirchhain hives (small Styrofoam hives for queen rearing and transportation) and two mud hives were compared. One of the mud hives was composed of a loam mixture (loam, hair, wood chips and water) applied to an MDF mould. The other mud hive was composed of the same mixture but with honeycomb structured cardboard for extra insulation. The cardboard simulated the dried Opuntia leaves that would be used in the final product. The iButton sensors were placed on the bottom of the hives.

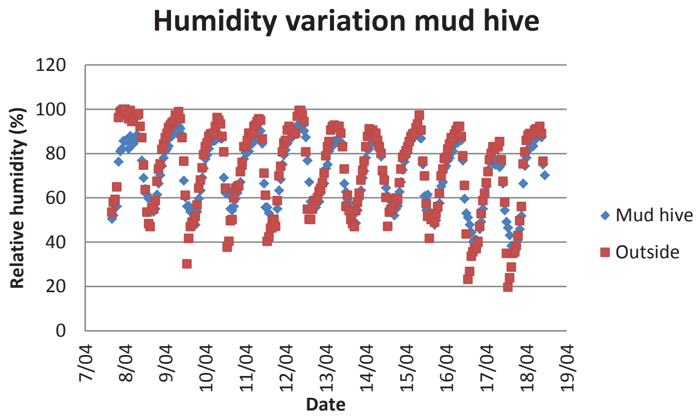
After 10 days the data were collected and compared. One sensor in the Kirchhainers did not record data so this one was excluded from the test. The temperature inside the hives was reduced with the outside temperatures. The absolute value of this operation was averaged. The absolute difference between the hive temperature and outside temperature should be large, as this means that the hive cools down slow at night and heats slow during the day.

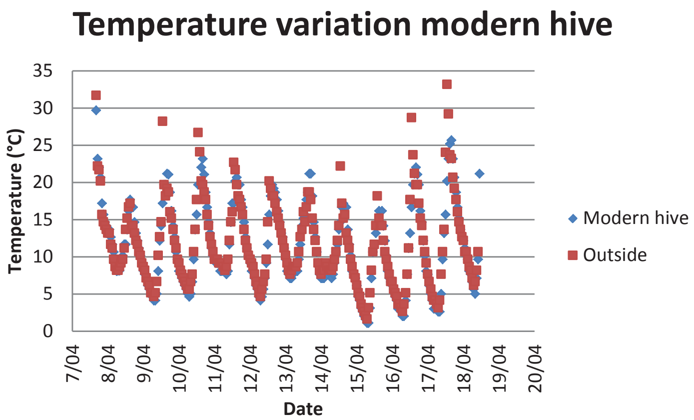
Also the difference in both time and value of the peak records from inside and outside were compared. The same method was used for the humidity. The sensors measure the relative humidity, so some records in the data set of over 100% should not be excluded. The hives were ranked according to the difference between inside and outside temperature and humidity.

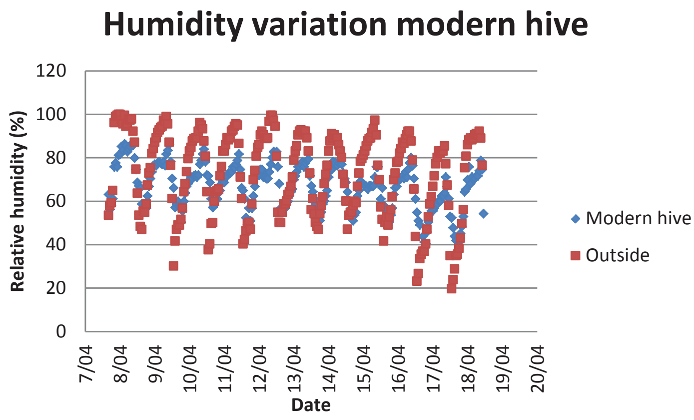

2x

TESTING CYCLE 3: MATERIALS









Type	Difference temperature		Difference humidity
Topbar 1	0,910	Ethiopian Mud	5,779
Modern 2	0,992	Kirchainer 2	6,118
Ethiopian Mud	1,034	Topbar 1	9,717
Modern 3	1,099	Kirchainer 1	10,139
Ethiopian Cartboard	1,135	Modern 1	11,255
Skeps 1	1,156	Topbar 2	11,759
Modern 1	1,163	Modern 3	11,958
Topbar 2	1,220	Modern 2	13,456
Skeps 2	1,298	Ethiopian Cartboard	15,213
Kirchainer 2	1,787	Skeps 1	21,464
Kirchainer 1	2,068	Skeps 2	41,322

In the temperature measurements it is remarkable that hives of the same type show a difference in insulation qualities. But as the data are close together, there is no significant difference. This means the mud hives are in the range of the classical hives and their insulation value is thus acceptable.
The humidity values lie further apart. The two mud hives score respectively the best and third worst. There is too much variation in this values to draw conclusions.

There is no significant difference between the hives with and without cardboard. Therefore, the cactus leaves will not be used in the body of the hive.

TESTING CYCLE 4: COVER

The lid

Now, the top bars are covered with plastic sheeting that is stretched over a wooden frame.
As one the aims of this project was to develop a hive composed of local and sustainable materials, no wood could be used. Another goal was to work with nearly free materials. This was accomplished by using 4 bamboo sticks (those can be the leftovers from building the actual hive), cactus leaves and jute bags and plastic bags (used for flour storage).

The jute bag is loosely woven, leaving room for ventilation. The vapour produced by the bees can escape through the holes. Inside the bag are cactus leaves and hay, serving as both thermal insulation and vapour buffer. The amount of ventilation holes can be regulated by the bees themselves, by blocking or opening some holes with propolis (the sticky substance bees use to seal cracks). This was inspired on the eco-hive [12]
The lid can be taken off by loosen the cords holding the bamboo sticks together. The bags can be shoved backwards over the bamboo sticks instead of opening the whole hive. This principle is also used in modern beekeeping. With only half of the hive opened, the bees remain calmer.
The lid has to be waterproof as the hives are kept outside all year round. Therefore, the top of the lid is covered with plastic bags and sealed with waterproof cactus mixture (see Tests waterproofing).




Waterproofing with cactus juice

In Ethiopia the Opuntia fica-indica, also known as the prickly pear cactus is a very common plant. The leaves are used for animal fodder. [30] The fruits, called 'beles' are eaten as a sweet snack. Recent research shows that the Opuntia can also be used as a filter to remove pesticides. [31]

[33] and [32] describe that the prickly pear can be used as thermal insulation and used in mortar to make it waterproof. Both of these less common application of the prickly pear cactus are suitable for the Ethiopian hive: the leaves can be used as insulation and thermal buffer in the lid of the hive. The juice of the leaves serves as waterproofing of the hive and lid.

In the context of the SUDU (Sustainable Urban Dwelling Unit) [32] project, this waterproof mortar was re-introduced in Ethiopia. There is proof that this mortar was used for centuries but is now forgotten. This is one of the reasons why more and more houses in Ethiopia have a corrugated iron roof: without the waterproof mortar the inhabitants are unable to repair their roof.

There is no exact recipe to produce the waterproof mortar: it depends on the soil type and weather conditions. But, regardless these parameters, the main ingredients remain the same: loam, sand, salt, lime and fermented prickly pear juice. To order to verify the role of the prickly pear in the mortar, in other words: are all these ingredients necessary or is it sufficient to just smear the juice onto the mortar, following test was carried out.

Some Opuntia leaves were collected from the botanical garden of the Ghent University. In this test, leaves of the Opuntia Phaeacanta v. pierces and the Opuntia leucotricha where used. All varieties of the Opuntia species contain pectin but the amount can vary from 0.8 to 3.3% of the wet weight [34]

TESTING CYCLE 5: WATERPROOF

	Filtered juice applied on loam	Unfiltered juice applied on loam	Loam mixed with filtered juice	Loam with unfiltered juice	Recipe with filtered juice	Recipe with unfiltered juice
Cracks	xxx	xxx	xxxx	xxx	xx	xx
Waterdrops remain on the surface	xxxxx	xxxx	x	x	xx	xx
Water penetrates to the back	xx	xx	xxxx	xxxx	x	x
Mixture gets sticky	x	x	xxxx	xxxx	xx	xx

TESTING CYCLE 5: WATERPROOF

Each of the tiles with mud and cactus was sprayed with water and then turned around, to see if the water penetrated the mud. The left column show the front, the rigth photos show the back of the tiles. From top to bottom: mud smeared with unfiltered cactus juice, mud smeared with filtered cactus juice, mud mixed with cactus juice, mud prepared according to the 'SUDU' recipe.

Conclusion:

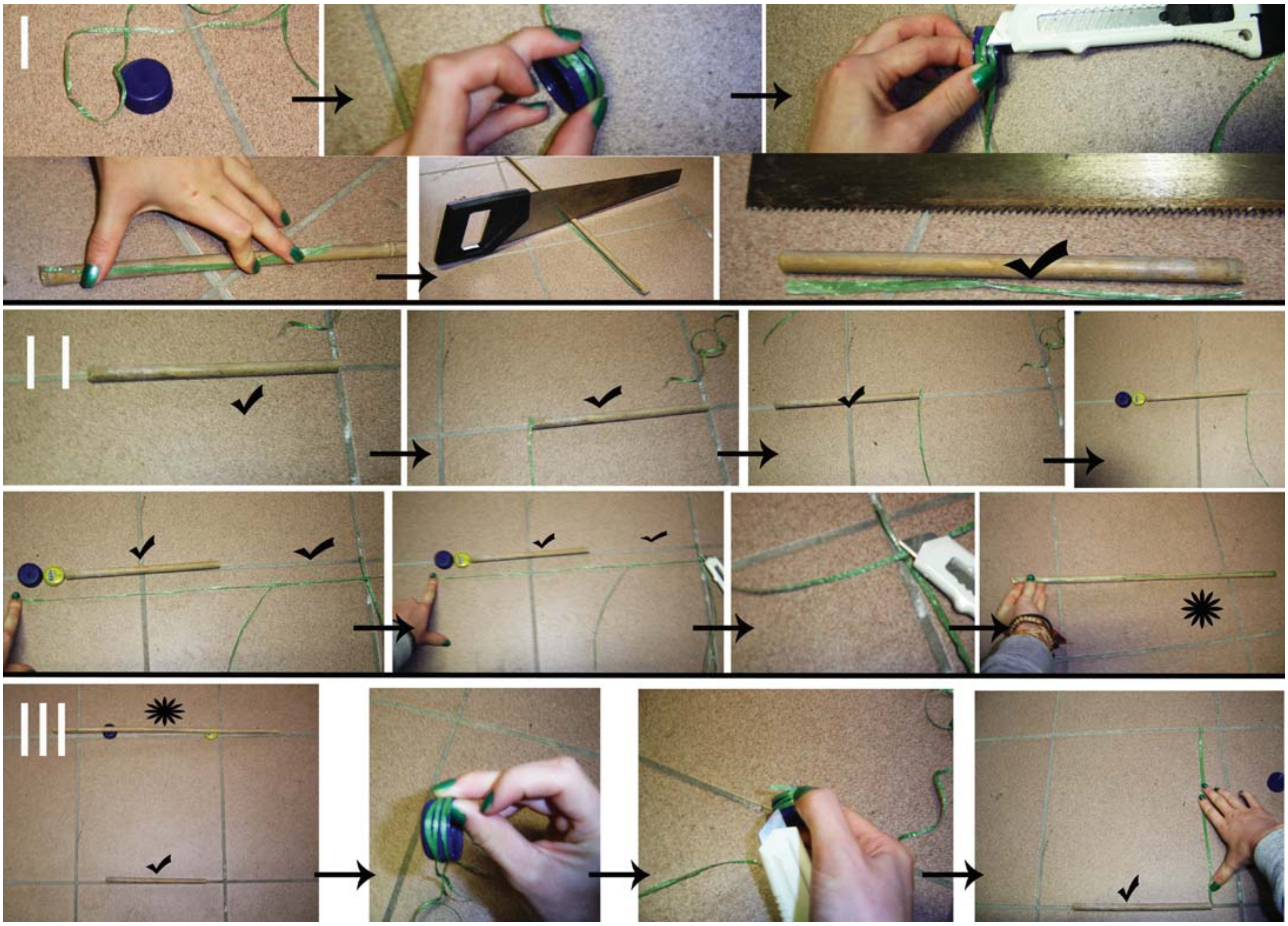
The cactus juice that is smeared on the surface of the loam mixture is suited. After 10 days outside, the tile was still firm and after spraying on it, only at the edges, water came through. The mud recipe were the mud was mixed with cactus juice was not suited: the tile crumbled and water came through. This is probably because the concentration of cactus juice was not high enough.
The Sudu recipe was also very well suited.

There was no significant difference between the tiles wit filtered and unfiltered juice. As using unfiltered cactus juice is easier than filtered and because smearing gave good results, smeared unfiltered cactus juice will be used.

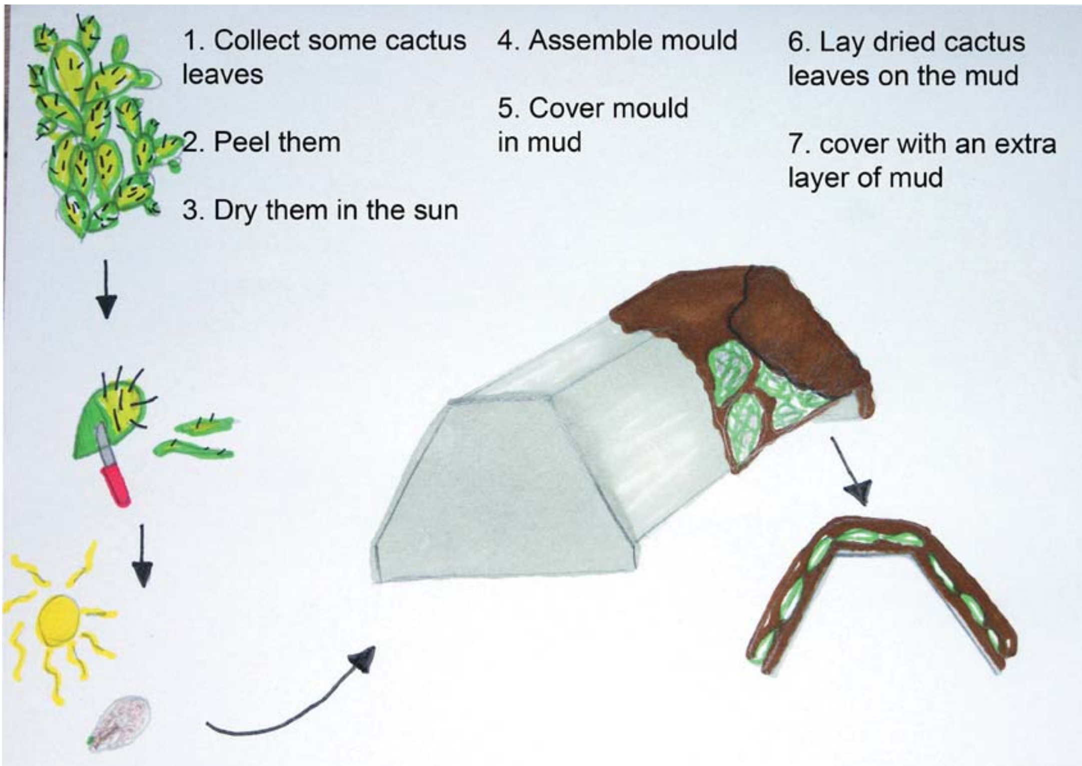
The cactus was also smeared on the plastic bag to make sure it was also working on that underground. After lying outside for two weeks, the bag was still waterproof.

TESTING CYCLE 6: MANUALS

One of the main difficulties in this project was designing tests and communication with the end-users and intermediaries, without physically being there to give instructions or deliverables.
In the first tests a manual with pictures was sent by e-mail to the intermediaries, with the question to carry out the instructions.
However, this did not work. The pictures were not clear enough and the goal did not serve the intermediaries: it was only about measuring things, but there was no real end product after performing this test. As the test was not useful for the test persons, they did not carry out this test.



Next step in the manual process was to draft a template that could be used in each of the future tests. The template starts with the goal and purpose of the test. Then the needed materials and tools are summed up. Then their is a description of the test in sketches. Finally, there is an evaluation sheet for the findings during the test, using the premo evaluation tool.



User test evaluation

why did you take this picture?

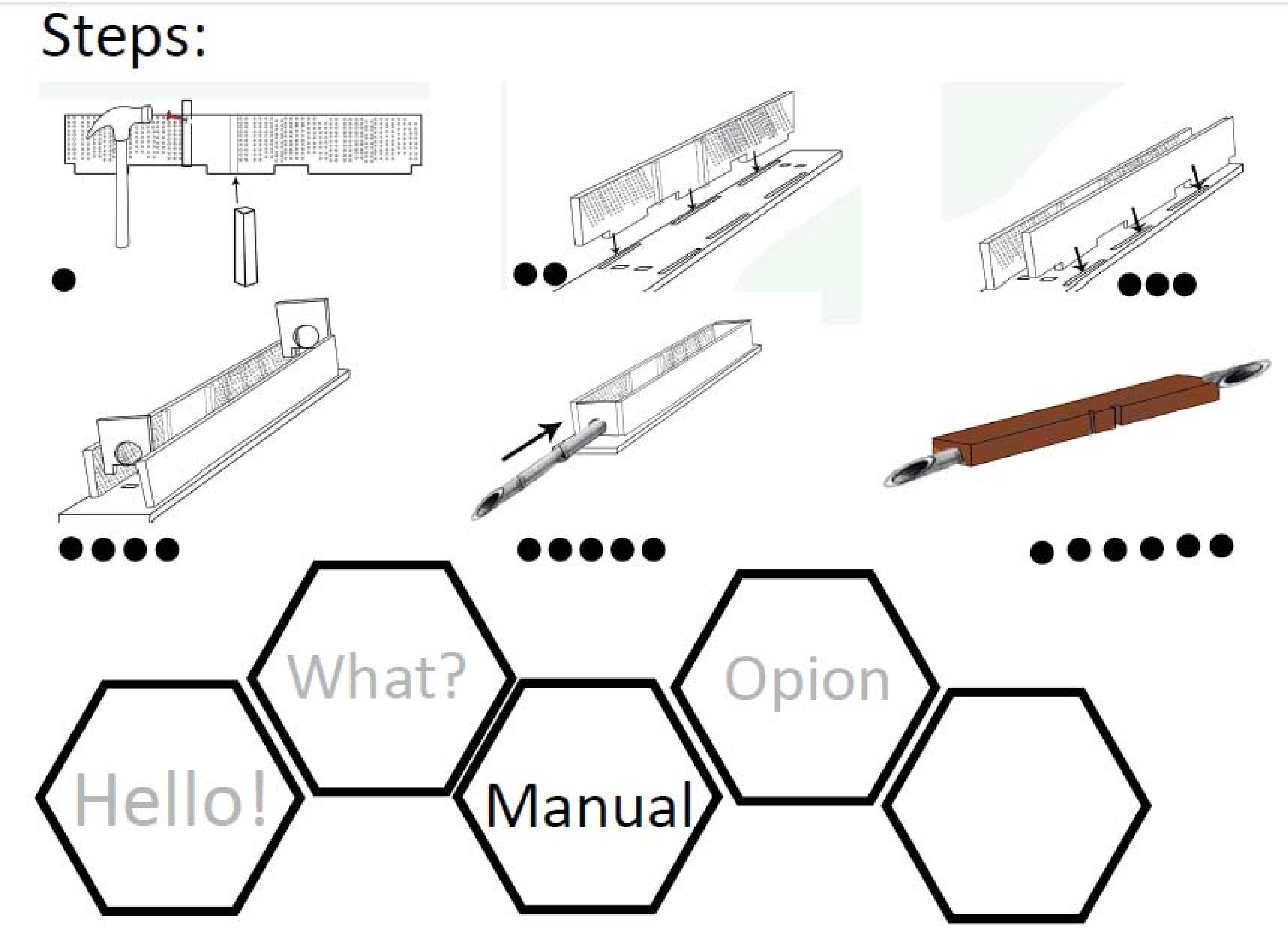
photo number: ___
was the experience positive or negative?

why did you take this picture?

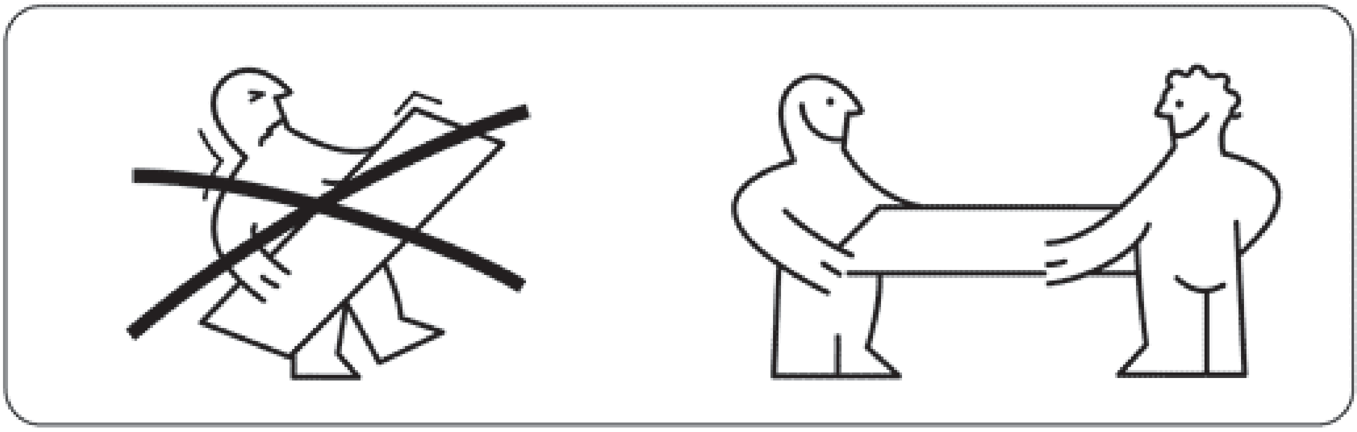
photo number:
was the experience positive or negative?

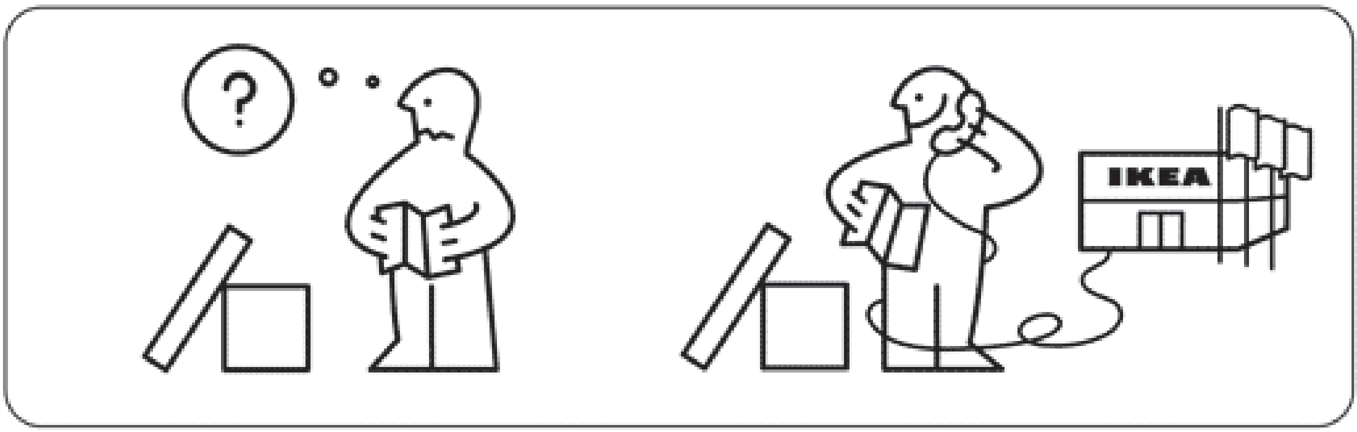
TESTING CYCLE 6: MANUALS

This approach systematically evolved to manuals purely based on (computer) drawings, as they are clear, and easy to manipulate. The manual shown below was sent to the intermediaries together with an Adis kit for testing. These tests are currently being executed in Ethiopia.

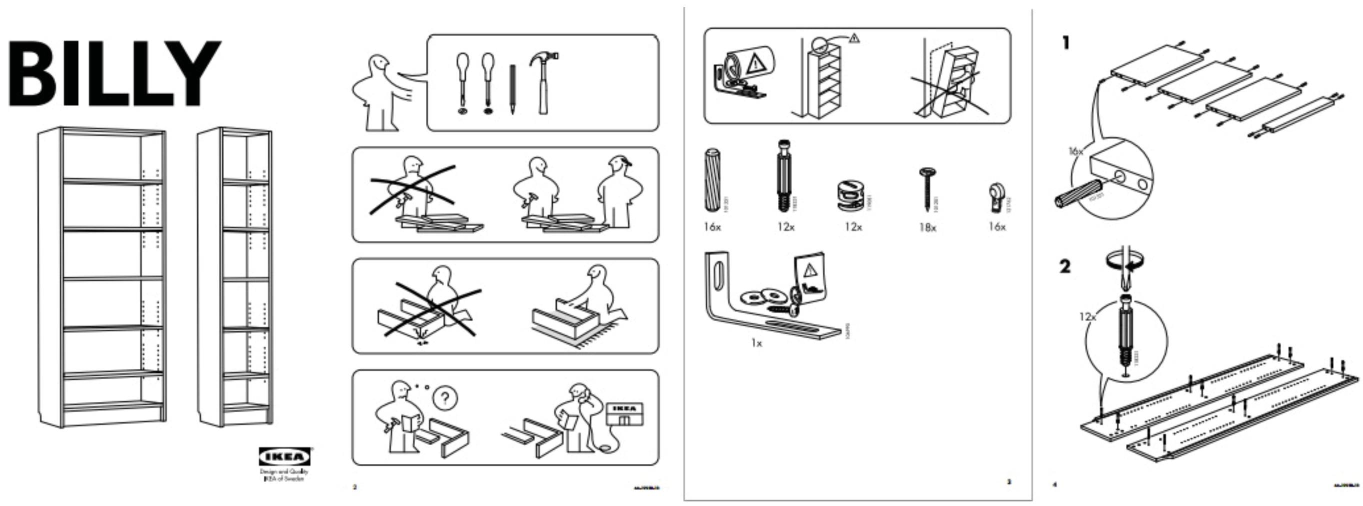


Benchmarks





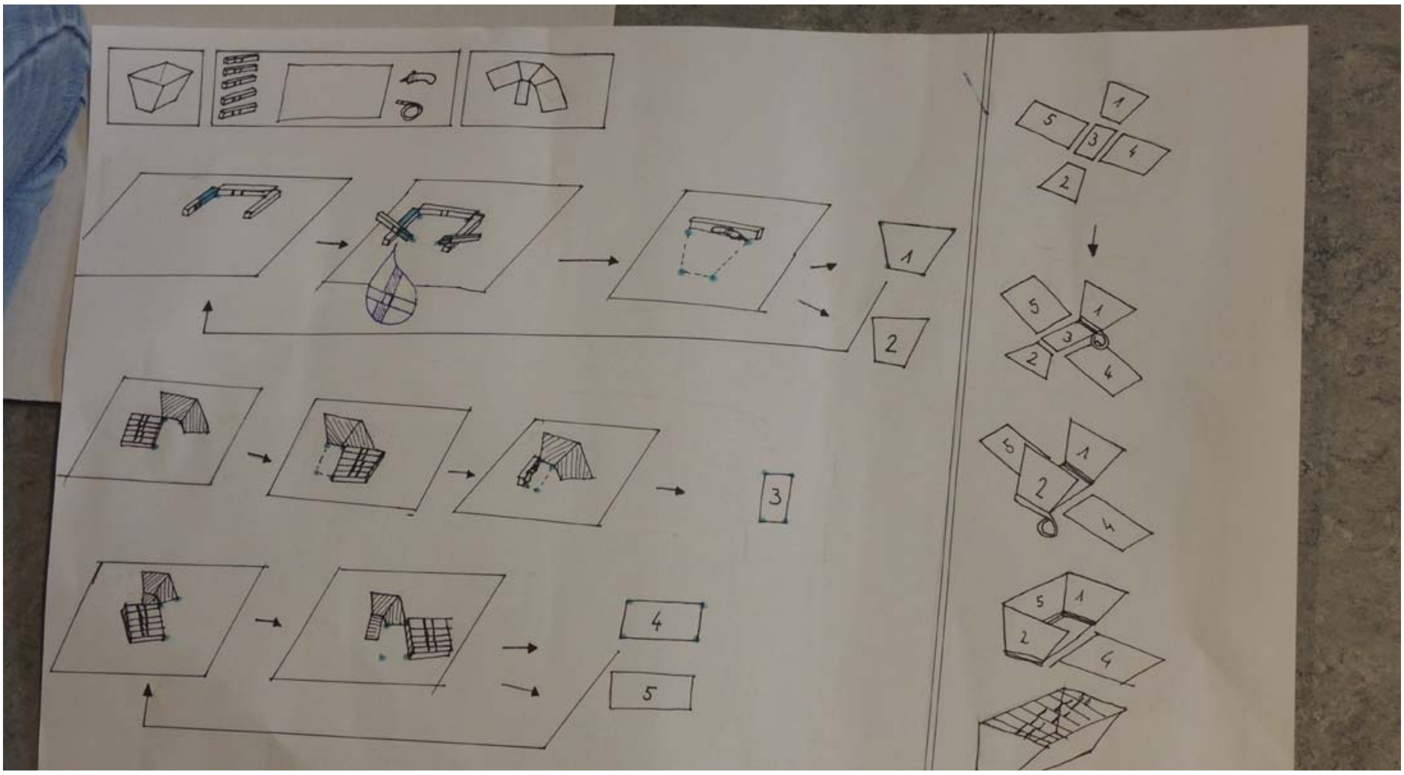
IKEA is the stereotype of a clear manual [35]. It has a clear visual language and small easy steps. The manuals use isometric perspective with little close-ups to demonstrate the key elements of each step. Important in this manuals is that not a single word is used. This is one of the goals of the manual to build the beehive, as a lot of the farmers are illiterate.



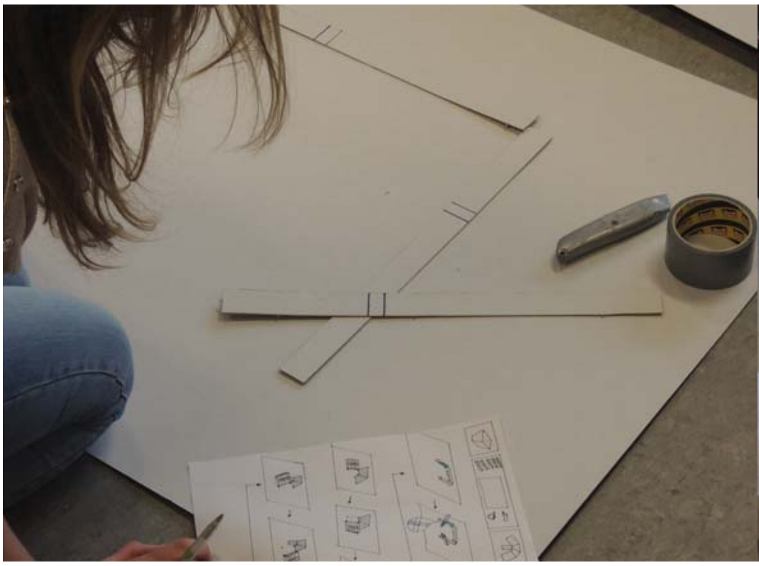
TESTING CYCLE 6: MANUALS

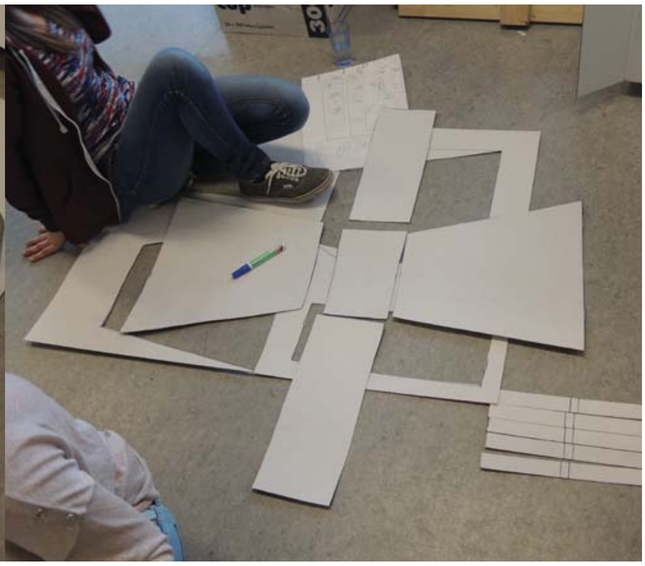
The manual above, from the design agency Special Projects, [36] for Samsung literally guides the user through the installing process of a new phone. The interesting aspect for my project is that the manual is inherent to the product.

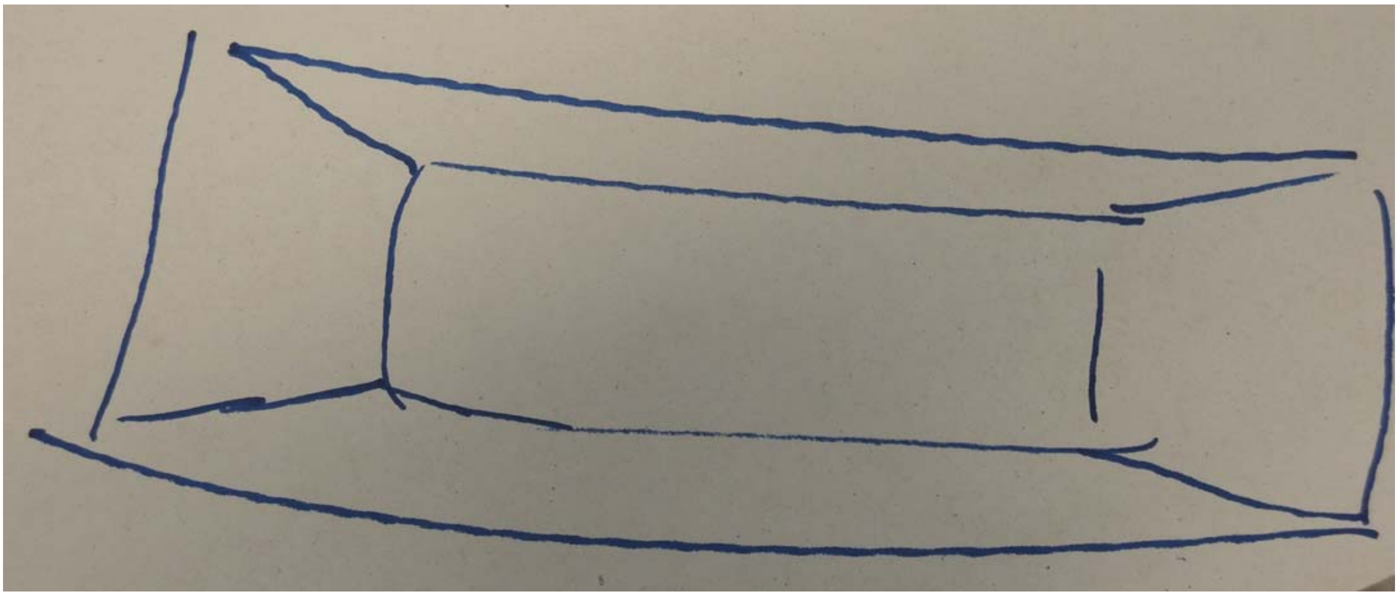
The manual below is from the brand Parelli [37] and uses different media to train the user. The manual consists of 'levels': in each level you learn to perform a task and get a sneak peak of what is next. The manual of the hive will also consist of different sections, the end user can complete any section separately.



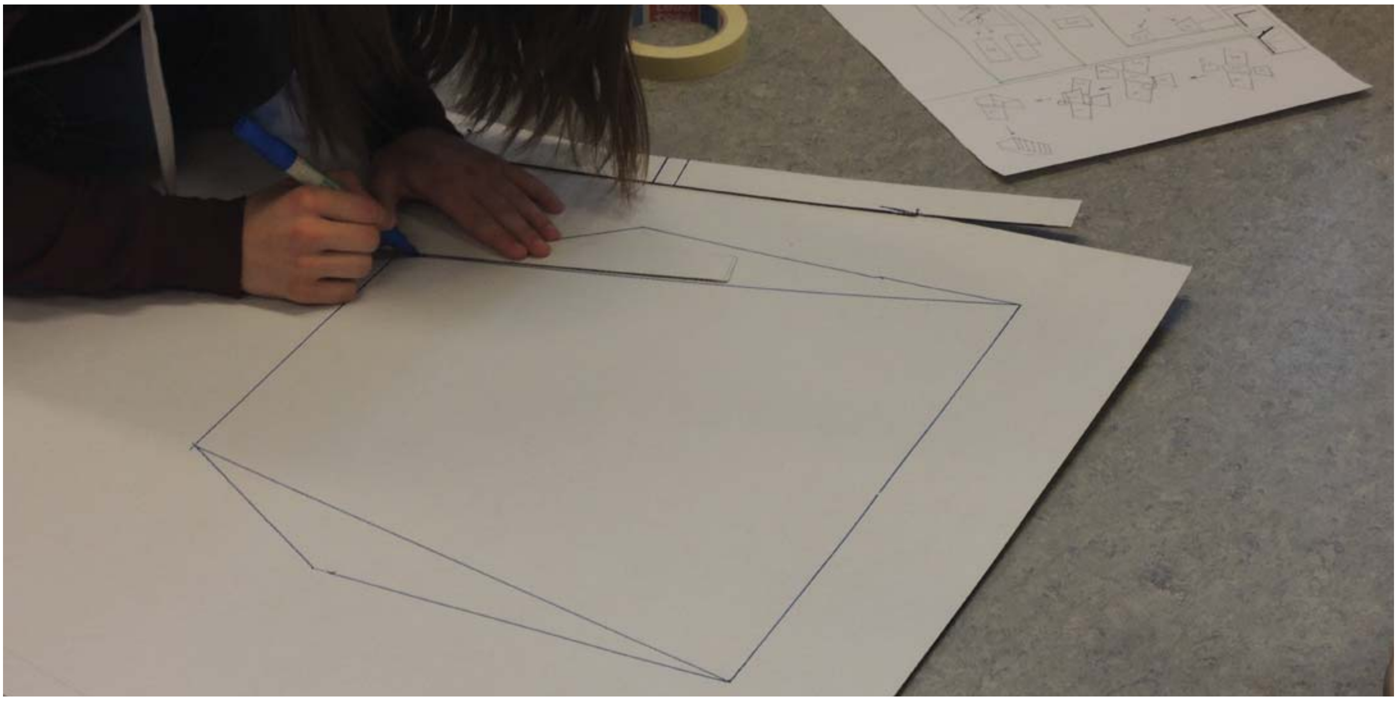
The first actual test of a manual, was with the above sketch manual. The participants for this test were ergotherapy students who indicated about themselves to have low technical skills and interests. The participants were given this manual and the material to make a cardboard model of a top bar beehive. First the end result and needed materials are showed, next there is a step by step guide to construct the hive. The creation process was filmed and afterwards the participants were asked to indicate their findings on a UX-curve [38] and bar graph.



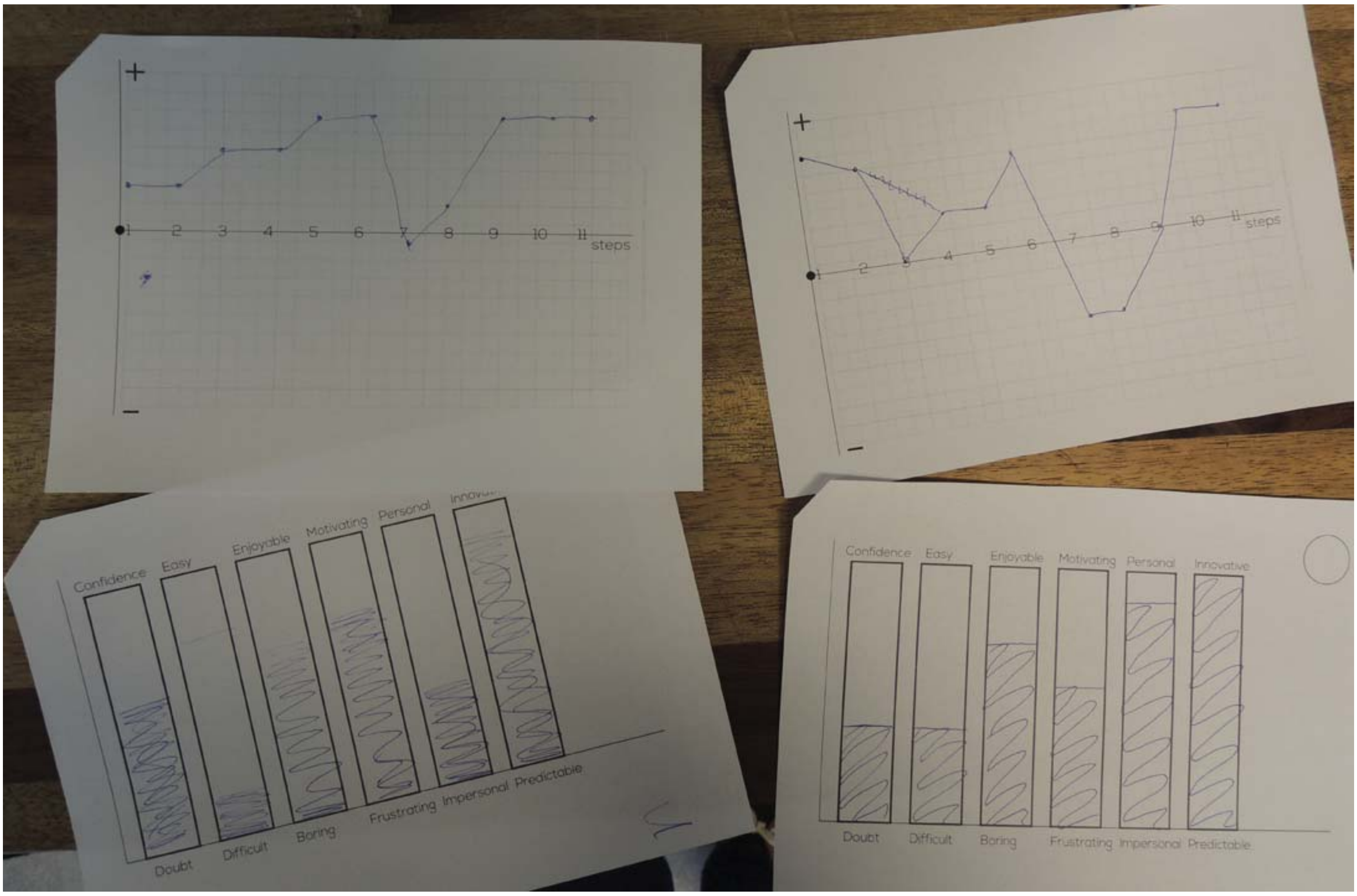




Apart from some steps that were not documented well enough in the manual (there was confusion because of the exaggerated 3D representation of step 2), all hives were completed. One test person did not follow the manual, but drew an unfolding herself by looking at the assembly process. Because the unfolding was incorrect, the entire hive was built incorrect. To prevent this, the final manual will be a booklet, showing just one step at the time.
The test persons indicated that they enjoyed the creation process and were proud of their end result. This phenomena is also called the IKEA effect [39]. They were motivated because they thought of the test as a challenge they wanted to complete.



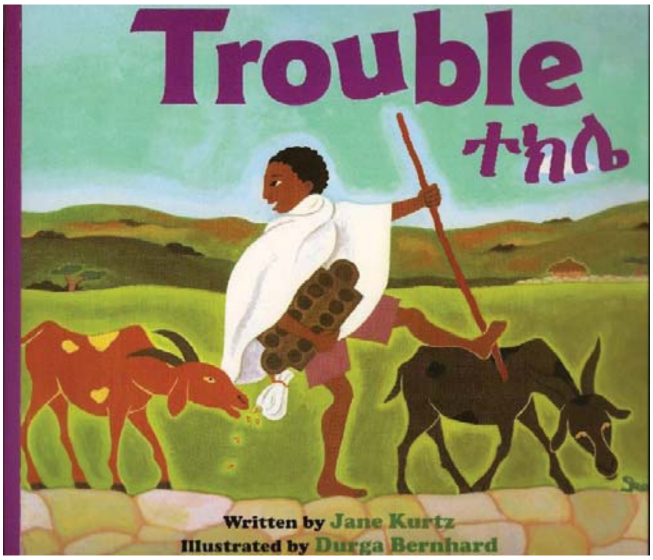
TESTING CYCLE 6: MANUALS

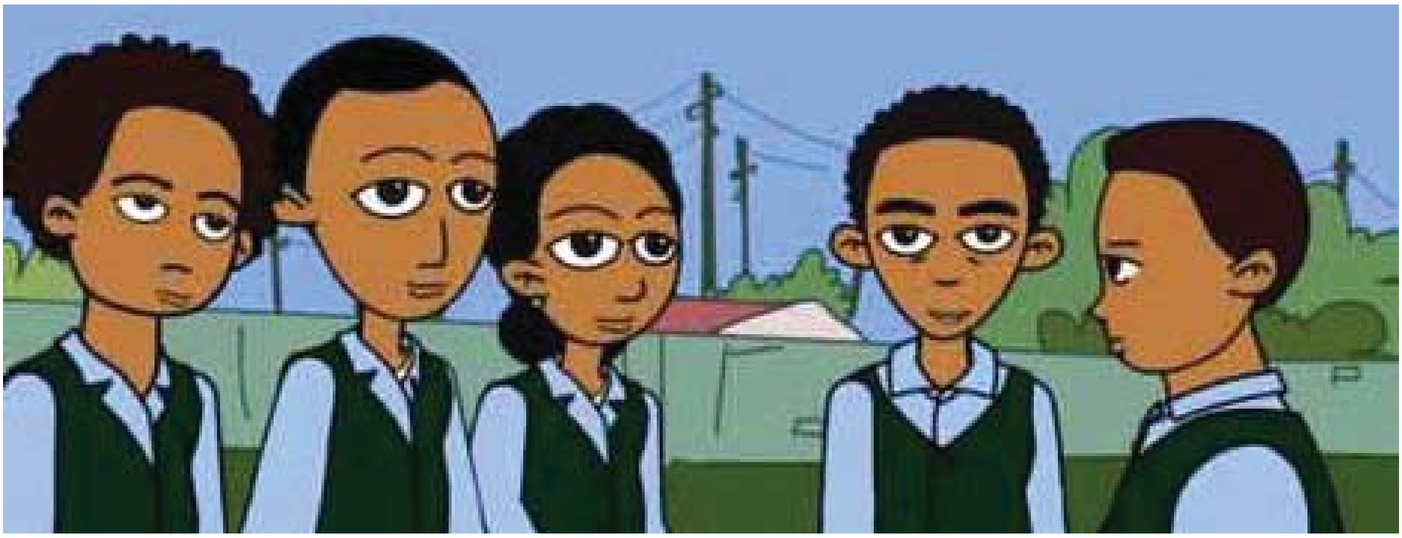


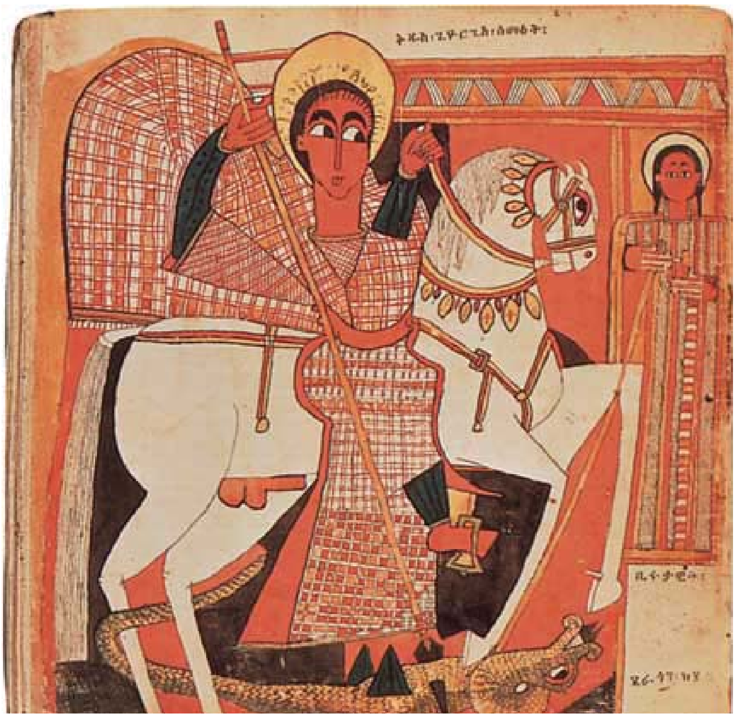
Visual culture

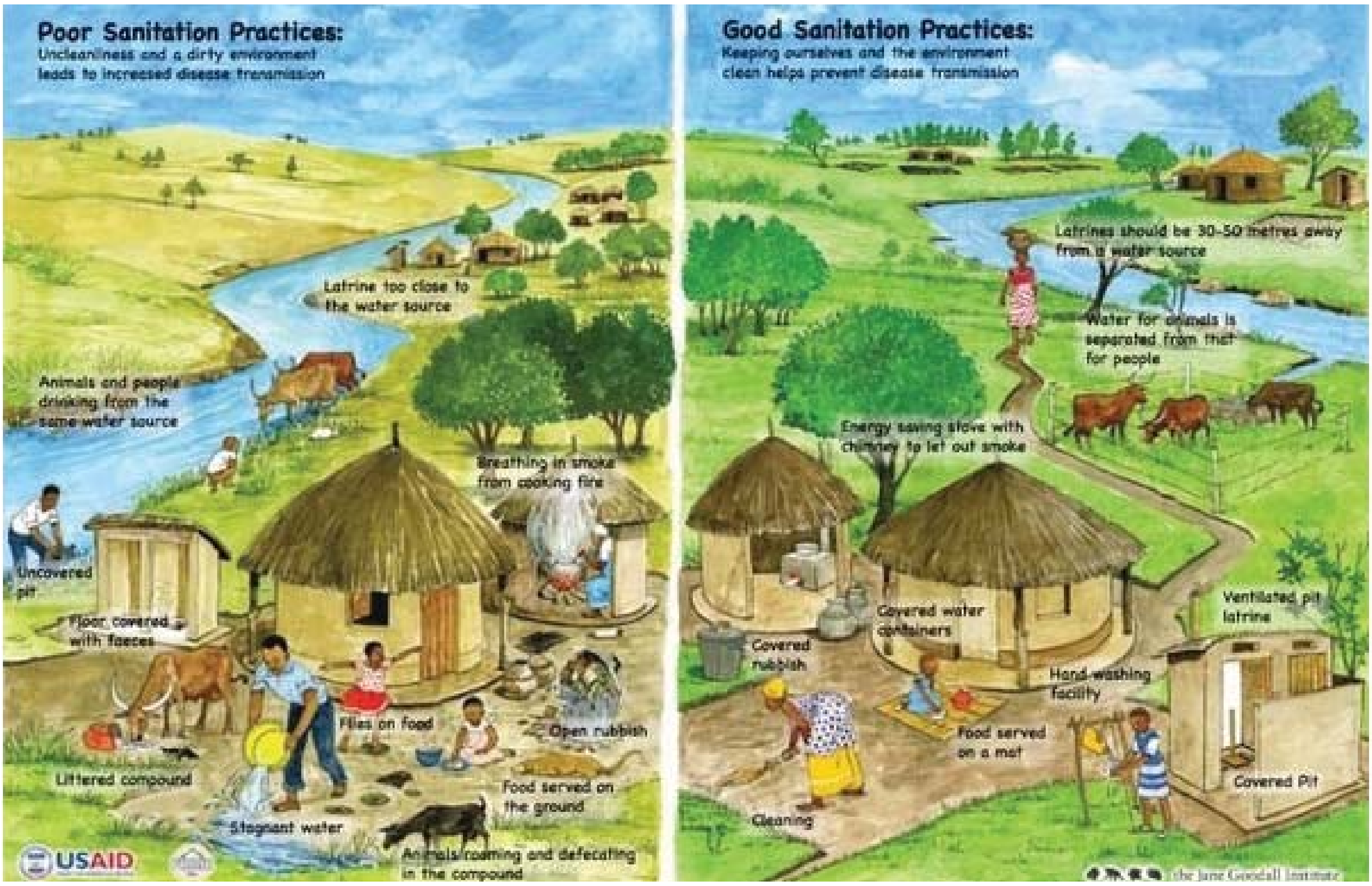
To visual language used in a manual is not to be underestimated. In Western countries, we are used to manuals with abstract, wire frame images in perspective. When looking at the graphic trends in Ethiopia, it becomes clear that they mostly use a form of perspective related to the form of perspective the ancient Egyptians used. Practically this means: legs are seen from aside, the torso is in front view and the head and arms are seen from aside. Another aspect that attracts attention is the distinctive shape of the eyes used in all illustrations.

Mimicking these characteristics can make the manual more familiar for the end user.









Conclusion:

The final manual is an A5 booklet, mounted on a calender standard so that it can stand-up. This will come in handy as the farmers don't have workbenches or tables but sit on the ground to make the manual. The calender standard prevents the manual from becoming dirty when working on the ground. The manual is divided in three chapters with an Ethiopian looking front cover and an own colour. The main steps of this manual can be found in the concept section.

TESTING CYCLE 7: FRAME

TESTING CYCLE 7: FRAME

The first prototype of a frame hive had a lashed bamboo frame filled entirely with the mud mixture of loam, water, hair and wood chips.
The lashing in this prototype was not strong. It appeared to be impracticable to lash three bamboo sticks together in one point, retaining the right angles.
The next step was to look at other was to compose the frame and look how the connections could be realised. The most bamboo are high tech solutions that require either special bolts, special raisin (for the connection of bamboo bikes) or special skills. None of these connections are useful in this project.
The final frame is composed of laths of bamboo set oblique and than lashed together. The laths rest on each other, minimizing the deformation. Afterwards, the frame is covered with the mud mixture to seal the hive. To guarantee good attachment of the mud to the bamboo, leaves are woven through the bamboo.

TESTING CYCLE 7: FRAME

CONCEPT

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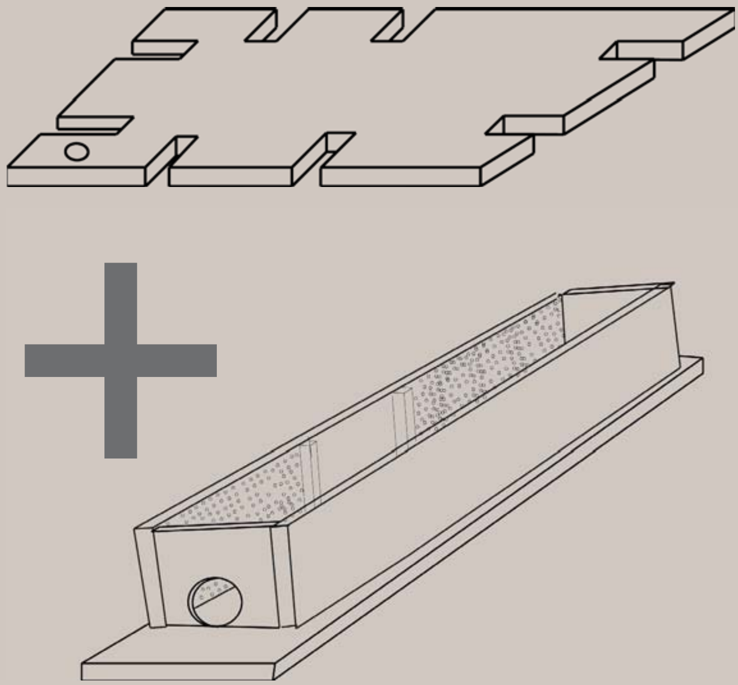
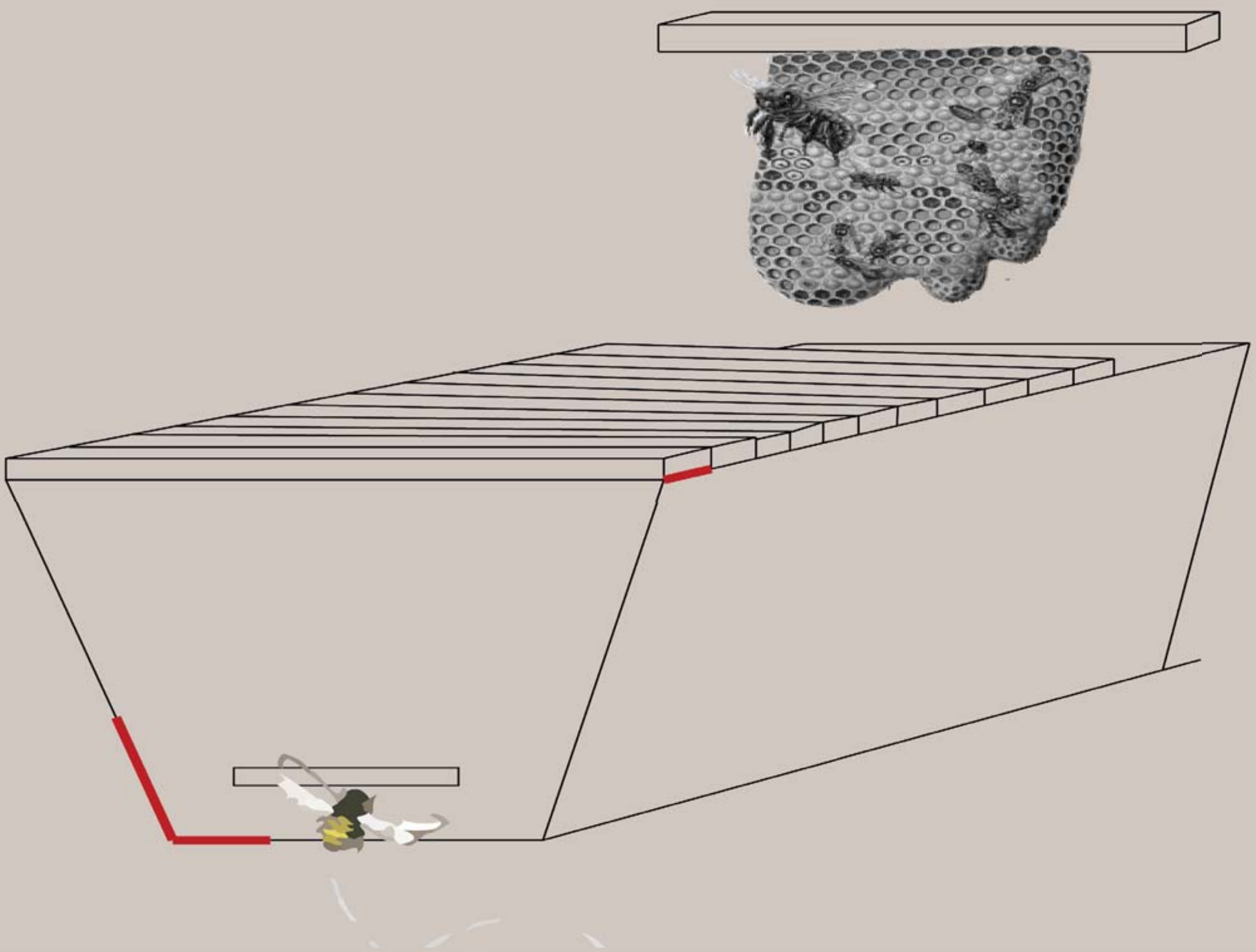
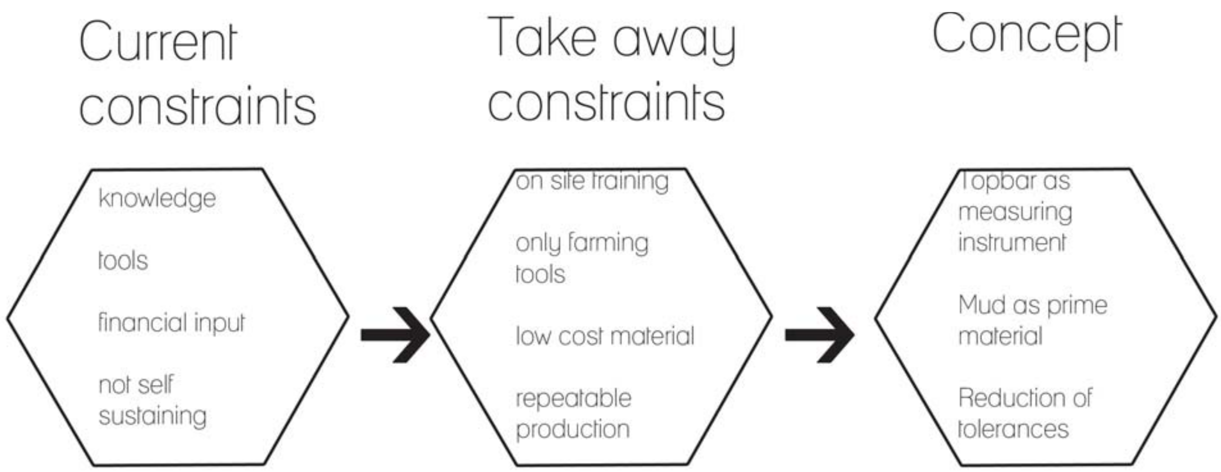
ADIS





CONCEPT



The interviews with the beekeepers in Ethiopia pointed to the major constraints for adoption of new beekeeping technologies.
The first one is lack of knowledge on bee-management and on how to construct a hive themselves. The farmers don’t have woodworking and measuring tools which they need to fabricate the current type of hives.
Another major constraint is the financial input needed to buy a modern hive. The poorest of the poor are characteristically risk-averse [1] and stick to hive making techniques that are passed between generations.
So by minimizing both the technological and the financial constraint, a transitional hive becomes within reach. This constraints can be lowered by using known and nearly free tools, materials and techniques.

By using 2 instruments to measure and build the whole hive, namely the top bar as measuring instrument and the angle mould to construct the angles, a lot of these constraints can be lowered.
The difficulty of building the hive is lowered by determining the dimensions that are necessary to guarantee a good performance and thus need to bee in tolerance.
The investment is lowered by using materials that are naturally abundant and (almost) free to use.
The offered tool is cheap to produce and can only serve for the intended purpose, namely: producing top bars to construct hives with these top bars. By distributing a tool that has limited material value but becomes valuable by using the tool to create, the risk of selling the tool decreases. For instance: a full scale mould for a hive, made out of aluminium, has a great material value: aluminium sheeting is scarce and expensive. In the short term it can thus be profitable to sell the sheeting. To encourage long-term commitment, the material worthless tool was created.

ኣዲስ ADIS

CONCEPT

The end product of this research is a kit called Adis that will be distributed to impecunious farmers during small scale beekeeping training sessions in rural Ethiopian villages.
Adis means 'new' in Amharic, the national language of Ethiopia. The word new refers both to the new way of making and measuring the hive and the new research appraoch used in this project.

As mentioned before, this thesis is part of a larger program called BEETH. Up to now, twelve Ethiopian researchers have participated in a four month beekeeping course in Belgium. They are the ambassadors of the program and will organise small scale beekeeping trainings in rural areas. At the training each farmer gets an Adis kit with: 1 mould to make top bars (the bars on top of the hives to which the bees attach their combs), a calibre to control angles during the manufacturing of the hive and a manual.

The content of the kit

To manufacture the beehives there are two key components: tolerances should be respected and the used techniques should be familiar with the end-user as much as possible.

The mould in the kit is made of laser cut wood to guarantee the correct dimensions. Because it can be flat packed, over 50 of these moulds can be transported in one suitcase or shipping package. Regularly Ethiopian students come to Belgium for their PhD degree. They can take bring back some of the moulds or they could be shipped to Ethiopia. The central figure in this project, Sebsidie, can further distribute the moulds among the ambassadors of the beekeeping training programme.
The kit is built with the idea of only using local materials and skills in mind. The main materials that is used, is bamboo. For a lot of farmers this will be a free material, as it grows on their farm, for others the bamboo sticks are still cheap: about 2 birr (8 euro cent) per stick of 5 meter. The total cost of bamboo per hive would be about 10 birr. Another important construction material in this hive is rope, with a cost of approximately 60 birr. This can, if necessary, be replaced by vegetal fibres. Other materials are leaves of the Opuntia cactus and dried plant leaves, both to be obtained for free.
The techniques used to make the Adis hive are inspired by the traditional hive: both have weaving as a core technique. Important is that women take part in the weaving. So with the Adis hive they remain involved in hive making, in contrast to the modern and existing top bar hives.

Detail of the hive with one topbar and comb

Item	Quantity	Unit	Unit price	Total price
Transitional hive	9	no	334	3010
Shanbako(Bamboo type)	200	no	2	400
Eucalyptus	50	no	35	1750
Plastic sheeting	14	meter	40	560
Shebo (iron wire)	1	kg	60	60
Mesmar (nail)	2	kg	60	120
Gmde (rope)	2	teklal	60	120
Ethiopian hive	9		+/- 60	520
Bamboo	200	no	2	400
Rope	2	teklal	60	120
Opuntia leaves	200	no	0	0
Plastic / jute bag	9	no	0	0

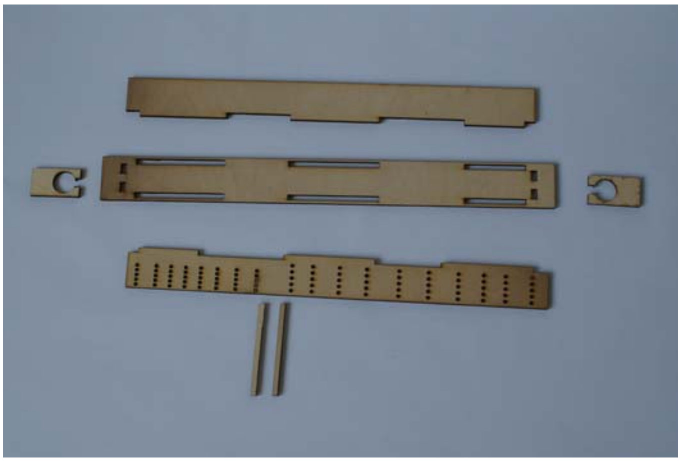
The goal was to create a cheap hive type. With an estimated cost of 60 birr (2.5 euro) per hive this goal is reached. The price can vary depending on the fact that some farmers grow their own bamboo.
In comparison: a modern hive costs about 900 birr, a transitional hive about 300 birr, a traditional about 70. So the Adis hive is in the price range of a traditional hive.
The kit itself will be sponsored by the Rotary. This will cost about 5 euro per kit.

A topbar with honeycomb

CONCEPT: PARTS

The first part of the Adis kit is the mould to make top bars. The mould is made of lasercut 6 mm multiplex. This mould will be produced in Belgium and will be transported to Ethiopia. The end-user will assemble the mould according to the images in the user manual. The mould is filled with bamboo and a mud mixture and after 3 days the top bar is dry.
There are lasercut caveties in one side of the mould, this has a double function. First: speeding up and distributing the drying process. One side of the mould has square cavities, while the other side has round cavities. This is used in the manual to give a more clear explanation.

All parts of the mould can be held together with rope when it is not in use to prevent loss of parts.



The second part of the mould is the angle calibre. This part is also lasercut out of 6 mm multiplex. Out of one panel of 600 mm x 450 mm (the work surface of the lasercutter), three Adis kits can be lasered.

The mould serves as a control calibre for both angles of 120° and 90°. The gabs in the sides make it possible to tie the calibre to bamboo sticks.

This part also has a round hole to tie it to the other part of the kits to make sure no parts are lost.

CONCEPT: PARTS

The final part of the Adis kit, the part that is the glue between the kit and the end-project, is the user manual. The manual has the structure: a front page, a title page for each 'chapter' showing the end result of the chapter, a materials page for each chapter and finally the steps of the chapter.
The front page and the chapter pages are designed with the visual culture in mind. To fully blend in with the Ethiopian visual culture, an Ethiopian artist can paint these images.
Each chapter (making top bars, making the hive, making the cover of the hive) has his own colour code. The codes form the Ethiopian flag (green, yellow, red). Each step has a separate A5 page. At the bottom of the page circle marks show how many steps are left.

The manual is stand alone. This will come in handy as the Ethiopian farmers will construct these hives on the ground. Because of the stand, the manual itself does not have to lie on the ground. The pages are waterproof as they are printed on polypropylene 'paper'.

The manual can be replenished with extra chapters about beekeeping topics such as honey harvesting, queen rearing, ...

First, the mould is assembled for the first time by the end-user at the beekeeping training organized by one of the ambassadors.
Secondly a bamboo stick is placed in the mould and the mould is further mixed with mud, loam, wood mixture.
After 3 days the first top bar can be taken out of the mould. This process is repeated until the farmer has the desired amount of top bars (between 8 and 20).
With 5 top bars it is possible to dimension the entire hive.

To make the top bar frame bamboo is tied together with rope. Later on the frame is plastered with waterproof mud on both the in- and outside. The mud on the inside makes that the right dimensions are obtained and that there are no cavities in the hive (otherwise the bees have to fill them with propolis, the more time they have to spend filling cavities, the less time there is to produce honey). The mud on the outside makes sure that the hive is durable for outside use and that the hive is always windproof.

The lid of the hive is made out of leftover bamboo sticks and jute bags. The jute bag is filled with dried cacti leaves and hay which serve as thermal insulation and humidity buffer. Bamboo sticks are tied to the lid. Cord is used to tie the bamboo sticks tight around the outside of the hive. When opening the hive for inspection it is possible to open only a part of the hive by shoving the bags backwards over the bamboo sticks. When a part of the hive remains covered during hive inspection, the bees remain calmer.

The last step of the production process is waterproofing the hive with cactus juice. This is made by cutting cactus leaves in small pieces, putting them in water and letting them ferment for a few days. Afterwards the juice is smeared on the outside of the hive and on the lid.

Each of the production steps is described in a manual. The visual language of the manual is inspired on the visual language used in Ethiopia. Main characteristic of these images is the limited use of perspective. In the future the manual can be further adapted with cooperation of an Ethiopian painter.
The manual comes in the form of a booklet so that the user sees one step at the time and is not tempted to look ahead and make his own dimensions. The booklet can stand up for easy reading during the production process. It is possible to attach all parts of the mould to the manual to prevent the user from losing parts.

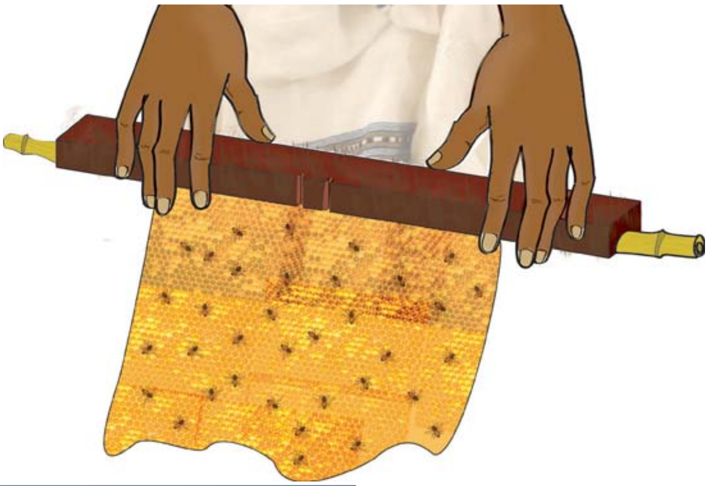
The material used for the construction of the mould can be varied according to the abundance of local plants and materials. The regions I visited had a loam clay soil and a lot of bamboo and Opuntia cacti, materials that can be found in the final product. Other regions may have other soils, which will require an other amount of reinforcing materials. This can be determined by trial and error.

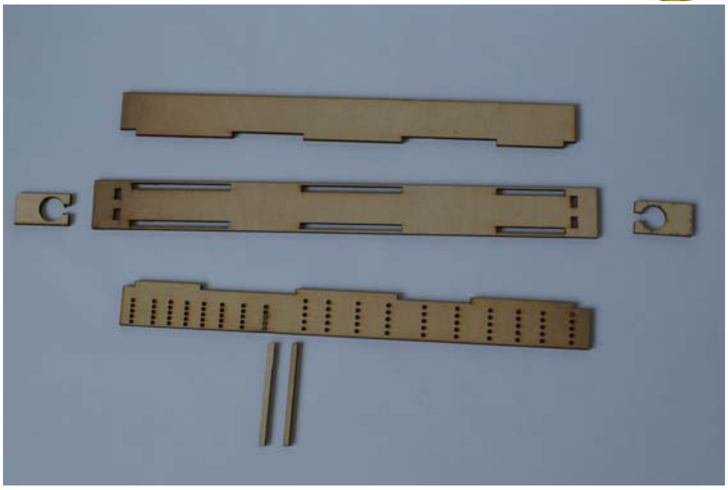
The manual is 'self-reproducing': because of the use of carbon paper the farmer can make several manuals and hand them to his 'trainees'.

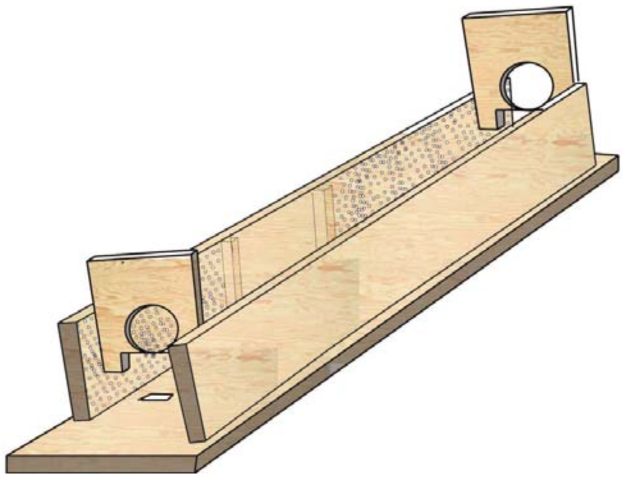
All the parts of the kit can be held together by rope to prevent people from loosing parts.

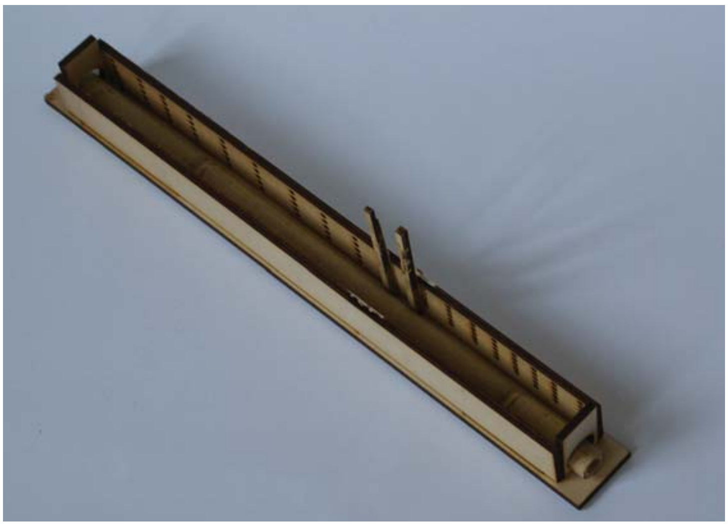
1. Making top bars with the mould

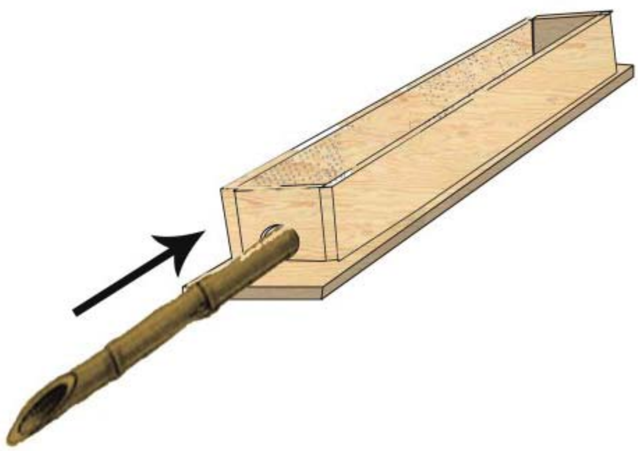
In the left collum there are pictures of the production process. In the right collum are images from the manual showing the same steps in the production process.

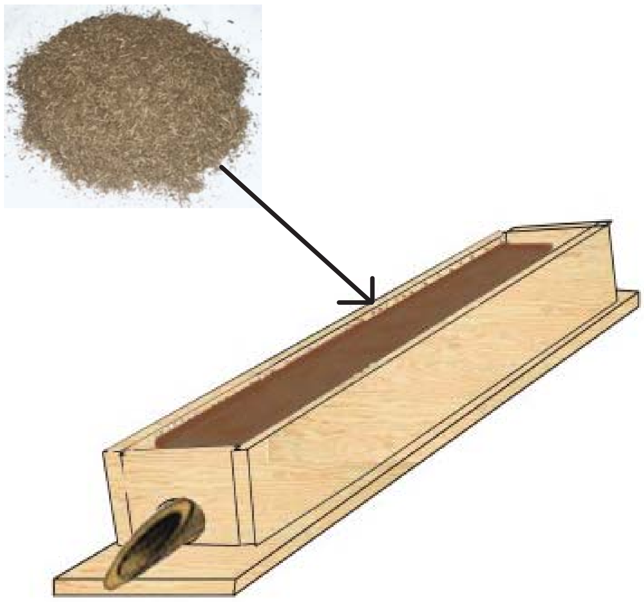


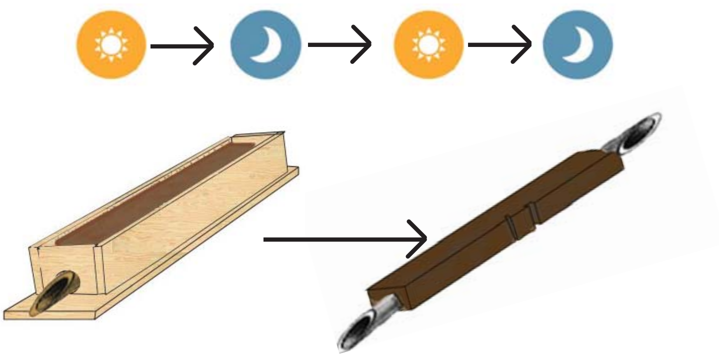




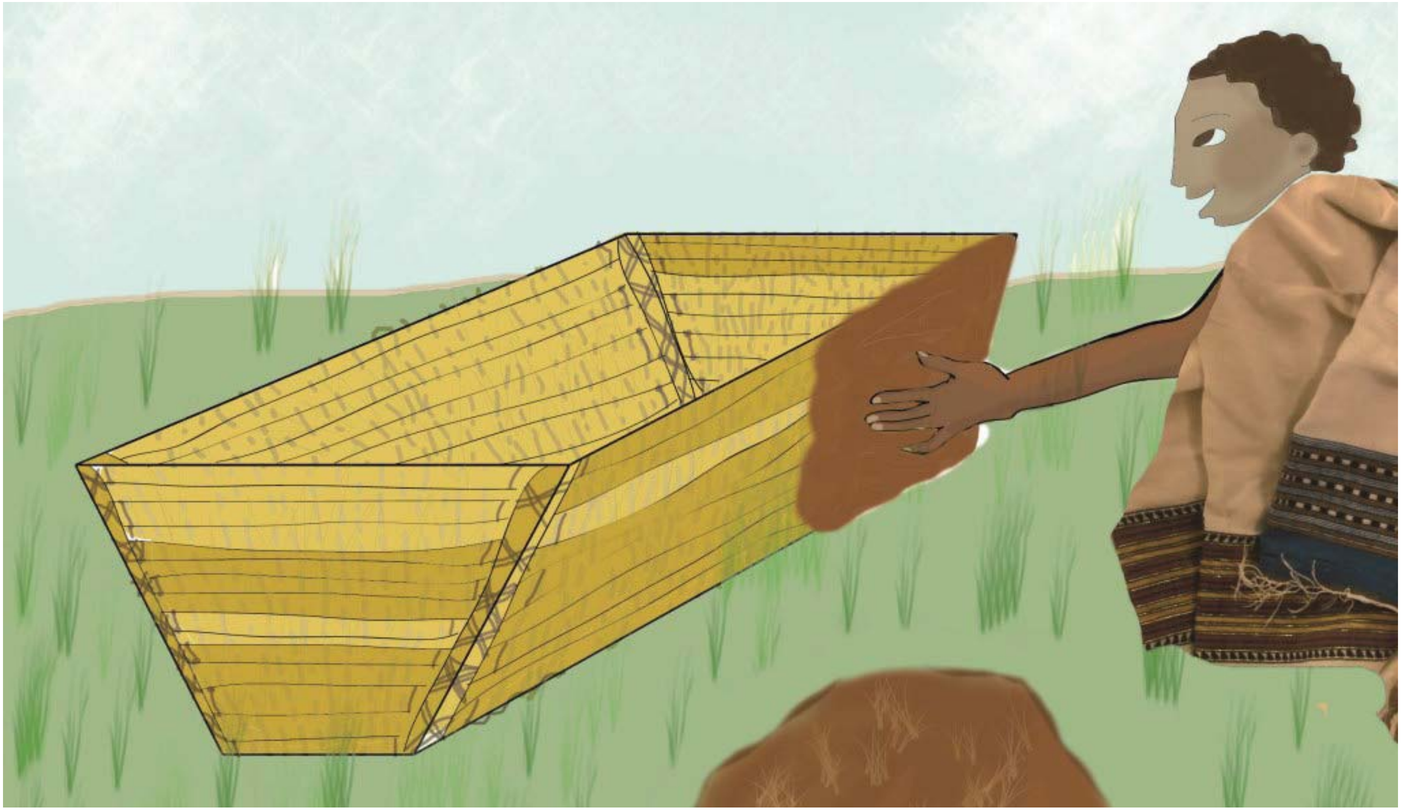


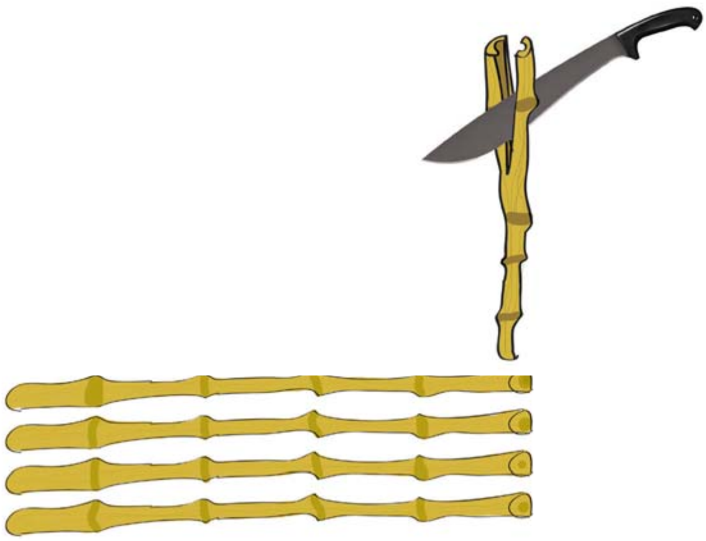




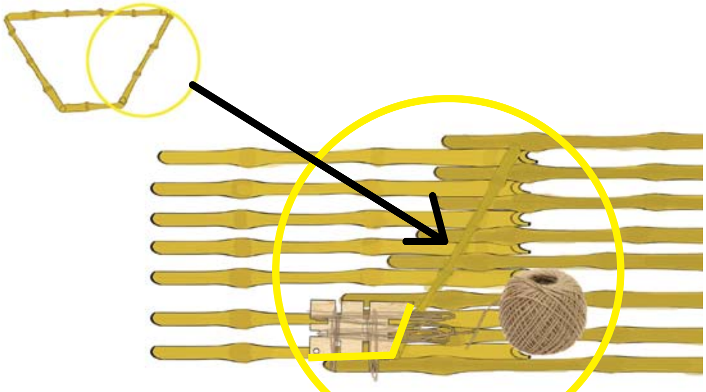


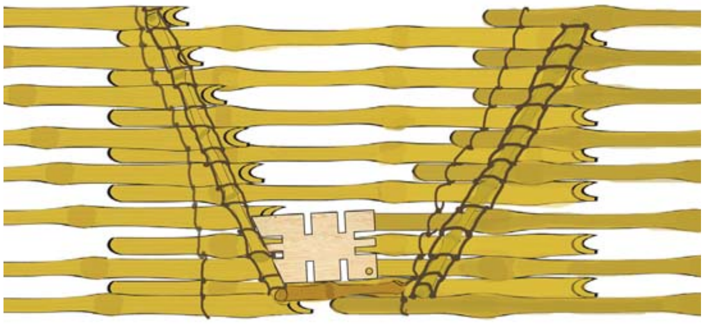
2. Making the frame with bamboo and mud

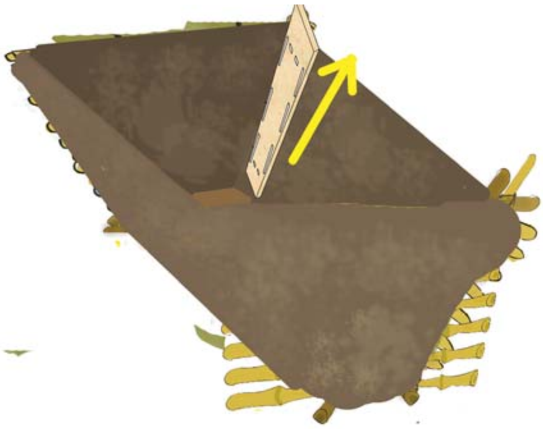




CONCEPT: THE MAKING OFF







The construction of the hive would be as following:

A. Construction of the top bars

1. First a mould is made with the dimensions as shown below.
2. One branch of bamboo or stick is put in the mould and the rest of the mould is filled with mud mixture
3. The top bar dries
4. The top bar is taken out and because of the shape of the top bar it can now be used as a measuring tool to construct the rest of the hive.

B. Construction of the actual hive

The hive can be simplified as following:
- the inner length = # of used top bars x width of top bar
- The outer width = length of top bar
- The inner bottom = first mark on top bar
- the height = second mark on top bar

All these measurements can be used to construct the inner measurements of the hives.

CONCLUSION

CONCLUSION

The main challenges in the development of this project were: working together with far away stakeholders and to design a hive that is: cheap, dimensionally stable, locally producable hive with respect for the local knowledge and cultural aspects.

The first challenge had an enormous influence on the communication with the stakeholders and on the test set-ups. The communication was as personal as possible: the intermediaries were contacted one by one through email. This direct source of communication prove to be the most effective. All tests were explained visually, without words. Those manuals formed the base of the final user manual.
The tests set-ups had to be without the use of materials that had to be purchased (as those require a procedure to approve budget). The tests had to be useful both for the designer as for the test person, to motivate the test person to act.
Working with remote stakeholders remains difficult because the information process is slowed down. Motivating stakeholders and obtaining the right information is also harder when you are not present in the context you are designing for.

The second challenge was to design a beehive following the measurements set by Pam Gregory in close relation to the Ethiopian culture. The culture had impact on the materials and techniques that were used. The idea of the mould kit for the Adis hive was inspired by the idea of making things with exact dimensions in a culture where most products are produced by hand without measuring first. With the two moulds it is possible to define all the dimensions of the hive. Especially the 120° of the bottom ange and the 3.2 cm of the top bars will be very precise. Those are the two measurements that have to be respected the most.

The Adis hive makes use of the local materials soil and bamboo and the local weaving techniques. The hive is constructed with techniques that women are allowed to use (meaning: there is no cultural taboo on them). Now, some women make traditional hives for their husband, with the Adis hive they can continue doing so.

In the transitional hives of Pam Gregory, a lot of wood is used. By switching to other materials, people are not encouraged any longer to deforest their surroundings. The materials bamboo and wood are currently used by research centres to build hives, but they lack precision. With the Adis tool kit, the same materials can be used to make a more precise hive.

The total cost per hive is about 2.5 euros, which is the same cost to manufacture a traditional hive.
With both the cost and the measuring constraint minimized, this hive has a great chance of becoming a standard hive type for Ethiopian farmers, but the long-term use of this system is yet to be investigated.

The Adis toolkit is not gold,
but it can turn a bit of bamboo and mud into gold for a lot of farmers.

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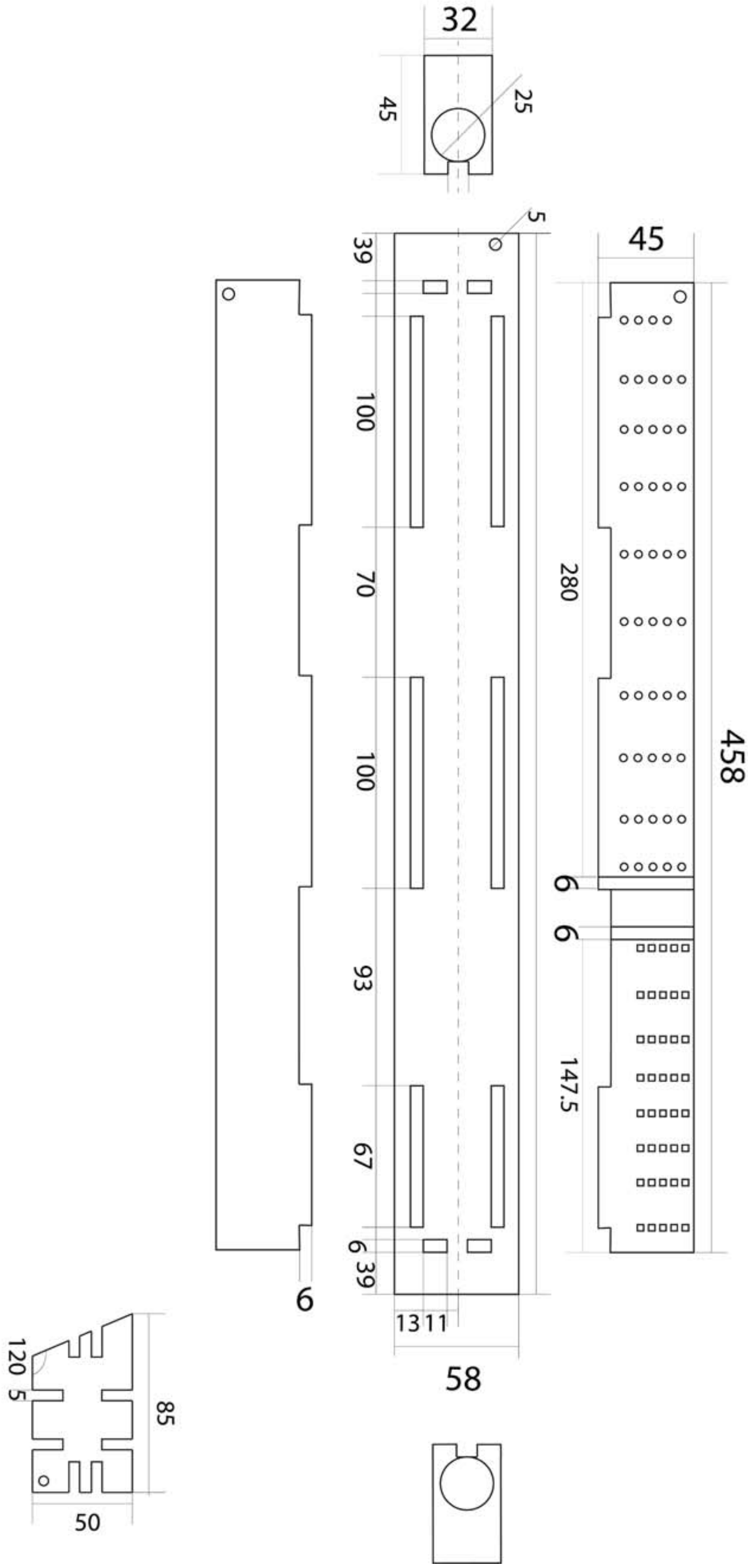
APPENDIX I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