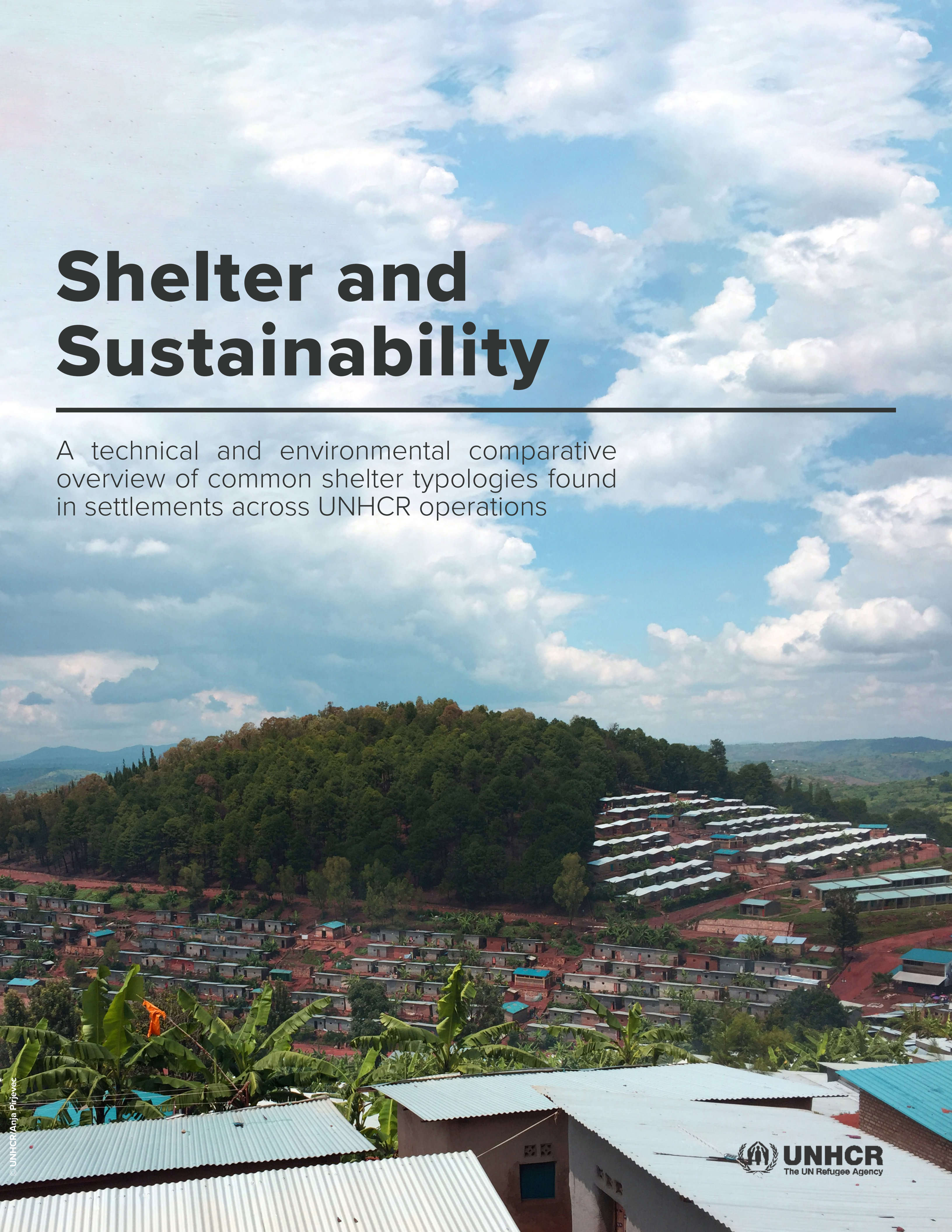
Shelter and Sustainability

A technical and environmental comparative overview of common shelter typologies found in settlements across UNHCR operations



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I. Introduction

Refugees and others of concern to UNHCR have the right to adequate shelter, which should be ensured in all stages of the displacement cycle: prior to, during and after displacement. Adequacy of shelter goes beyond the mere physical living space. It includes security of tenure, affordability, habitability, accessibility, location, cultural suitability and availability of services, materials as well as infrastructure. Humanitarian crises impact access to safe and adequate shelter for women, girls, men and boys in different ways. Each step of a shelter program must be therefore considered with regard to different needs and “do no harm” principles. The identification of the specific needs, roles and capacities of the displaced populations is essential to ensure their participation and ownership. Providing culturally appropriate shelters which are conceived to be convenient for women and men of different age groups and backgrounds is crucial as well as it is the proximity of shelters to basic services and infrastructure. Protection principles should be mainstreamed across all aspects of shelter programing.

1.1 Purpose

Shelter cannot be looked at in isolation; any response must consider the settlement and the context in which the households are sheltered. Preferred shelter solutions must be designed and engineered on the basis of context-specific structural and performance requirements. The shelter should provide a secure and healthy living environment with privacy and dignity to persons of concern (PoCs) and protect them from a range of risks, including eviction, exploitation and abuse, overcrowding, poor access to services, and unhygienic living conditions. The development of an appropriate shelter response is a process and not simply the delivery of a product and it is important to ensure the social aspects and needs become also design drivers, alongside all the other characteristics and specifications assessed in this study.

This document is a comparative overview of different shelter typologies, which were recently implemented in various field locations and in different stages of a humanitarian response to forced displacement. Using established criteria to determine the technical performance, habitability, affordability as well as the environmental impact of each shelter design, this study outlines the real costs of shelter interventions taking into consideration the specificities of each context and material used.

The scope of the Shelter and sustainability overview is not to review or update the technical specifications of shelters presented in the UNHCR shelter design catalogue, which was developed as a quick reference tool presenting a diverse range of applied examples of shelter designs. Rather, it seeks to examine shelter designs, the life-cycle of the materials used and analyze possible strategies to increase the sustainability of humanitarian responses and reduce their carbon footprint, while at the same time ensuring shelter adequacy and suitability. Ultimately, this overview aims to assist humanitarian practitioners and host governments in evaluating the performance of shelter solutions, technically, culturally and environmentally, in a given context and response.

1.2 Intended users

This document is designed for use by all UNHCR staff and partners working in the shelter sector across different humanitarian contexts and countries. The information may be particularly relevant to practitioners who are supporting the development of shelter assistance programs with consideration to shelter type, operational context and the long- and short-term environmental impacts of humanitarian responses. The document should be used in conjunction with existing environmental assessment tools seeking to identify potential impacts of shelter and settlement interventions and the associated mitigation measures to be adopted.


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2. Assessment of shelter sustainability

The sustainability performance of shelter solutions presented in this document uses technical drawings and bills of quantities of types of designs that were implemented in different UNHCR operations and was carried out by comparing four main criteria (environmental impacts, technical performance, shelter habitability and costs of construction materials & labor) through a Life Cycle Sustainability Assessment (LCSA) approach. The LCSA is a trans-disciplinary framework which allows the comparison of different design options through a multi-criteria decision analysis with the aim of finding the best compromise between costs, environmental impacts and functionality for a specific shelter. By giving a comprehensive overview of the shelter response the LCSA allows informed decision making leading to the selection of the most appropriate shelter design to address the needs in a specific context.

2.1 Assessment methodology

General Considerations

In order to holistically evaluate the sustainability of a shelter response, the shelter type is evaluated considering a range of characteristics, to ensure their adequacy[1*] in the broad sense of the term, notably:

- Provide protection from the elements, a space in which the beneficiaries can live and store belongings, and privacy, comfort and emotional security;
- Provide a habitable covered living space that ensures a secure and healthy living environment;
- Address hazard risks and safety of the occupants;
- Build using similar materials and techniques as by the displaced population or the host communities;
- Adapt to take account of the local context and climate, cultural practices and habits, local skills, and available construction materials;
- Consider the wider settlement context in which the households are sheltered.

[1*] Based on Sphere Standards.

Shelter and settlement assistance should minimize as much as possible the negative impacts on the natural environment. Environmental impact assessments and mitigation strategies should accompany all shelter and site planning activities throughout the program cycle. Among the options available, the most sustainable materials and construction techniques should be prioritized. Energy supply as well as solid waste management practices should be taken into consideration early on in the planning phase to ensure safe, hygienic, reliable, affordable and environmentally sound systems. The protection, restoration and improvement of the natural environment in UNHCR operational sites should be mainstreamed throughout the program cycle and considered before, during and after the establishment of such sites with special attention on the impact of shelter interventions on the host population's needs for natural resources.

Each typology assessed throughout the study is accompanied by details on set up time, life span, number of workers, the level of expertise required for set up and finally the temperature range that the shelter is able to sustain in a given location.

Shelter life span

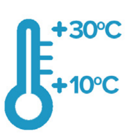
Shelter materials deteriorate with time. The shelter life span defines the period beyond which the shelter and/or its elements might begin to deteriorate.

Shelter set up time

Shelter set up time defines the time in hours or days needed to build the shelter with a specific number of workers. The set up time does not involve the time needed to produce specific shelter materials (bricks, cement blocks, etc.).

Workforce required for set up

The number of people required for set up is defined in conjunction with the set-up time. The workforce might include skilled and unskilled labor. All the shelters in this document were assessed taking into consideration two unskilled and one skilled worker for the construction.



Suggested temperature range

The temperature range defines the internal temperatures in a shelter during which the thermal comfort is sustained without artificial cooling or heating.

To develop a comprehensive rating framework, four main criteria were developed to guide the assessment of shelter sustainability: i. Environmental impacts, ii. Technical performance, iii. Habitability, and iv. Affordability. While some criteria might be evaluated in a descriptive manner, others are assessed based on a quantitative approach using a specific formula.

The environmental impacts of dwellings are typically divided into:

- **Embodied impacts,** which are associated with the pre- and post-use phases of LCA, when raw materials are harvested and turned into construction materials, transported to the site and assembled into the finished dwelling which includes the end-of-life impacts.
- **Use impacts**, which are associated with energy consumption and other operational and maintenance impacts.

This evaluation is assessing only the environmental impacts caused by a specific shelter during its lifespan (including the end of life stages), therefore only the embodied impacts are analyzed.

Different maintenance needs and the impacts linked to the use of a dwelling or a shelter (e.g. water and electricity usage, impacts from cooking, sanitation and solid waste) are excluded from this study, because the majority of these activities are not part of the shelter itself and are being used in isolation from the units. Integrating these additional criteria would make the comparability of shelters extremely challenging and in some cases unfeasible, and they were therefore excluded from the calculations. It is important however to mention that although not covered in this document, all the above-mentioned aspects need to be considered from the onset of the emergency and integrated in the site plan.

The details of the evaluation methodology to assess the environmental impacts, the technical performance, the shelter habitability and affordability are elaborated throughout the document, however the structure of the main evaluation criteria is outlined below:

1. Environmental impacts per shelter

Analyzing the negative effects of production, transportation, construction and disposal of construction materials of a specific shelter, by considering:

a) Material consumption (raw material, man-made material, water)
b) CO_2 footprint (CO_2 emissions and CO_2 absorption cease)
c) Direct damage of natural habitat
d) Reuse or recycle options

2. Technical performance per shelter

Assessing the performance and behavior of a specific shelter by taking into account:

a) Structural resistance of the shelter
context specific assessment

- wind resistance
- flood mitigation
- seismic resistance

b) Suitability of shelter design
general assessment

- natural ventilation
- fire and flammability
- thermal comfort
- personal security
- accessibility

3. Shelter habitability

Evaluating the appropriateness of a shelter typology in terms of the following criteria:

a) Covered living area
b) Privacy
c) Natural lightning
d) Artificial lightning
e) Appropriateness of materials and construction techniques
f) Complementary facilities

4. Shelter affordability

Considering the cost of a specific shelter by taking into account all the associated costs: production, supply and transportation of construction material and the shelter set up

2.2 Shelter sustainability assessment criteria

Environmental Impacts

The environmental impacts assessment will analyze the negative effects of production, transportation, construction and disposal of construction materials. The assessment is carried out via an analysis of the following criteria:

a) Material consumption

The material consumption is calculated by taking into consideration the materials / resources needed to build one shelter. It does not reflect the materials / resources used for the preparation and maintenance of the site implementation.
The materials / resources are divided in two main groups:

- Raw materials used (in kilograms or liters): any naturally sourced product or physical matter (water, timber, soil, etc.).
- Man-made materials (in kilograms or liters): any product or physical matter that goes through rigorous processing. (steel, plastic, concrete, etc.).
- Water: water consumption is calculated for all the man-made materials and products used to build the shelter. The water consumed by naturally grown materials is not considered (trees, thatch, bamboo, etc.)

b) CO_2 footprint

The CO_2 footprint is calculated by taking into consideration CO_2 emissions as well as the CO_2 absorption cease. However, the CO_2 footprint is not only assessing the amount of CO_2 that was released in the air and / or not absorbed by trees. By including also, the shelter life span and covered living area in the equation, we ensure comparability, across different shelter typologies.

- **CO_2 emissions in kg of CO_2 :** the calculation considers the CO_2 emissions associated with the production of construction materials, the transportation of construction materials to the final construction site (national and/or international transport- depending weather the material was imported or locally produced), the set up / construction of the shelter, and if relevant, the disposal or destruction of the shelter.

- **CO_2 absorption cease in kg of CO_2 :** the calculation considers the cease in the CO_2 absorption per year due to deforestation for obtaining construction material (wood, bamboo).

For the purpose of calculating the CO_2 footprint the following equation was developed:

CO_2 footprint = CO_2 emission + CO_2 absorption cease

Measured in kg of CO_2 / Shelter life span in years / Area in m^2

c) Direct damage of natural habitat

The destruction of natural habitat happens due to activities related to the construction of a specific shelter. Habitat is lost and degraded when natural or human-caused activities alter ecosystems often causing irreversible destruction. The following activities are considered:

- Deforestation and vegetation removal, which fosters soil erosion, degradation of water quality and reduces natural infiltration of rainwater which leads to further habitat loss.
- Creation of settlements with all the annexed activities that damage or destroy natural areas (pollution and deforestation due to open fire cooking, construction and agricultural activities, fall through hazards due to soil excavation for brick production, human waste and solid waste production and their unsafe disposal as well as freshwater exacerbation).

d) End of life stage options for shelter materials

The end of life stage analysis examines if the materials of a shelter could be re-purposed, recycled, up-cycled or down-cycled. While recycling is the process used to make waste or other materials suitable for reuse, the goal of up-cycling is to prevent wasting potentially useful materials by making use of existing ones with little or no change. With down-cycling on the other hand, the recycled material decreases in value with each reprocessing. If the materials can be recycled but there are no recycling facilities in the country of implementation, then the recyclability option is not considered.

Table A: Baseline data used to calculate the CO_2 emissions and water waste due to material production

Type of material	Average quantity (in kg) of CO_2 emitted per kg of material produced	Average quantity of water used (in liters) per kg of material produced
Plastic (PE)	6 kg of CO_2 emitted for 1 kg of PE produced	17 l of water used for 1 kg of PE
Steel	2 kg of CO_2 emitted for 1 kg of steel produced	705 l of water used for 1 kg of steel
Cement	1 kg of CO_2 emitted for 1 kg of cement produced	0.2 l of water used for 1 kg of cement
Burned bricks	0.3 kg of CO_2 emitted for 1 kg of bricks produced	Depending on brick density
Glass	0.8 kg of CO_2 emitted for 1 kg of glass produced	5.8 l of water used for 1 kg of cement

Table B: Baseline data used to calculate the CO_2 emissions due to transport

Means of transport	Average quantity of CO_2 emitted (in kg)
Land transport by truck	0.105 kg of CO_2 emitted per ton of material transported per kilometer
Sea freight	0.025 kg of CO_2 emitted per ton of material transported per kilometer

Table C: Baseline data used to calculate the CO_2 absorption cease due to deforestation

Age of trees or bamboo poles	Average quantity of CO_2 absorption cease (in kg) per year
Young tree (up to 10 years old)	6 kg CO_2 / year
Old tree (above 10 years old)	21 kg CO_2 / year
Young bamboo pole (up to 4 years old)	5 kg CO_2 / year

Technical Performance

The technical performance is assessing the performance and behavior of a specific shelter typology in terms of structural resistance and suitability of the shelter design.

a) Structural resistance in the event of a hazard

The structural resistance analyses the behavior of a shelter typology in the event of a natural hazard (winds, floods and earthquakes). Not all the shelters and their variations will be assessed in all of these categories. A specific shelter typology will only be assessed against the risks of natural hazards occurring in the area of implementation – **context specific assessment.** If the area of shelter implementation is not subject to flooding, extreme winds or earthquake activity, the shelter will not be assessed in this regard.

Wind resistance

Wind exerts pressures (inward or outward) on all exterior shelter surfaces. If a shelter's exterior cladding does not have the capacity to resist these pressures, the structure behind must. Structural components and cladding in a shelter or structure must be anchored to resist wind-induced overturning, uplift and sliding, and to provide continuous load paths for these forces to the foundation.

Flood migation

There are several different kinds of flood, and each one bears a different impact in terms of how it occurs, how it can be forecasted, the damage it causes, and type of mitigation or adaption measures that need to be put in place to prevent major damage, inluding temporary evacuation or relocation.

Pluvial floods, occur due to extreme rainfall events.
There are two common types of pluvial flooding:

- **Surface water floods**, which occur when the drainage capacity of an area is overwhelmed. It generally occurs gradually, which provides people time to move to safe locations, and the level of water is usually shallow.
- **Flash floods**, which are characterized by an intense, high velocity torrent of water triggered by torrential rain falling within a short amount of time within the vicinity or on nearby elevated terrain. The shelter typology will pass the flood resistance assessment if it is adapted to the flood risks of the area, hence if either its design previews the finished floor level of the shelter above flooding levels and/or if the flooding risks are mitigated through site and plot level drainage interventions or other flooding mitigation measures.

Fluvial, or river floods, which occur when the water level in a river, lake or stream rises and overflows onto the surrounding banks, shores and neighboring land.
For the purpose of this research we will assess shelters only in terms of pluvial flood resistance.

Seismic resistance

Earthquake-resistant structures are intended to withstand the largest earthquake of a certain probability that is likely to occur at a specific location. For the purpose of this overview we will assesses if the shelter design is appropriate to withstand a seismic risk in the area of implementation. In general light weight, single storey structures, such as emergency shelters are less prone to seismic risks (no major risk of collapse).

Table 1: Structural resistance grading system

Risk[1*]	Pass	Fail
Wind resistance	The shelter withstands maximum winds in the area of implementation	The shelter does not withstand maximum winds in the area of implementation
Flood mitigation	The shelter is adapted to mitigate flooding risks in the area of implementation	The shelter is not adapted to mitigate flooding risks in the area of implementation
Seismic resistance	The shelter withstands the seismic loads of the area of implementation	The shelter does not withstand the seismic loads of the area of implementation

[1*] The risks of natural hazards occurring in a specific area of implementation are outlined in the introductory sheet of every shelter typology.

Table 2: Broad overview of hazard classifications for information purposes, considering international standards

Risks	Wind speed intensity *How well the shelter type withstands winds	Flood intensity (based only on flood depth) *How well the shelter type withstands the flood intensity	Seismic activity magnitude *How well the shelter type withstands earthquake magnitudes based on the Richter scale
Intensity	Strong winds (39 – 74 km/hr)	High intensity flooding (> 50 cm)	High magnitude seismic events (>7)
	Moderate winds (12 – 38 km/hr)	Moderate floods (> 20 and < 50 cm)	Moderate magnitude seismic events (>5 <7)
	Light winds (0 – 11 km/hr)	No floods or minor floods possible (< 20 cm)	Low magnitude seismic events (> 1 < 5)

b) Suitability of the shelter design

The shelter sustainability analyses the appropriateness of shelters considering the indoor environmental quality and how well the shelter is suited for its designated role or purpose. While a shelter is assessed against the risks of natural hazards only if they represent a risk in the area of implementation, the suitability of the shelter design will be assessed across all the shelter typologies – **general assessment**. The suitability of a shelter typology is assessed in terms of the following criteria:

Natural ventilation

Natural ventilation helps maintain a healthy internal environment, prevents condensation and reduces the spread of communicable diseases. It also reduces the effect of smoke and other pollutants which might concentrate inside the shelter (cooking, storing toxic products or materials, such as fuel for cooking/heating). The ventilation needs for a shelter typology are calculated and assessed by using a rule of thumb calculation formula. If the surface of all the window openings together is more than 5 % of the surface of the floor area, the ventilation is adequate. The rule of thumb was based on ASHRAE standard which requires a minimum air change of 35 m^3/ hr per person to ensure internal comfort. The floor to ceiling height of the shelter plays also an important role in determining the internal air quality. The Sphere standards recommend at least 2 meter floor to ceiling height at the highest point of the shelter (2.6 meters in warm climates). Furthermore, the addition of upper vent openings (near the ceiling) will allow the warm air to escape outside, which is especially relevant in warm/ tropical climates. In cold climates, it is important to ensure the gases and fumes caused by heating stoves are properly released from the shelter.

Fire and flammability

Fire risk assessments should inform site planning and shelter design. Including 30-meter fire breaks every 300 meters between built-up areas (clear from debris, litter or other items at all times) and ensuring a minimum distance of 2 meters, ideally twice the height of the shelters (to the ridge), between structures will ensure safe evacuation in the case of fire. The choice of shelter materials as well as considering local cooking practices and providing designated spaces to cook (on individual plots or communal kitchen spaces) will minimize fire risks. Fire prevention measures on a site level and for individual shelters should be based on the following three mitigation strategies:

- Limiting the spread of fire and formation of smoke;
- Ensuring safe escape time, safe distances between shelter units and sound evacuation plans;
- Informing residents about fire prevention and management.

For the purpose of this assessment only the shelter materials and therefore the proportion (in %) of fire–resistant, fire–retardant and flammable construction materials integrated in the shelter design will be analyzed. Fire-resistant materials are designed to resist burning and withstand heat while fire-retardant materials are conceived to burn slowly. Flammable materials on the other hand, are combustible materials that ignite easily at ambient temperatures and catch fire immediately on exposure to flame.

Thermal comfort

If thermal comfort in a shelter is adequate people living inside it are comfortably warm or cold, covered and dry. Ideally, a comfortable indoor temperature in moderate climate[1*] is approximately between 20-25°C (+/- 2°C, ASHRAE standard). These values can increase in hot climate conditions and reduce in cold climate conditions but generally should not be less than 13°C. However, the thermal comfort inside a shelter is not linked only to the temperature and weather patterns of the area and the shelter materials (especially the insulation properties of the shelter envelope), but also to the perception of hot and cold of the shelter occupants. For the purpose of this assessment the satisfaction rates of the occupants will not be assessed. Only the insulation factor of the materials of the shelter envelope (walls and roof) in relation to the climate conditions will be analyzed.

Personal security

Personal security is extremely important in a shelter both to provide protection and to support groups at risk to feel safe. This criteria is highly context-specific and may vary from household to household as well as from individual to individual and may be highly influenced also by family/household composition (female headed households, tensions with host communities or with other displaced groups). For the purpose of this evaluation the personal security in a shelter will be assessed considering the following criteria:

[1*] Temperate climates occur in the latitudes which span between the tropics and the polar regions of Earth. These zones generally have wider temperature ranges throughout the year and more distinct seasonal changes compared to tropical climates, where such variations are often small.

- Inner and outer locks for all doors and windows;
- Artificial lightning source;
- Strong, non-transparent shelter cladding materials;
- Window openings not bigger than 60 x 60cm.

Accessibility

To accommodate persons with disabilities and those facing mobility or access barriers (e.g. elderly, children, pregnant women) the shelter needs to be designed considering the following accessibility criteria:

- All doors in the shelter need to be wider than 90 cm (to allow the passage of wheelchairs);
- If the shelter is elevated or has steps other architectural barriers a ramp with handrails and a parapet should be installed to facilitate access;
- The door of the toilet area should open outwards.

Table 3: Shelter design suitability (ventilation, flammability, thermal comfort) grading system

Ventilation	Grade	Flammability	Grade	Thermal comfort	Grade
The shelter exceeds the ventilation requirements	3	The shelter is made from materials which are fire resistant (>75%)	3	The shelter is adapted to the climate and mitigates extreme temperatures (high insulation factor of wall and roof materials)	3
The shelter meets minimum ventilation requirements	2	The shelter is partially or fully made from fire retardant materials (>50%)	2	The shelter partially mitigates extreme temperatures (either wall or roof materials have a high insulation factor)	2
The shelter does not meet ventilation requirements	1	The shelter is made from at least one flammable material (>25%)	1	The shelter is not fit for extreme temperatures (wall and roof materials do not have high insulation factor)	1

Table 4: Shelter design suitability (personal security, accessibility) grading system

Personal security	Grade	Accessibility	Grade
The shelter provides all the above listed measures	3	The shelter provides all the above listed measures	3
The shelter provides all the above listed measures, except one	2	The shelter provides all the above listed measures, except one	2
Two or more of the above listed measures are not provided	1	Two or more of the above listed measures are not provided	1

Shelter Habitability

The shelter habitability is assessing the appropriateness of a shelter typology in terms of the following criteria:

a) Covered living area

Living space should be adequate to accommodate daily activities such as sleeping, preparing and eating food as well as storing food and belongings. According to the Sphere standards the shelter should provide a minimum covered living area of 3.5 m2 per person in hot climate conditions and 4.5 m2 per person in cold climate conditions (where people are forced to stay inside the shelter for longer periods of time). This standard however can be adapted in specific contexts to reflect cultural and social norms. Land scarcity, host community habits and local shelter typologies might make it difficult to implement humanitarian minimum standards and cause tensions between the host community and displaced populations. The minimum living space should reflect cultural and social norms, the context, the phase of the shelter response (emergency, recovery, protracted) the local codes and humanitarian standards, therefore before adopting the minimum calculated space all the considerations need to be carefully considered.

b) Privacy (internal partition)

The need for internal subdivisions of a shelter should be assessed based on existing practices and customs. Where appropriate for gender, age or cultural reasons, family and / or gender segregated partitions (curtains or walls) should be installed. These should be made from non-transparent materials.

c) Natural lighting

Adequate lighting, including access to daylight, are among the basic elements required to ensure the health and well-being of shelter inhabitants. Daylighting is inseparably linked to the energy demand and the indoor climate of a shelter. The size and placement of window openings should be determined based on adequacy needs and security concerns. Adequate lighting conditions indoors do not only contribute to the health and well being of the shelter users, they also ensure a living space that can enhance the learning potential of schooling children and provide a space adequate to perform specific livelihood activities. For the purpose of this analysis the natural lightning needs for a shelter typology is calculated by using a rule of thumb calculation formula. If the surface of all the window and ventilation openings together is more than 10 % of the surface of the floor area, natural lightning is adequate.

d) Artificial lighting

Artificial lighting should be provided as needed to contribute to personal safety in and around the shelter. The access to artificial lighting could be on a site level, where only strategic spaces and communal areas in the site are artificially lit and on an individual level where individual shelters have access to it. The sources of artificial lighting can be of different nature. Besides candles, which present considerable fire risks, and connection to an electricity grid or generator, the use of different renewable energy lighting sources (solar panels) is also possible and encouraged.

e) Appropriateness of materials and set up techniques

The appropriateness of shelter materials and construction techniques is assessed in comparison either with the local practices of the host community or the displaced population. The shelter solutions should preferably be designed on the basis of context-specific structural and performance requirements. Familiarity with the construction techniques and materials will ensure that the shelter occupants are able to maintain and / or repair the shelter without the need of technical guidance or procurement of costly parts.

f) Facilities (kitchen areas, toilets, showers)

An adequate living space does not depend only on the appropriateness of the shelter unit. Access to complementary spaces and facilities are also considered, as they support and maintain health, dignity and safety and they allow the undertaking of daily activities in and around the shelter. It is important to provide designated spaces to cook and ensure adequate and appropriate toilets and showers to allow rapid, safe and secure access at all times by all their users, including children, older persons, and pregnant women. Communal toilets should be considered as an immediate solution and replaced by individual toilets as soon as possible. Safe and sustainable excreta management should be considered as a priority as well as solid waste management which should be safely contained to avoid pollution and health risks.

Table 5: Shelter habitability grading system

Covered living area	Grade	Privacy	Grade	Appropriateness of shelter materials	Grade
The shelter complies with Sphere standards	3	The shelter provides minimum privacy (has an internal partition, has more than one room)	3	Shelter is made by local materials and locally adapted construction techniques	3
The shelter does not comply with Sphere standards; however, it was designed to reflect the local standards and avoid conflict with host communities, or the design and space allow for shelter expansion	2	The shelter does not provide minimum privacy, however the design and space allow for modifications and upgrading to offer minimum privacy	2	Shelter is partially made by local materials and locally adapted construction techniques	2
The shelter does not comply with Sphere standards	1	The shelter does not provide minimum privacy	1	The shelter materials / construction techniques are not locally adapted	1

Table 6: Shelter habitability grading system

Natural lighting	Grade	Artificial lighting	Grade	Facilities (kitchen area, toilets, shower)	Grade
The shelter exceeds the natural lighting requirements	3	The shelter has artificial lighting	3	The shelter or plot is equipped with the facilities	3
The shelter meets minimum natural lighting requirements	2	The shelter does not have artificial lighting, however, there is artificial lighting in the site in strategic spots	2	The shelter or plot is not equipped with the facilities; however, there are communal facilities in the site	2
The shelter does not meet natural lighting requirements	1	The shelter does not have artificial lighting	1	The shelter or plot is not equipped with the facilities and there are no communal facilities in the site	1

Shelter Affordability

The shelter affordability is defined by considering the cost of a specific shelter and taking into account all the associated costs: production, supply and transportation of construction material, the shelter set up / construction costs and also by considering the shelter life span and the shelter covered living area. By including the shelter life span and covered living area in the equation, we ensure a comparable unit cost, across different shelter typologies. The cost assessment is calculated in USD and it considers the prices of materials, transport and construction according to the 2019 local market assessments. The price of the land where the shelter is built it is not considered in the calculation.

For calculating the shelter affordability the following equation was developed:

Affordability = cost (BoQ) / life span / shelter area

Measured in USD / Shelter life span in years / Area in m^2

Sustainability Score card

The concept of the Shelter Sustainability Score Card is based on the understanding that the built environment can have profound effects on the natural environment, as well as people who inhabit dwellings/shelters, independently of the implementation context.
The Sustainability Score Card is an effort to amplify the positive and mitigate the negative effects of these activities throughout their life cycle. It was conceived as a standardized data format that provides an overview of the resources used to build a specific shelter, their impacts on the natural environment and the shelter characteristics themselves, with the overall aim to ease cross-typology comparison of resources and shelter aspects.
The structuring of shelter data and tangible assets in a comparable format enables all the stakeholders in the supply chain to work together towards a more sustainable shelter response.

Tree protection (environmental impact)

The tree protection is assessed based on the decrease in forest area (wood and bamboo) due to shelter construction activity. It is calculated by taking into account the quantity of trees and/or bamboo poles used to build a specific shelter type.

CO_2 emission mitigation (environmental impact)

The CO_2 footprint is calculated by taking into account CO_2 emissions as well as the CO_2 absorption cease in relation to the shelter life span and covered living area.

Material efficiency (environmental impact)

Material efficiency is evaluating the quantity of the construction material used for a specific shelter typology and its impact on the environment during extraction, production and processing (CO_2 emissions and water usage). Material reuse options after disposal are also taken into account. The material intensity is then weighted in relation to the shelter covered living area.

Technical performance

The technical performance of a specific shelter typology is determined by assessing its structural resistance in the event of a hazard and the suitability of the shelter design.

Shelter habitability

The shelter habitability is determined by assessing the covered living area, privacy characteristics, appropriateness of shelter materials and construction techniques, the natural and artificial lightning aspects and access to facilities.

Shelter affordability

The shelter affordability is determined by considering the cost of a specific shelter with all the associated expenditures (production, transport, construction) in relation to the shelter life span as well as the shelter covered living area.

3. Emergency shelter solutions

UNHCR defines emergency shelter as a habitable covered living space providing a secure and healthy environment with privacy and dignity. Individual family shelters are always preferred to communal accommodation as they provide the necessary privacy and psychological comfort. They also provide safety and security for people and possessions and help to preserve or rebuild family unity. Emergency shelter needs are best met by using materials and designs that persons of concern or the local population would normally use. Wherever possible, displaced populations should be empowered to build their own shelter, with the necessary organizational, material and / or cash assistance support. This will help ensure that the shelter meets their particular needs, promote a sense of ownership and self-reliance, and reduce costs and construction time considerably. It is important to keep in mind that the initial shelter design as well as the site selection and planning will determine the long term sustainability of the site, therefore it is important to develop a shelter response focused beyond the emergency phase and linked to more durable solutions.

3.1 Emergency shelter
Ituri settlements

The shelter was implemented to respond to the internal displacement crises during the upsurge in violence in Ituri province, Eastern Congo. In 2019, more than 360 000 people fled their homes to seek safety in host communities and IDP settlements. In response of the humanitarian crises UNHCR has provided to the most vulnerable 8 621 IDPs households with emergency shelters across more than 14 settlements. The PoCs and the host community were involved in the project through cash for work modality. The shelters are simple, one room structures implemented to provide critical life saving emergency assistance. In addition to emergency shelters the sites were equipped with access to improved water sources, communal toilets and showers and as kitchen areas.

Shelter service area
10.5 m² [3m x 3.5m]

Regionally or locally sourced materials
Water, timber, bamboo, clay-rich soil and thatch

Imported materials
Cement, plastic based items, steel, iron and its end products are imported from abroad usually from China

Climate classification
Tropical savanna

Yearly temperatures
Vary from 17°C to 30°C
Rarely below 15°C or above 34°C

Rainy season
September to November with
160 mm of precipitation per month on average

Dry season
December to March with
45 mm of precipitations per month in average

Wind speed
Winds up to 8.3 km/hr

Flood risks
- Clay reach soil (rain water retention)
- Important volumes of rain water runoff
- No service water drainage in the site

Flood mitigation opportunities
Site slope around 5 - 6 %

Site level environmental challenges
- Site cleaning (trees and other types of vegetation) due to construction;
- No strategy for a sustainable disposal of fecal waste;
- Refuse pits implemented, but without strategy for long term solid waste management;
- Firewood collection and open fire cooking.

Variation A

Structure	gable timber frame
Walls	UNHCR plastic tarpaulins
Roof	UNHCR plastic tarpaulins
Footing	poles 50 cm deep with compacted earth
Floor	natural earth
Openings	one door [90 cm x 190 cm]
	no windows, ventilation under each eave

+30°C / +10°C
Suggested temperature range

Number of people required for setup

2 DAYS
Time required for setup[5*]

1 YEAR
Average life span of the shelter

Environmental impacts

Raw materials used[3*]	gum trees	0.5 m³
	water[1*]	3 910 liters
Manmade materials used	plastic (tarpaulins)	0.13 m³
	steel (nails)	5.3 kg
CO_2 emissions	material production	84 kg
	transportation	35 kg
CO_2 absorption cease	due to deforestation	90 kg/year
	Total	209 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	208.7 kg / 1 year / 10.5 m²	
	= 20 kg of CO_2 / year / m²	
Damage of natural habitat	Deforestation & erosion	
Material reuse	Timber elements and tarpaulins can be upcycled	

Technical performance

Wind resistance	complying
Flood mitigation	on plot/site flood mitigation measures
Ventilation	meets minimum vent. requirements
Flammability	meets fire retardant criteria
Thermal comfort	not fit for extreme temperatures[2*]
Personal security	not guaranteeing personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 3 occupants (Sphere)
Privacy	not designed for minimum privacy
Natural light	no natural light
Artificial light	no access to artificial lightning
Shelter materials	not adapted to local practices
Facilities	communal facilities in the site

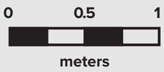
Affordability

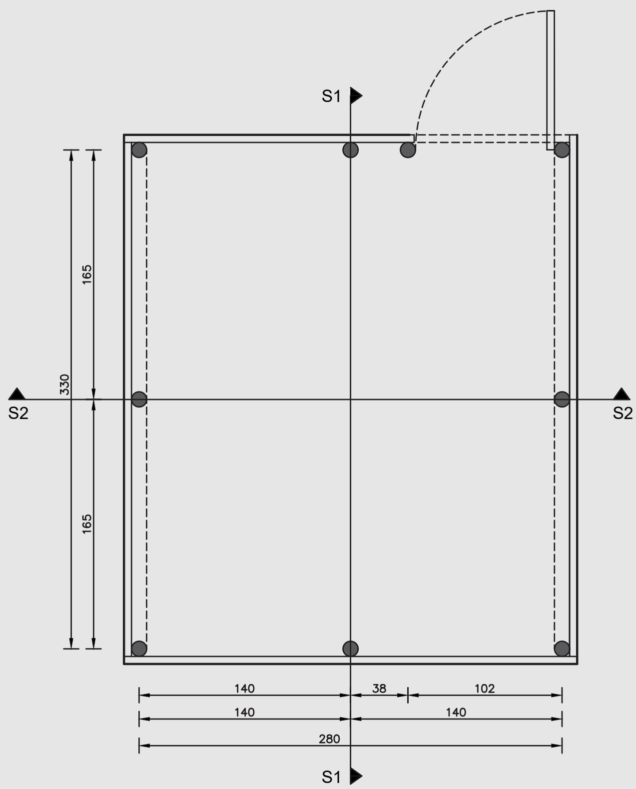
Costs	Cost / Life span / Area
	$ 124.65 / 1 year / 10.5 m²
	= $ 11.9 / year / m²

[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

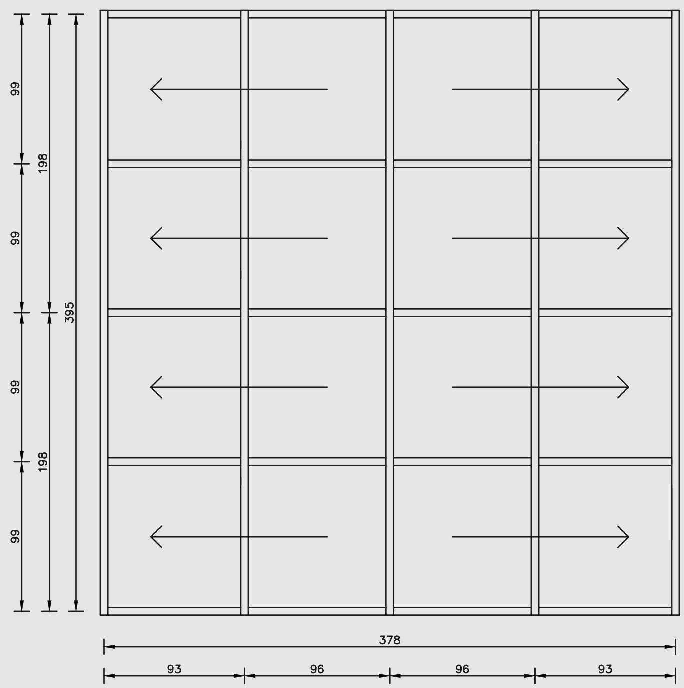
Technical drawings

All measures in cm

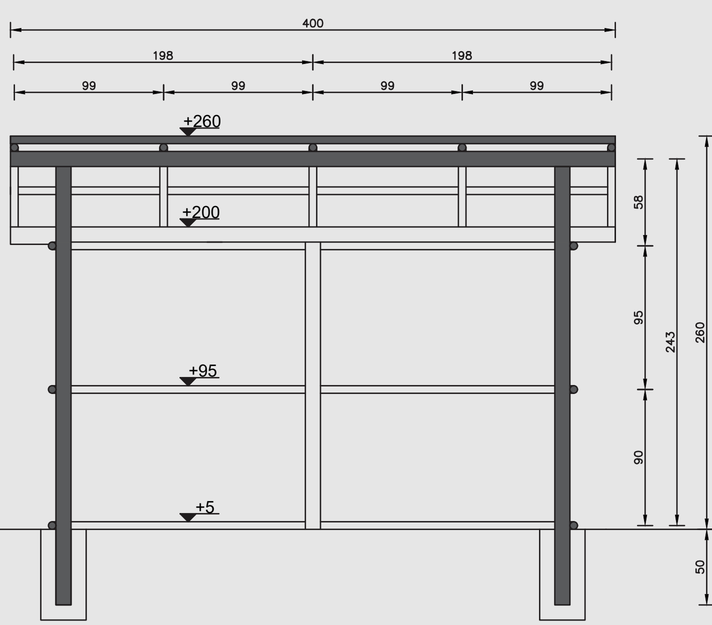




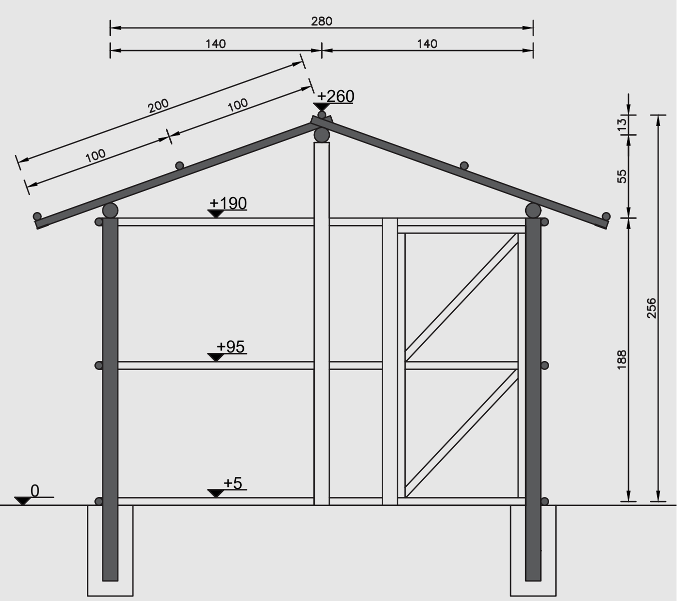
Floor plan



Roof plan



Section S1



Section S2

Bill of Quantities

	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Shelter Super Structure	Gum poles with ø 8-10 cm, 3.5 m long	pieces	5	1.2	6
	Gum poles with ø 8-10 cm, 2.5 m long	pieces	7	1.2	8.4
	Gum poles with ø 4-5 cm, 3.5 m long	pieces	11	1	11
	Gum poles with ø 4-5 cm, 3 m long	pieces	6	1	6
	Gum poles with ø 4-5 cm, 2 m long	pieces	10	1	10
	UNHCR plastic tarpaulin, sheet 4 x5 m	pieces	3	12	36
	Nails 10 cm long	kg	2.5	3	7.5
	Nails 4 cm long	kg	1.75	3	5.25
	Roofing nails (umbrella type), 5 cm long	kg	1	3	3
Openings	Timber plank 10x5 cm, 3.5 m long	pieces	3	3.5	10.5
	Door locking system	pieces	1	0.5	0.5
	Door hindges	pieces	2	0.25	0.5
Labour	2 unskilled	day	2	3	12
	1 skilled worker	day	1	8	8
					104.65 + 20
	Total				**124.65**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

- Tree protection
- C0₂ emission mitigation
- Material efficiency
- Technical performance
- Shelter habitability
- Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

Variation B

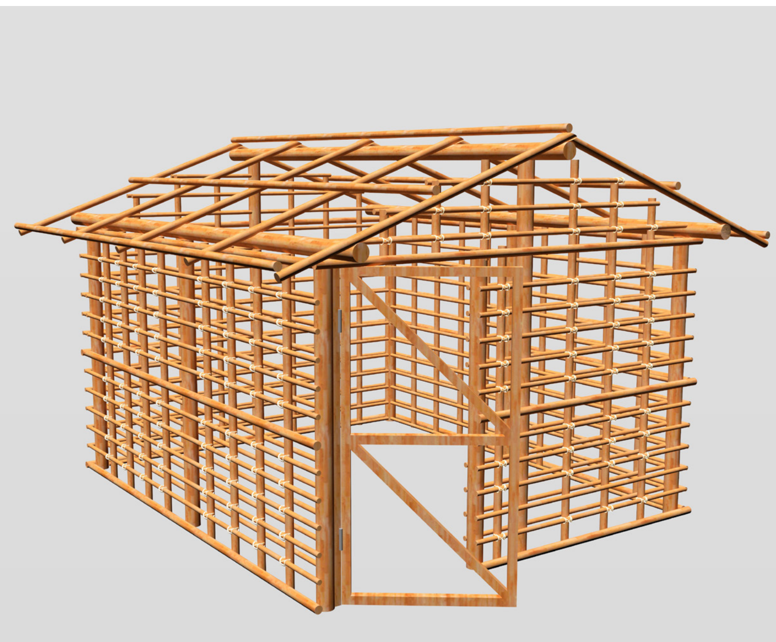
Structure	gable timber frame
Walls	wattle & daub with straw reinforced earth
Roof	UNHCR plastic tarpaulins
Footing	poles 50 cm deep with compacted earth
Floor	natural earth
Openings	1 door [90 x 190cm]
	no windows, ventilation under both eaves

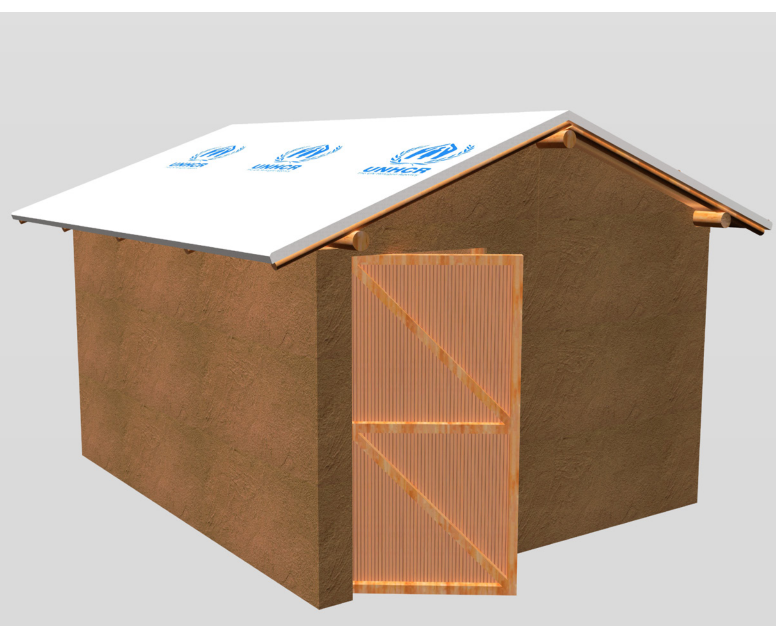
+35ºC
+10ºC
Suggested temperature range

Number of people required for setup

7 DAYS
Time required for setup[5*]

2 YEARS
Average life span of the shelter





Environmental impacts

Raw materials used[3*]	gum trees	0.48 m³
	bamboo	0.35 m³
	water[1*]	4 641 liters
	soil	5 m³
	straw	12 kg
Manmade materials used	plastic (tarpaulins)	0.04 m³
	steel (nails)	4.5 kg
CO_2 emissions	material production	33 kg
	transportation	38 kg
CO_2 absorption cease	due to deforestation	225 kg/year
	Total	296 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	296 kg / 2 years / 10.5 m²	
	= 14 kg of CO_2 / year / m²	
Damage of natural habitat	Deforestation & erosion	
	fall through hazards due to soil excavation	
Material reuse	Timber elements and tarpaulins can be upcycled	

Technical performance

Wind resistance	complying
Flood mitigation	on plot/site flood mitigation measures
Ventilation	meets minimum vent. requirements
Flammability	meets fire retardant criteria
Thermal comfort	partially mitigates extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 3 occupants (Sphere)
Privacy	not designed for minimum privacy
Natural light	no natural light
Artificial light	no access to artificial lightning
Shelter materials	partially adapted to local practices
Facilities	communal facilities in the site

Affordability

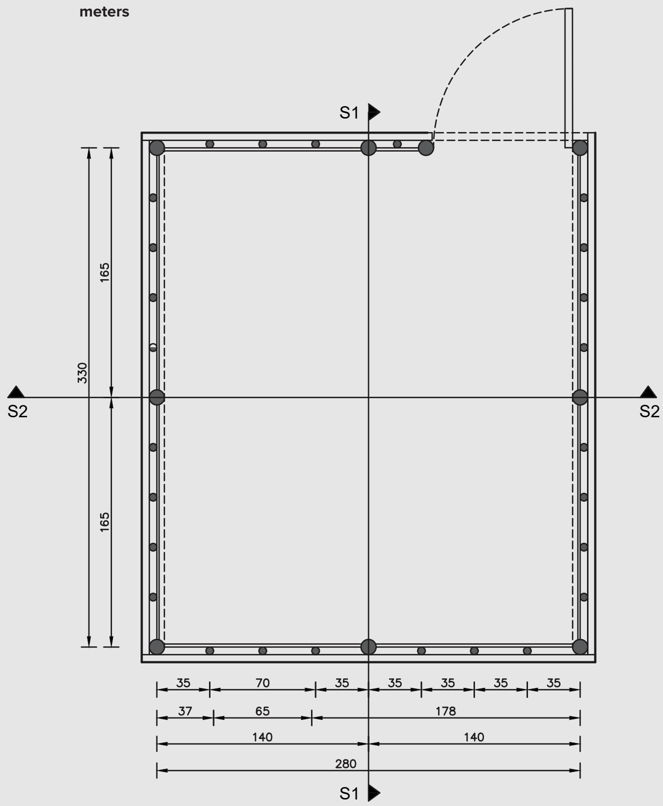
Costs	Cost / Life span / Area
	$ 190.15 / 2 years / 10.5 m²
	= $ 9.1 / year / m²

[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

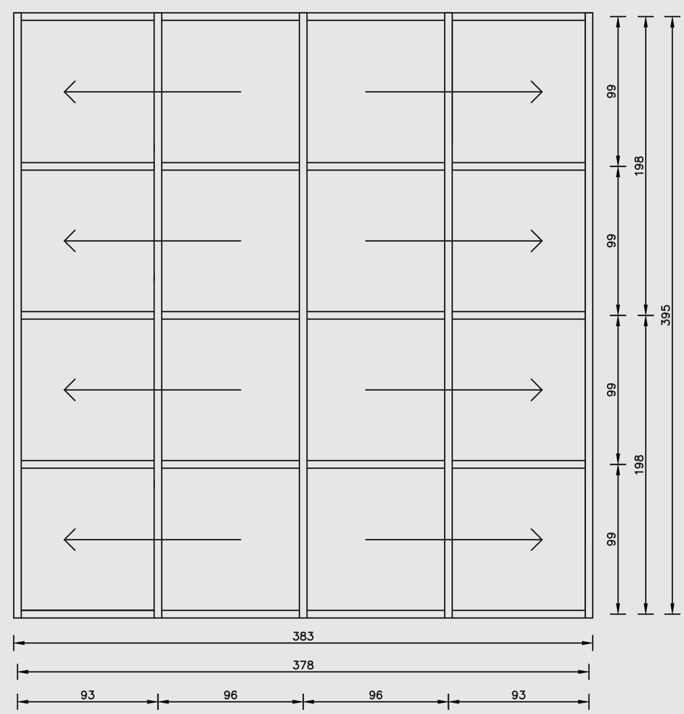
Technical drawings

All measures in cm

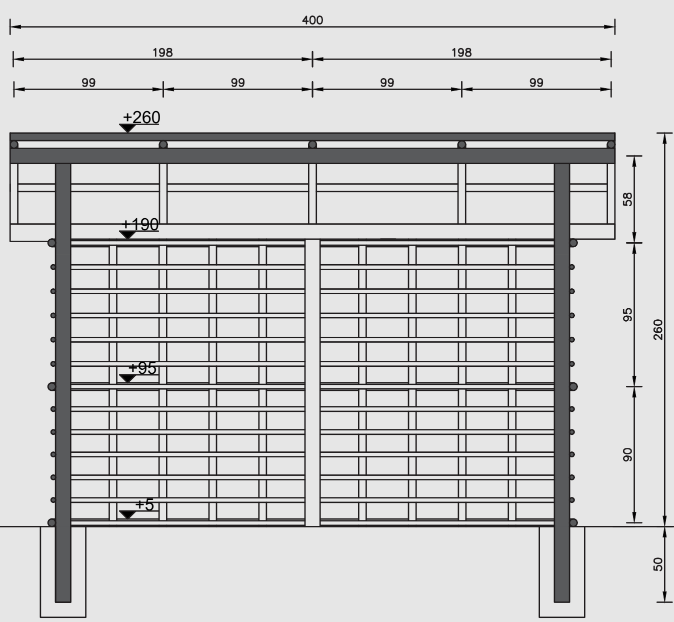
0 0.5 1
meters



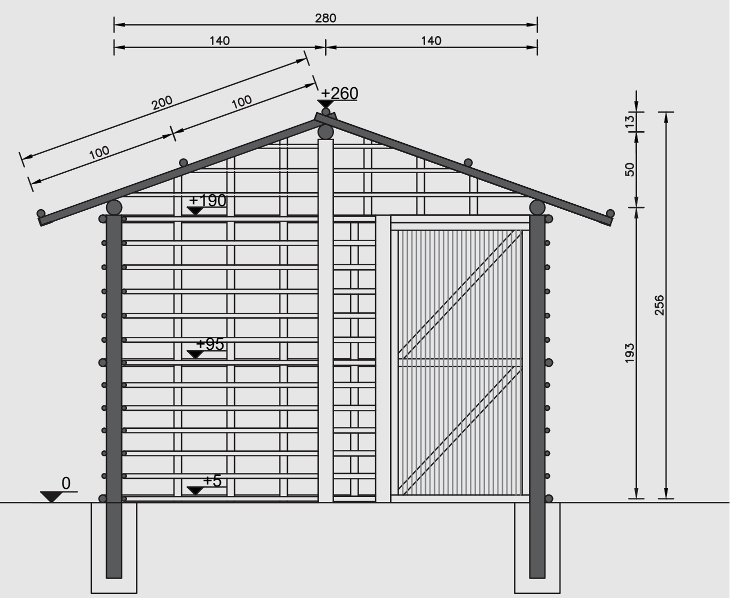
Floor plan



Roof plan



Section S1



Section S2

Bill of Quantities

Section	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Shelter Super Structure	Gum poles with ø 8-10 cm, 3.5 m long	pieces	5	1.2	6
	Gum poles with ø 8-10 cm, 2.5 m long	pieces	7	1.2	8.4
	Gum poles with ø 4-5 cm, 3.5 m long	pieces	11	1	11
	Gum poles with ø 4-5 cm, 3 m long	pieces	6	1	6
	Gum poles with ø 4-5 cm, 2 m long	pieces	10	1	10
	Bamboo sticks with ø 2-3 cm, 3.5 m long	pieces	56	0.25	14
	Bamboo sticks with ø 2-3 cm, 3 m long	pieces	23	0.2	4.6
	Bamboo sticks with ø 4-5 cm, 2.5 m long	pieces	10	0.25	2.5
	Bamboo sticks with ø 4-5 cm, 2 m long	pieces	17	0.2	3.4
	Bamboo sticks with ø 2-3 cm, 2 m long	pieces	35	0.15	5.25
	UNHCR plastic tarpaulin, sheet 4 x5 m	pieces	1	12	12
	Nails 10 cm long	kg	2.5	3	7.5
	Nails 4 cm long	kg	1	3	3
	Roofing nails (umbrella type), 5 cm long	kg	1	3	3
	Syntetic rope with ø 0.5 cm	m	80	-	15
	Soil excavation	m^3	5	-	-
	Straw (average 6 kg per bundle)	bundle	2	2	4
Openings	Timber plank 10x5 cm, 3 m long	pieces	3	3.5	10.5
	Door locking system	pieces	1	0.5	0.5
	Door hindges	pieces	2	0.25	0.5
	Bush stick braiding, 90x190 cm	pieces	1	5	5
Labour	2 unskilled worker	day	7	3	42
	1 skilled worker	day	2	8	16
					132.15 + 58
	Total				**190.15**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

- Tree protection
- C02 emission mitigation
- Material efficiency
- Technical performance
- Shelter habitability
- Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

Variation C

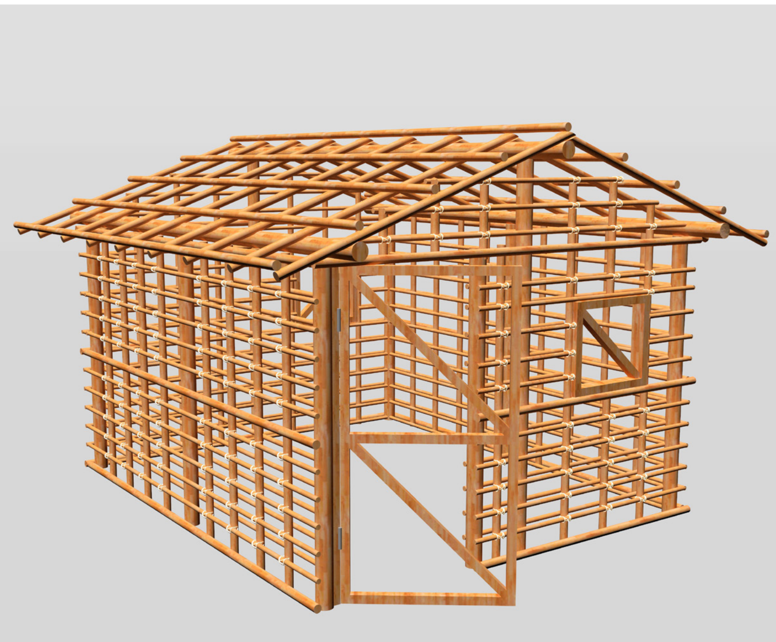
Structure	gable timber frame
Walls	wattle & daub with straw reinforced earth
Roof	thatch
Footing	poles 50 cm deep with compacted earth
Floor	natural earth
Openings	1 door [90 x 190cm], 2 windows [65 x 60cm], 2 eave vents & 2 gable vents [50 x 30cm]

+45°C / +7°C
Suggested temperature range

Number of people required for setup

9 DAYS
Time required for setup[5*]

4 YEARS
Average life span of the shelter



Environmental impacts

Raw materials used[3*]	gum trees	0.57 m^3
	bamboo	0.35 m^3
	water[1*]	4 320 liters
	soil	5 m^3
	straw	42 kg
Manmade materials used	steel (nails)	4 kg
CO_2 emissions	material production	8 kg
	transportation	37 kg
CO_2 absorption cease	due to deforestation	237 kg/year
	Total	282 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	282 kg / 4 years / 10.5 m^2	
	= 7 kg of CO_2 / year / m^2	
Damage of natural habitat	Deforestation & erosion	
	fall through hazards due to soil excavation	
Material reuse	Timber elements can be upcycled	

Technical performance

Wind resistance	complying
Flood mitigation	on plot flood mitigation measures
Ventilation	meets minimum vent. requirements
Flammability	partially flammable (roof)
Thermal comfort[*2]	mitigates extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 3 occupants (Sphere)
Privacy	not designed for minimum privacy
Natural light	meets minimum light. requirements
Artificial light	no access to artificial lightning
Shelter materials	adapted to local practices
Facilities	communal facilities in the site

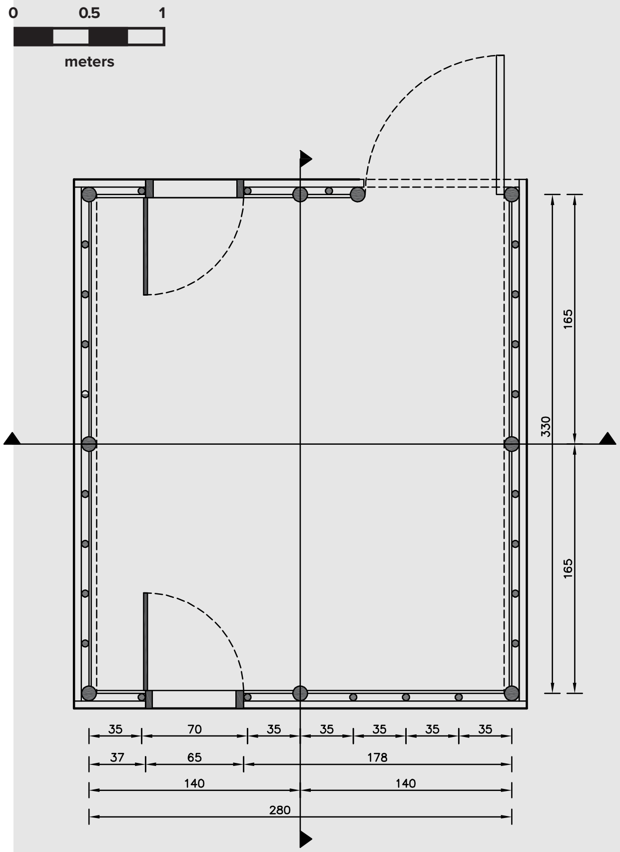
Affordability

Costs	Cost / Life span / Area
	$ 256.65 / 4 years / 10.5 m^2
	= $ 6.1 / year / m^2

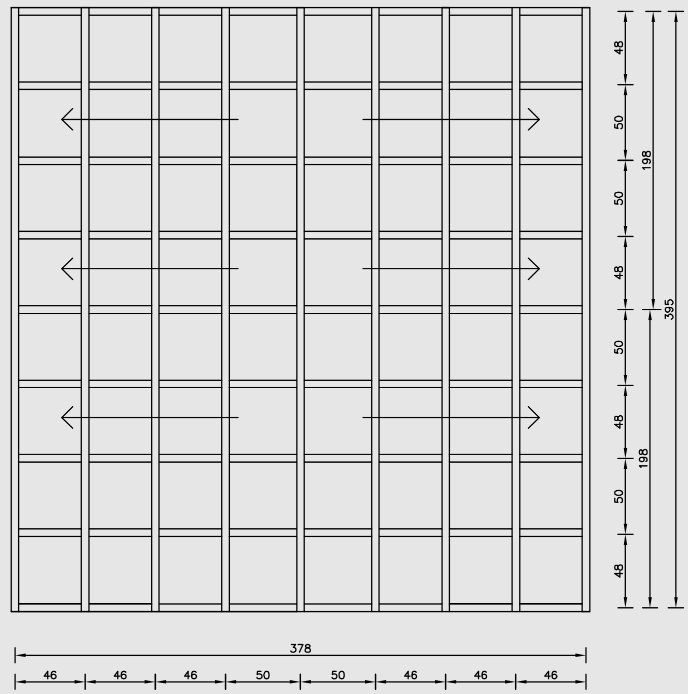
[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

Technical drawings

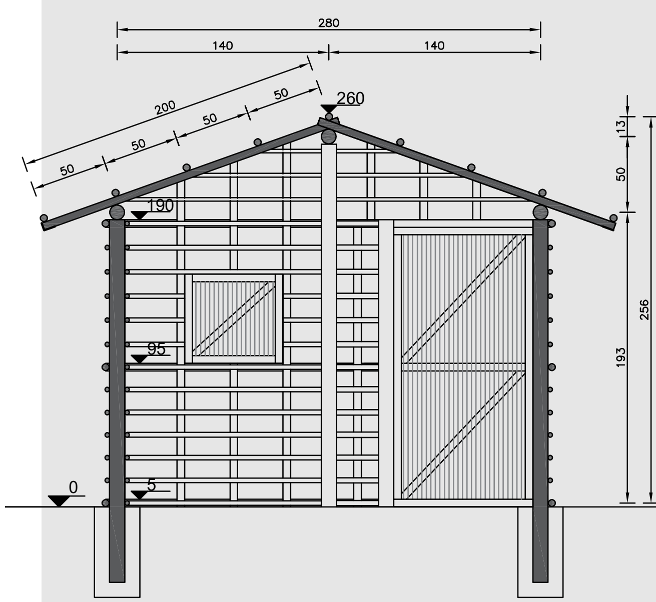
All measures in cm



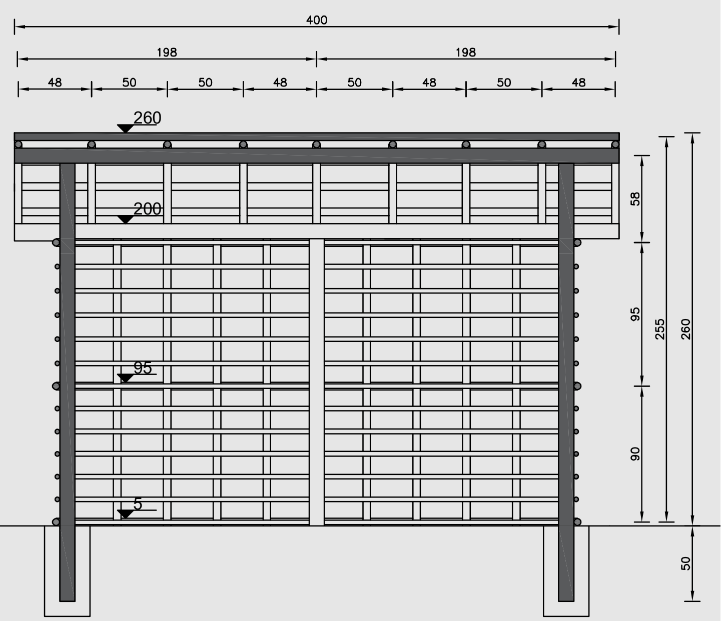
Floor plan



Roof plan



Section S1



Section S2

Bill of Quantities

Section	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Shelter Super Structure	Gum poles with ø 8-10 cm, 3.5 m long	pieces	5	1.2	6
	Gum poles with ø 8-10 cm, 2.5 m long	pieces	7	1.2	8.4
	Gum poles with ø 4-5 cm, 3.5 m long	pieces	15	1	15
	Gum poles with ø 4-5 cm, 3 m long	pieces	6	1	6
	Gum poles with ø 4-5 cm, 2 m long	pieces	18	1	18
	Bamboo sticks with ø 2-3 cm, 3.5 m long	pieces	56	0.25	14
	Bamboo sticks with ø 2-3 cm, 3 m long	pieces	23	0.2	4.6
	Bamboo sticks with ø 4-5 cm, 2.5 m long	pieces	10	0.25	2.5
	Bamboo sticks with ø 4-5 cm, 2 m long	pieces	17	0.2	3.4
	Bamboo sticks with ø 2-3 cm, 2 m long	pieces	35	0.15	5.25
	Nails 10 cm long	kg	2.5	3	7.5
	Nails 4 cm long	kg	1.5	3	4.5
	Syntetic rope with ø 0.5 cm	m	30		6
	Syntetic rope with ø 0.5 cm	m	80	-	15
	Soil excavation	m^3	5	-	-
	Straw (6 kg/bundle) - earth mix	bundle	2	2	4
	Straw (6 kg/bundle) - roof cover, 2 m long	bundle	5	3	15
Openings	Timber plank 10x5 cm, 3 m long	pieces	3	3.5	10.5
	Door locking system	pieces	1	0.5	0.5
	Door hindges	pieces	2	0.25	0.5
	Bush stick braiding, 90x190 cm	pieces	1	5	5
	Timber plank 10x5 cm, 3 m long	pieces	2	3.5	7
	Window locking system	pieces	2	0.5	1
	Window hindges	pieces	4	0.25	1
	Bush stick braiding, 65x60 cm	pieces	2	3	6
Labour	2 unskilled worker	day	9	3	54
	1 skilled worker	day	3	8	24
					166.65 + 78
	Total				**244.65**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

- Tree protection
- C02 emission mitigation
- Material efficiency
- Technical performance
- Shelter habitability
- Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

3.2 Emergency shelter
M'Bera settlement

M'Bera camp is located in south-east Mauritania and hosts some 50,000 refugees who have fled conflict and ongoing insecurity in northern Mali since 2012. New arrivals allocated a plot of land and being provided with transitional shelter and non-food items. The current shelter approach is based around a simple rectangular structure of steel pipe and timber frame, clad in thick canvas. The steel structure consists of 9 circular hollow section posts with a timber frame clad in canvas cloth. This option is climatically and culturally appropriate for the primarily rural and nomadic agro-pastoralist refugee population. In addition to the shelters the settlement was equipped with access to water sources, communal and household toilets and showers.

Shelter service area
14 m^2 [4m x 3.5m]

Regionally or locally sourced materials
Sandy-clayey soil, bricks, sand, aggregates, canvas, animal dung, cement

Imported materials
Plastic based items, steel and iron products are generally imported from China and timber is imported mainly from Mali

Climate classification
Desert, hot all year round

Yearly temperatures
Vary from 14°C to 42°C
Rarely below 11°C or above 44°C

Rainy season
July to October with
38 mm of precipitation per month on average

Dry season
November to June with
1.5 mm of precipitations per month in average

Wind speed
Windiest period from October to May with average wind speeds up to 20 km/h

Flood risks
- Areas prone to flash floods
- Sandy soil which easily washes away in rain
- Lack of vegetation cover and erosion

Flood mitigation opportunities
- Dykes across flood prone areas to prevent water reaching the settlement
- Service water drainage in the site

Site level environmental challenges
- Site cleaning (trees and other types of vegetation) due to construction;
- No strategy for a sustainable disposal of solid waste;
- Impacts of livestock on the environment, public health and aquifer depletion;
- No designated cooking areas;
- Firewood collection and open fire cooking.

Variation A

Structure	galvanized iron frame
Walls	UNHCR plastic tarpaulins
Roof	UNHCR plastic tarpaulins
Footing	steel poles, 70 cm deep with compacted earth
Floor	hand compacted
Openings	1 door [85 x 185cm]
	no windows, ventilation under each eave

+30°C / +10°C — Suggested temperature range

Number of people required for setup

03 DAYS — Time required for setup[5*]

1 YEAR — Average life span of the shelter

Environmental impacts

Raw materials used [3*]	gum trees	0.3 m^3
	water[1*]	100 600 liters
Manmade materials used	plastic (tarpaulins)	0.13 m^3
	steel (nails, poles)	142 kg
CO_2 emissions	material production	345 kg
	transportation	140 kg
CO_2 absorption cease	due to deforestation	180 kg/year
	Total	665 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	665 kg / 1 year / 14 m^2	
	= 48 kg of CO_2 / year / m^2	
Damage of natural habitat	Deforestation & erosion	
Material reuse	Steel poles are reusable	
	Timber elements and tarpaulins can be upcycled	

Technical performance

Wind resistance	complying
Flood mitigation	on plot/site flood mitigation measures
Ventilation	meets minimum vent. requirements
Flammability	meets fire retardant criteria
Thermal comfort	not fit for extreme temperatures[2*]
Personal security	not guaranteeing personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 4 occupants (Sphere)
Privacy	can be upgraded for minimum privacy
Natural light	no natural light
Artificial light	no access to artificial lightning
Shelter materials	not adapted to local practices
Facilities	household facilities in the plot

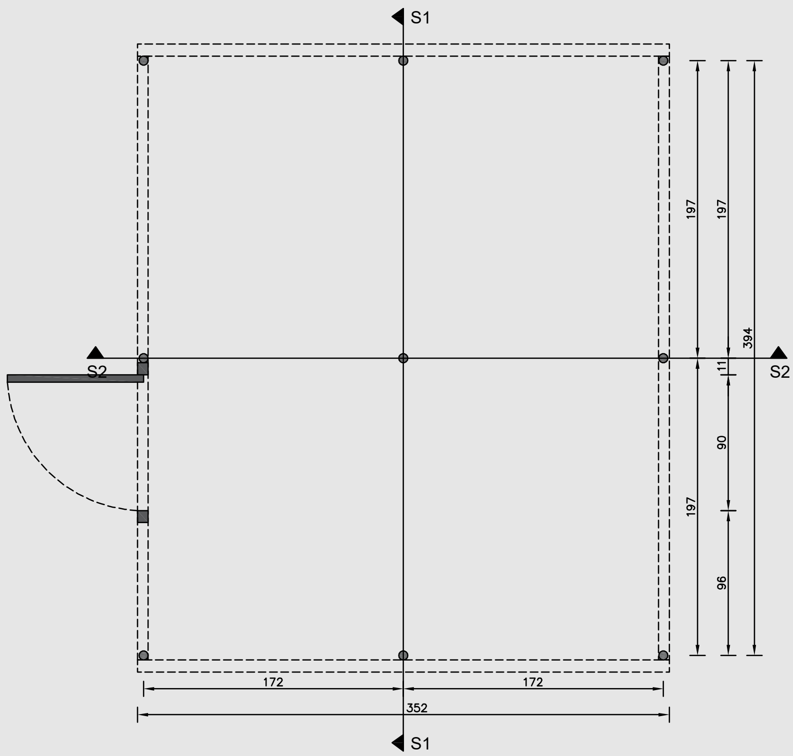
Affordability

Costs	Cost / Life span / Area
	\$ 528.8 / 1 year / 14 m^2
	= \$ 37.7 / year / m^2

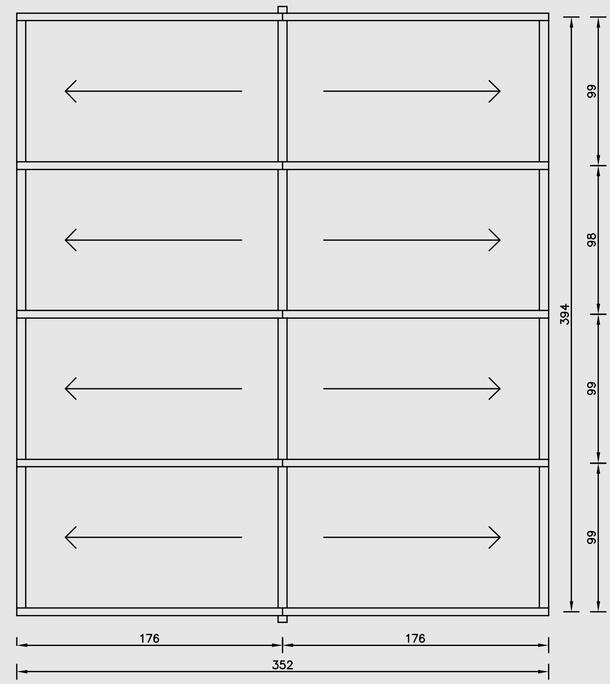
[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

Technical drawings

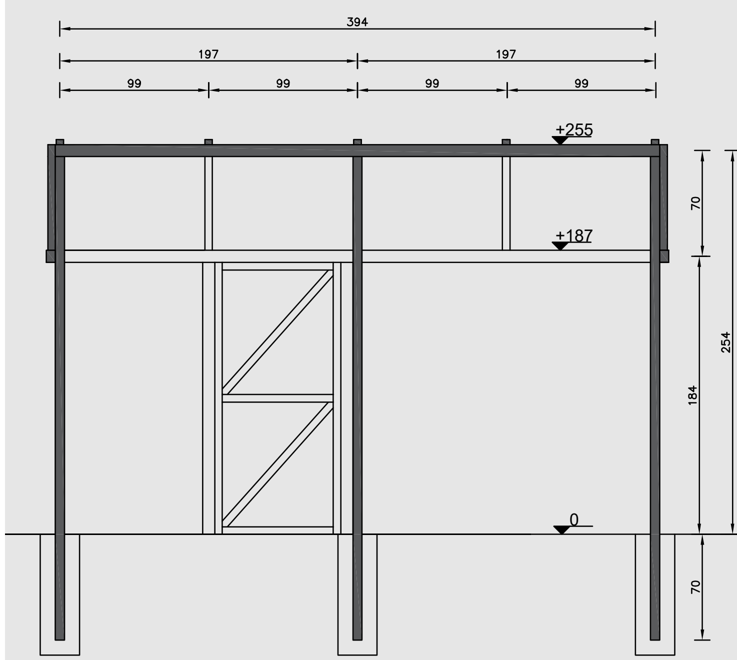
All measures in cm



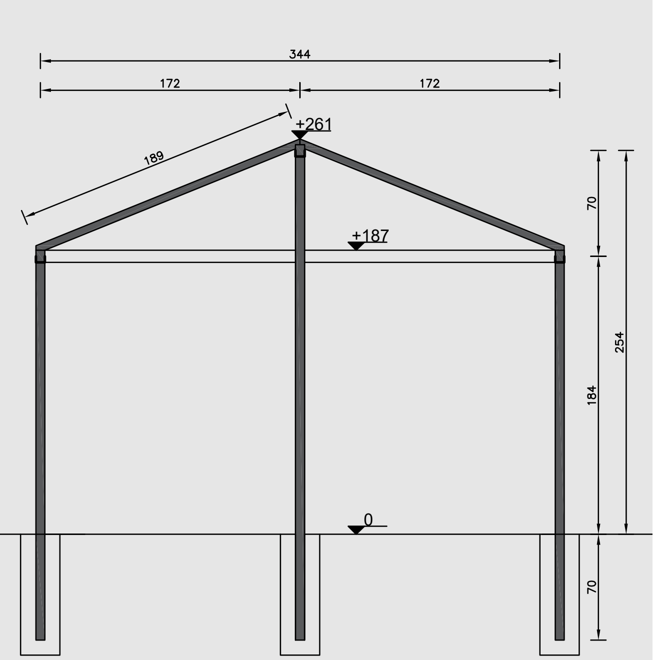
Floor plan



Roof plan



Section S1



Section S2

Bill of Quantities

	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Shelter Super Structure	Galvanized iron poles with ø 6 cm 3.2 m long	pieces	3	33.3	99.9
	Galvanized iron poles with ø 6 cm 2.5 m long	pieces	6	36.8	220.8
	Gum rafters, 8 x 6cm section, 4m long	pieces	3	4.5	13.5
	Gum rafters, 8 x 6cm section, 3.5m long	pieces	3	8	24
	Gum purlins, 5 x 5cm section, 2m long	pieces	16	2	32
	UNHCR plastic tarpaulin, sheet 4 x5 m	pieces	3	12	36
	Syntetic rope, small grain	m	45	-	9
	Syntetic rope, large grain	m	35	-	14.5
	Nails 10 cm long	kg	2	2	4
	Nails 4 cm long	kg	2	1.6	3.2
Openings	Door panel-CGI, gauge 30, 1.8x0.85 m	pieces	1	6	6
	Door locking system, 15 cm	pieces	1	0.8	0.8
	Door hinges & screws, 10-11 cm	pieces	2	0.25	0.5
	Gum plank 5x5 cm, 4 m min. length	pieces	2	4	8
	Nails 4 cm long	kg	1	1.6	1.6
Labour	2 unskilled worker	day	3	6	**36**
	1 skilled worker	day	1	19	19
					473.8 + 55
	Total				**528.8**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

- Tree protection
- C02 emission mitigation
- Material efficiency
- Technical performance
- Shelter habitability
- Shelter affordability

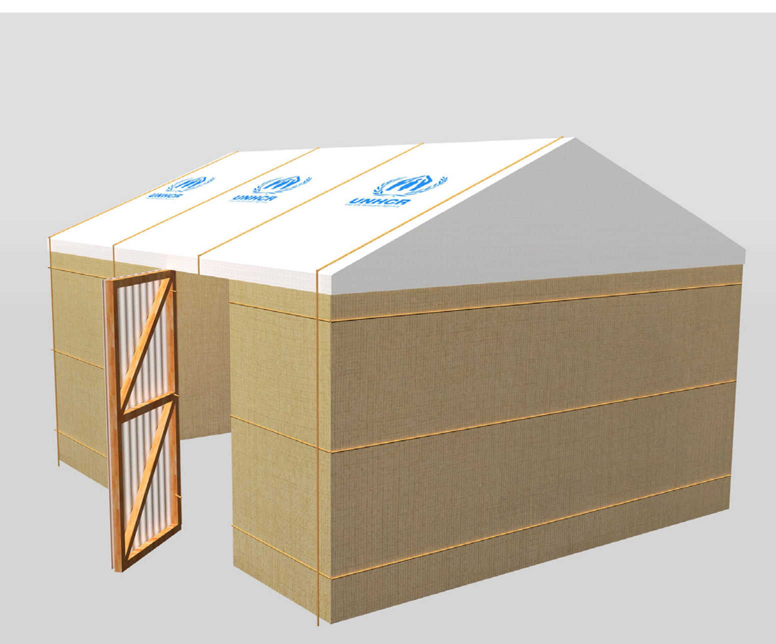
Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent

The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

Variation B

Structure	galvanized iron frame
Walls	UNHCR canvas roll
Roof	UNHCR plastic tarpaulins
Footing	steel poles, 70 cm deep with compacted earth
Floor	hand compacted
Openings	1 door [85 x 185cm]
	no windows, ventilation under each eave

Suggested temperature range — Number of people required for setup — Time required for setup[5*] — Average life span of the shelter



Environmental impacts

Raw materials used[3*]	gum trees	0.3 m^3
	water[1*]	118 300 liters
Manmade materials used	plastic (tarpaulins)	0.04 m^3
	steel (nails, poles)	142 kg
	cotton canvas	26 m^2
CO_2 emissions	material production	312 kg
	transportation	135 kg
CO_2 absorption cease	due to deforestation	180 kg/year
	Total	627 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	627 kg / 1 year / 14 m^2	
	= 45 kg of CO_2 / year / m^2	
Damage of natural habitat	Deforestation & erosion	
Material reuse	Steel poles are reusable	
	Timber elements, tarpaulins and canvas can be upcycled	

Technical performance

Wind resistance	complying
Flood mitigation	on plot/site flood mitigation measures
Ventilation	meets minimum vent. requirements
Flammability	meets fire retardant criteria
Thermal comfort	partially mitigates extreme temperatures[2*]
Personal security	not guaranteeing personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 4 occupants (Sphere)
Privacy	can be upgraded for minimum privacy
Natural light	no natural light
Artificial light	no access to artificial lightning
Shelter materials	partially adapted to local practices
Facilities	household facilities in the plot

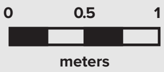
Affordability

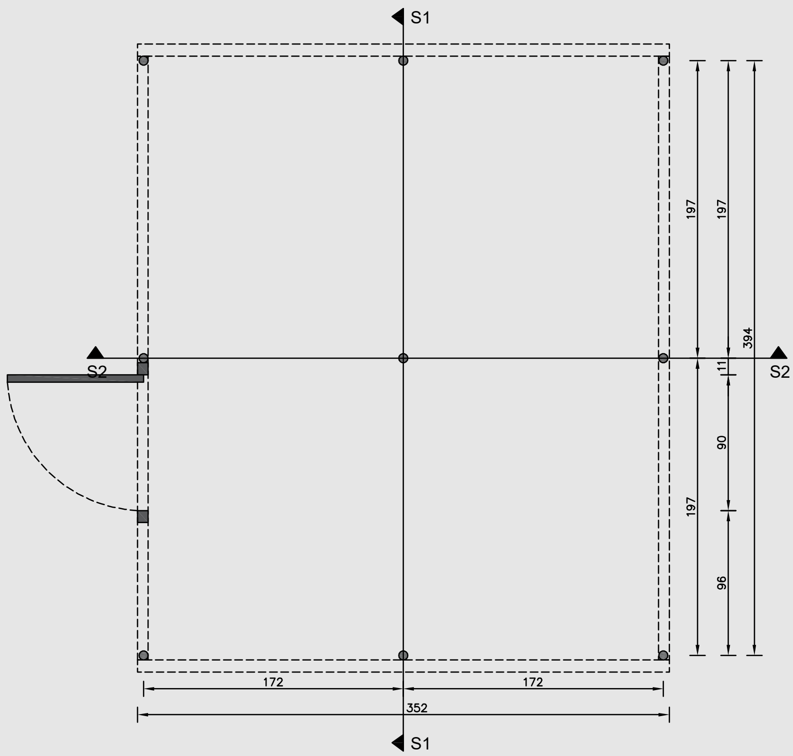
Costs	Cost / Life span / Area
	$ 536.3 / 1 years / 14 m^2
	= $ 38.3 / year / m^2

[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

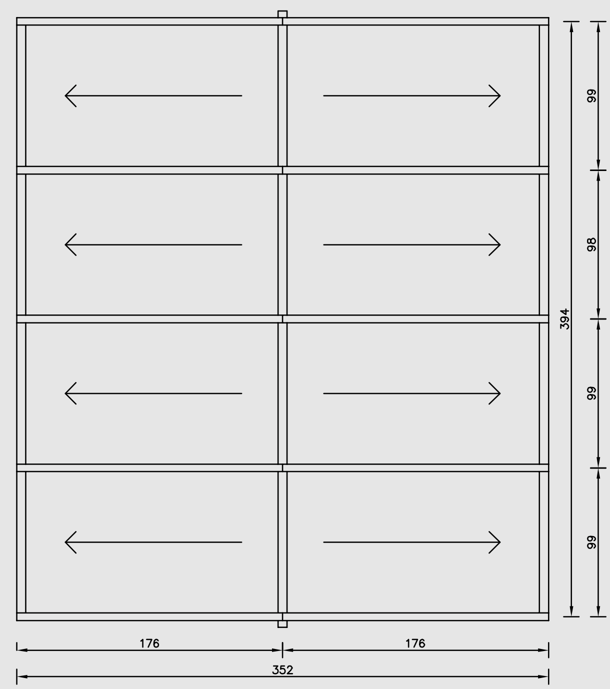
Technical drawings

All measures in cm

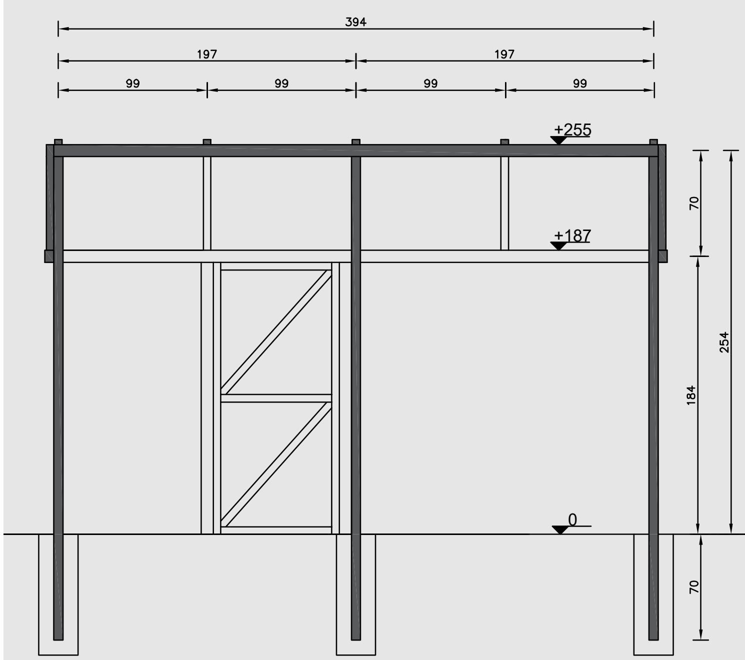




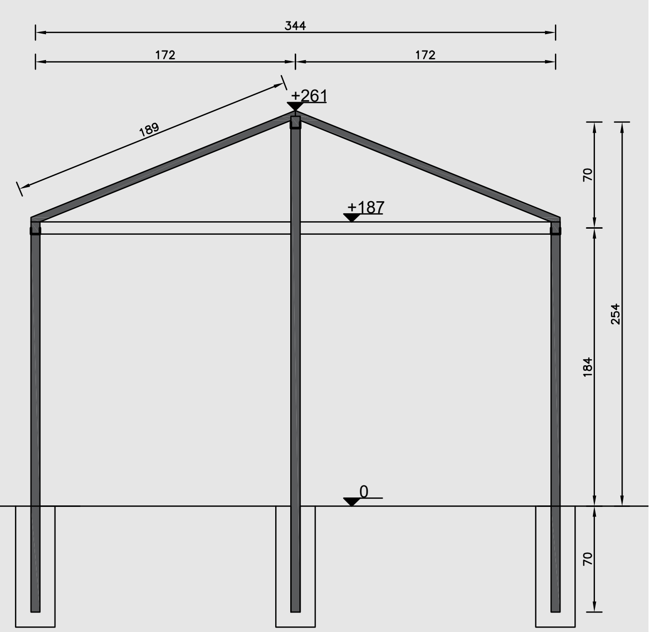
Floor plan



Roof plan



Section S1



Section S2

Bill of Quantities

	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Shelter Super Structure	Galvanized iron poles with ø 6 cm 3.2 m long	pieces	3	33.3	99.9
	Galvanized iron poles with ø 6 cm 2.5 m long	pieces	6	36.8	220.8
	Gum rafters, 8 x 6cm section, 4m long	pieces	3	4.5	13.5
	Gum rafters, 8 x 6cm section, 3.5m long	pieces	3	8	24
	Gum purlins, 5 x 5cm section, 2m long	pieces	16	2	32
	UNHCR plastic tarpaulin, sheet 4 x5 m	pieces	1	12	12
	UNHCR canvas roll, 16 m x 1.6m	roll	1	-	31.5
	Syntetic rope, small grain	m	45	-	9
	Syntetic rope, large grain	m	35	-	14.5
	Nails 10 cm long	kg	2	2	4
	Nails 4 cm long	kg	2	1.6	3.2
Openings	Door panel-CGI, gauge 30, 1.8x0.85 m	pieces	1	6	6
	Door locking system, 15 cm	pieces	1	0.8	0.8
	Door hinges & screws, 10-11 cm	pieces	2	0.25	0.5
	Gum plank 5x5 cm, 4 m min. length	pieces	2	4	8
	Nails 4 cm long	kg	1	1.6	1.6
Labour	2 unskilled worker	day	3	6	**36**
	1 skilled worker	day	1	19	481.3 + 55
	Total				**536.3**

4* Prices according to the 2019 local market assessment.

Sustainability Score Card

- Tree protection
- C02 emission mitigation
- Material efficiency
- Technical performance
- Shelter habitability
- Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

Variation C

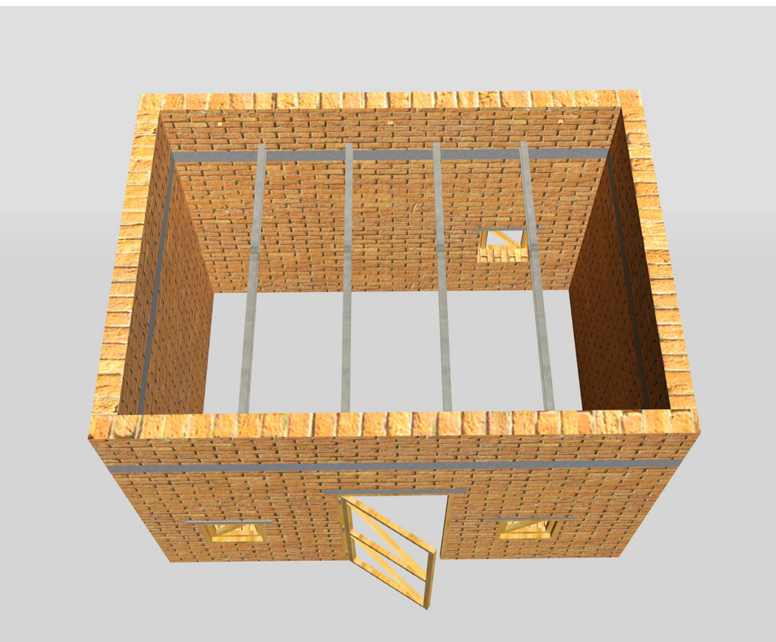
Structure	mud-brick load bearing walls-non reinforced masonry
Walls	mud plastered sun-dried clay brick
Roof	flat roof - I section steel profiles with brick infill
Footing	40 x 60 cm brick foundations
Floor	compacted earth
Openings	1 door [100 x 200cm], 3 windows [60 x 60cm]

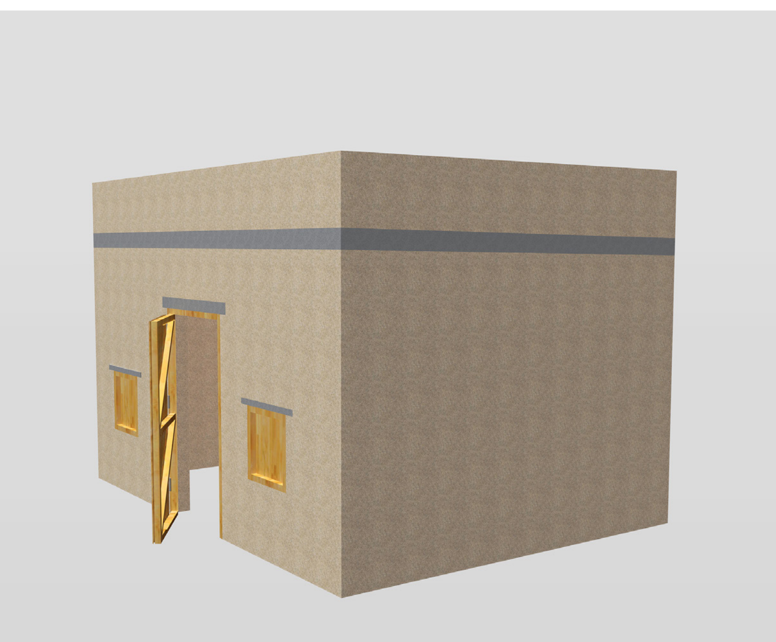
+45°C +7°C Suggested temperature range

Number of people required for setup

7 DAYS Time required for setup[5*]

10 YEARS Average life span of the shelter





Environmental impacts

Raw materials used [3*]	gum trees	0.1 m^3
	water[1*]	99 700 liters
	soil	24.4 m^3
	steel (nails, I profiles)	131 kg
Manmade materials used	cement	330 kg
	sand	0.56 m^3
	material production	547 kg
	transportation	228 kg
	due to deforestation	36 kg
CO_2 emissions	Total	811 kg/year
CO_2 absorption cease	kg of CO_2 / Life span / Area	
	811 kg / 10 years / 14 m^2	
CO_2 footprint	**= 6 kg of CO_2 / year / m^2**	
Damage of natural habitat	Deforestation & erosion	
Material reuse	Steel poles are reusable Timber elements and tarpaulins can be upcycled	

Technical performance

Flood mitigation	on plot/site flood mitigation measures
Ventilation	meets minimum vent. requirements
Flammability	meets fire resistant criteria
Thermal comfort	mitigates extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 4 occupants (Sphere)
Privacy	can be upgraded for minimum privacy
Natural light	meets minimum light. requirements
Artificial light	no access to artificial lightning
Shelter materials	adapted to local practices
Facilities	household facilities in the plot

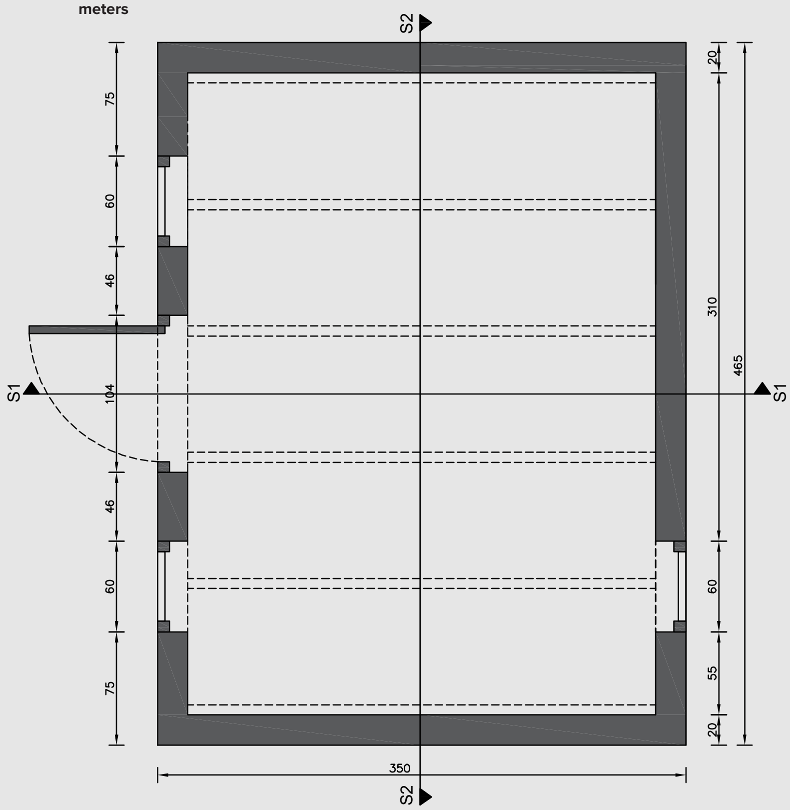
Affordability

Costs	Cost / Life span / Area
	$ 1 053.6 / 10 years / 14 m^2
	= $ 7.5 / year / m^2

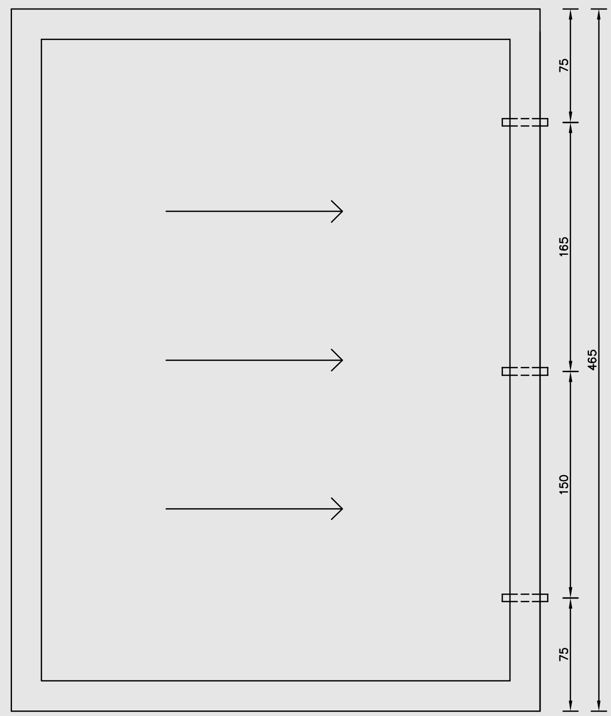
[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

Technical drawings

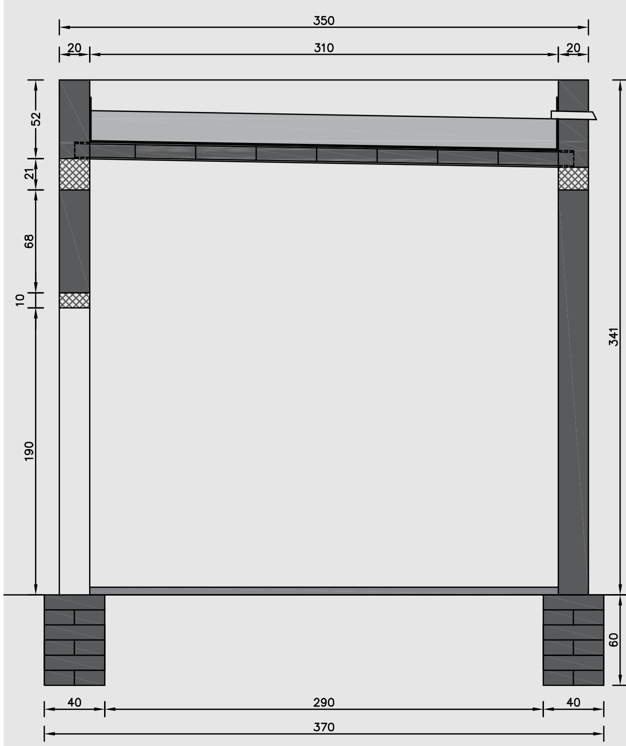
All measures in cm



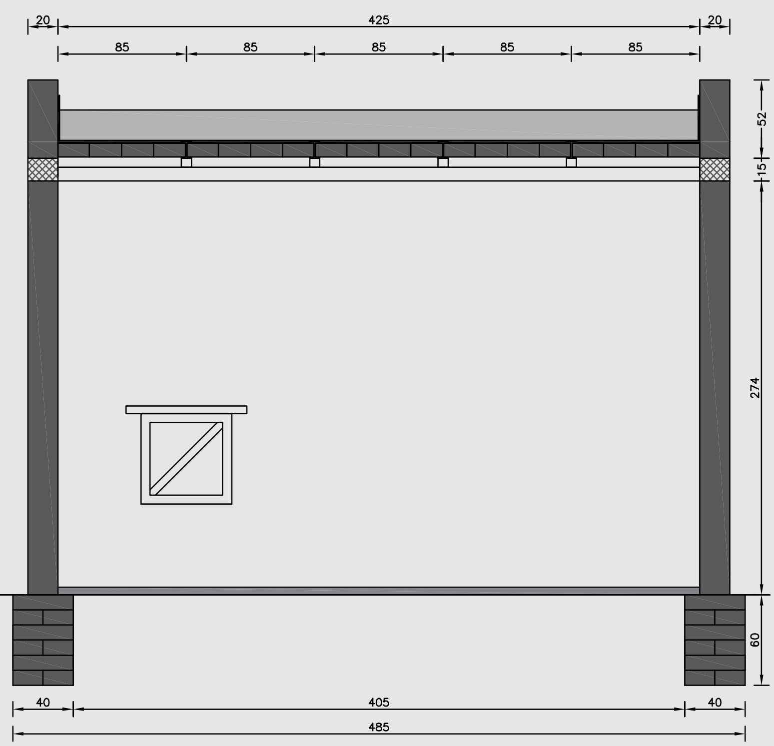
Floor plan



Roof plan



Section S1

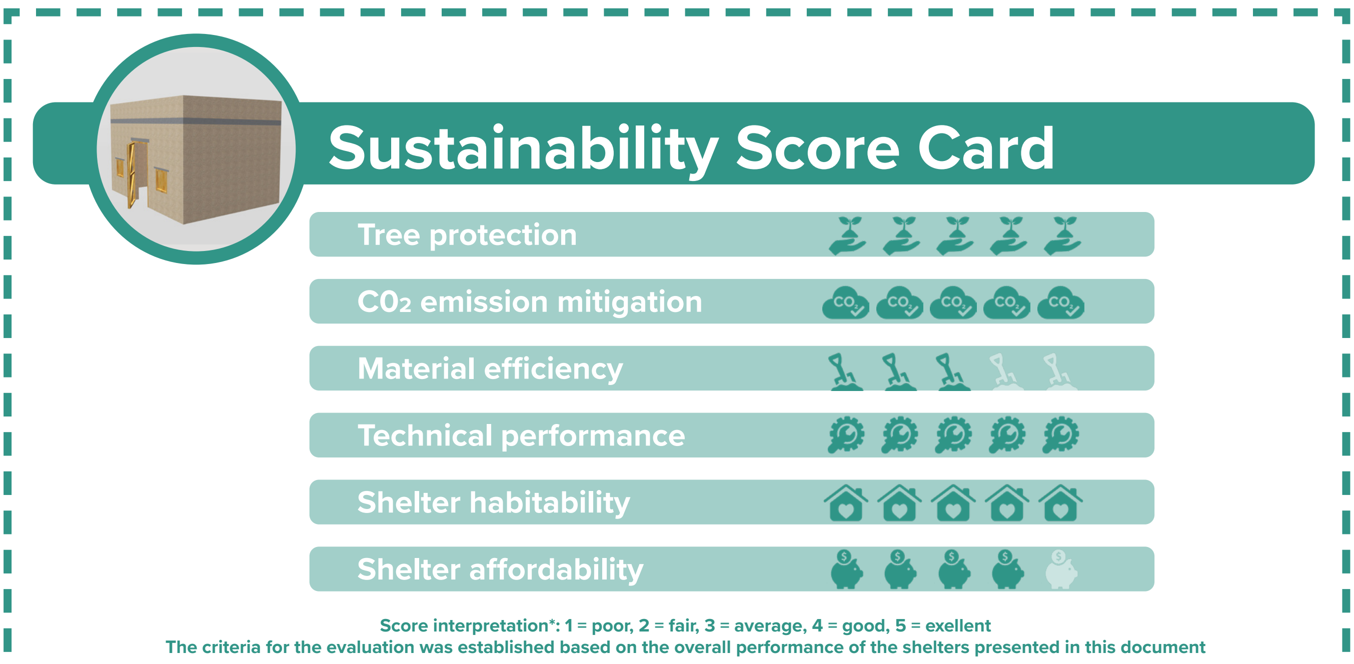


Section S2

Bill of Quantities

	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Shelter Super Structure	Galvanized iron I profile, 11 cm hight 3.5 m long	pieces	4	36.8	147.2
	Clay bricks, dimensions 40x20x10 cm	pieces	1900	0.2	380
	Soil excavation for joints mortar and plastering	m^3	5.4	3	16.2
	Soil excavation for roof infill	m^3	4	3	12
	Portland cement, 50kgs bag- plastering of fundations	pieces	3	11	33
	Sand - plastering of fundations	m^3	0.33	10	3.3
	Concrete ring beam with ratio mix 0.45:1:2:4	m^3	0.6	100	60
	Waterproof bitumen moist barrier layer	m^2	19	10	190
	Galvanized iron poles with ø 6 cm 1 m long	pieces	1	30	30
Openings	Door panel-CGI, gauge 30, 1.8x0.85 m	pieces	1	6	6
	Door locking system, 15 cm	pieces	1	0.8	0.8
	Door hinges & screws, 10-11 cm	pieces	2	0.25	0.5
	Gum plank 10x5 cm, 4 m min. length	pieces	2	4	8
	Nails 4 cm long	kg	2	1.6	3.2
	Gum plank 10x5 cm, 3 m long	pieces	4	3.5	14
	Window locking system, 7-8 cm	pieces	3	0.8	2.4
	Window hindges, 7-8 cm	pieces	6	0.25	1.5
	Window panel-CGI, gauge 30, 60x60 cm	pieces	3	1.5	4.5
Labour	2 unskilled worker	day	7	6	84
	1 skilled worker	day	3	19	57
					912.6 + 141
	Total				**1 053.6**

[4*] Prices according to the 2019 local market assessment.



4. Transitional shelter solutions

The term transitional shelter is used to define a range of shelter options that help populations affected by a humanitarian crises progress from an initial emergency arrangement to a more suitable shelter solution, better adapted to their needs in terms of habitability. Transitional shelter is sometimes misunderstood as being a one-off product, rather than a process whereby people upgrade their own house overtime, often through the reuse of some or all of its parts. Transitional shelters and their materials can aid with recovery, be resold to generate income, or recycled for reconstruction of a new shelter. Transitional shelter can sometimes provide additional options for affected populations with insecure land tenure as it may enable them to physically relocate their shelters if threatened by eviction. However, it cannot be used to solve this often very complex and political issue. It is important to keep in mind that the layout of settlements and the characteristics of plots and shelters allocated in the initial phases of a crises are critical determinants of all the subsequent development stages and the long term sustainability of the response.

4.1 Transitional shelter
Kutapalong settlement

Kutapalong became one of the world's most congested and largest refugee settlements after the 2017 crisis, that triggered an influx of 700000 Rohingya refugees into Bangladesh. The hilly landscape which was quickly deforested, became overcrowded and hazard sensitive in the cyclone-prone area. Since the onset UNHCR has sought to improve the site planning, infrastructure and facilities of the site, and prepare the land for new arrivals. The refugees are assisted with either finalized shelters or shelter kits. The transitional shelters were conceived as a bamboo structure, elevated from the ground to mitigate flooding and provided with concrete pad foundations to minimize landslide risks. The settlement was equipped with access to water sources and communal toilets and showers.

Shelter service area
17.5 m² [5 m x 3.5 m]

Regionally or locally sourced materials
Water, bricks, sand, aggregates, cement, timber and bamboo, steel, iron and its end products (CGI)
Imported materials
Plastic based items and some steel and iron products are generally imported from China

Climate classification
Tropical climate with monsoons

Yearly temperatures
Around 26°C
Rarely below 15°C or above 35°C

Rainy season
April to October (max in July with 1060 mm)
520 mm of precipitations per month on average

Dry season
November to March with
27 mm of precipitations per month on average

Wind speed
Average daily winds up to 14 km/hr
Windiest period from May to September
The maximum winds during monsoon season up to 89 km/hr

Flood risks
- Important volumes of rain water runoff
- Flood prone low lying areas with very complex river catchment area with slopes up to 45 % steep
- Sandy soil which easily washes away in heavy rain
- Lack of vegetation cover and erosion

Flood mitigation opportunities
- Elevated shelter typologies
- Service water drainage in the site

Site level environmental challenges
- Site cleaning (trees and other types of vegetation) due to construction;
- No strategy for a sustainable disposal of fecal and solid waste;
- No designated cooking areas;
- Firewood collection and open fire cooking.

Variation A

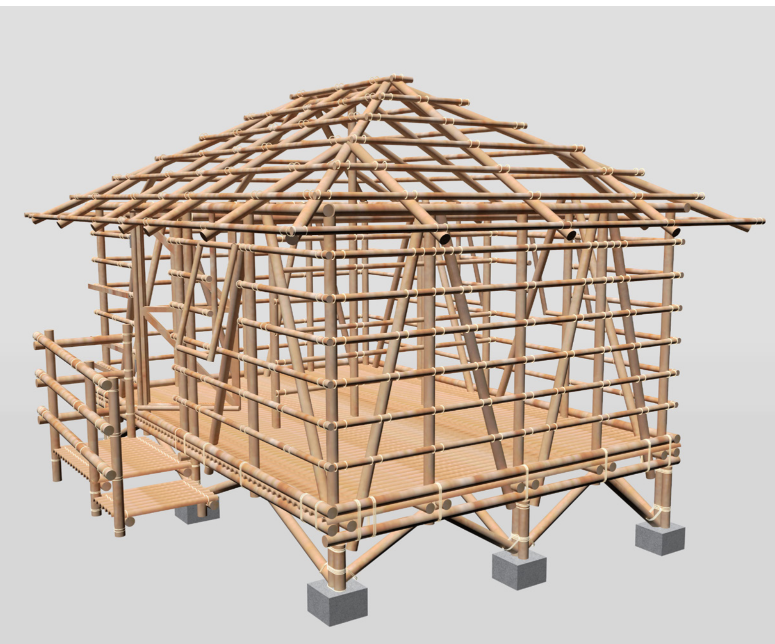
Structure	untreated bamboo frame
Walls	UNHCR plastic tarpaulins
Roof	UNHCR plastic tarpaulins
Footing	pre-cast reinforced concrete posts
Floor	woven bamboo mats on bamboo poles
Openings	1 door [90 x 200cm] 3 windows [60 x 100cm], bamboo ventilation lattice under each eave

+30°C +10°C
Suggested temperature range

Workforce required for setup

8 DAYS
Time required for setup[5*]

2 YEARS
Average life span of the shelter



Environmental impacts

Raw materials used[3*]	bamboo	3.15 m³
	water[1*]	14 689 liters
Manmade materials used	plastic (tarpaulin, rope)	32 kg
	steel (nails, wire)	20 kg
	cement	210 kg
	sand	0.32 m³
CO_2 emissions	material production	421 kg
	transportation	30 kg
CO_2 absorption cease	due to deforestation	885 kg/year
	Total	1 336 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	1 336 kg / 2 years / 17.5 m²	
	= 38 kg of CO_2 / year / m²	
Damage of natural habitat	Deforestation & erosion	
Material reuse	Structural bamboo elements and tarpaulins can be upcycled	

Technical performance

Wind resistance	complying
Flood mitigation	site and shelter flood mitigation measures
Ventilation	meets minimum vent. requirements
Flammability	meets fire retardant criteria
Thermal comfort[*2]	not fit for extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 5 occupants (Sphere)
Privacy	provides minimum privacy
Natural light	meets minimum light. requirements
Artificial light	no access to artificial lightning
Shelter materials	partially adapted to local practices
Facilities	communal facilities in the site

Affordability

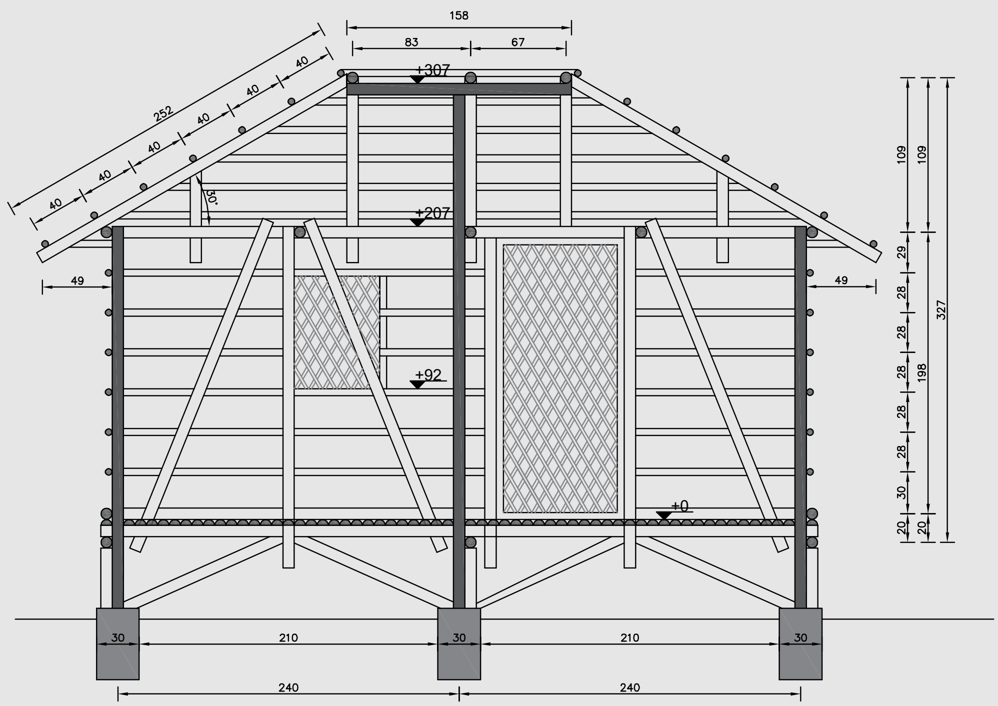
Costs	Cost / Life span / Area
	$ 739 / 2 years / 17.5 m²
	= $ 21.1 / year / m²

[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

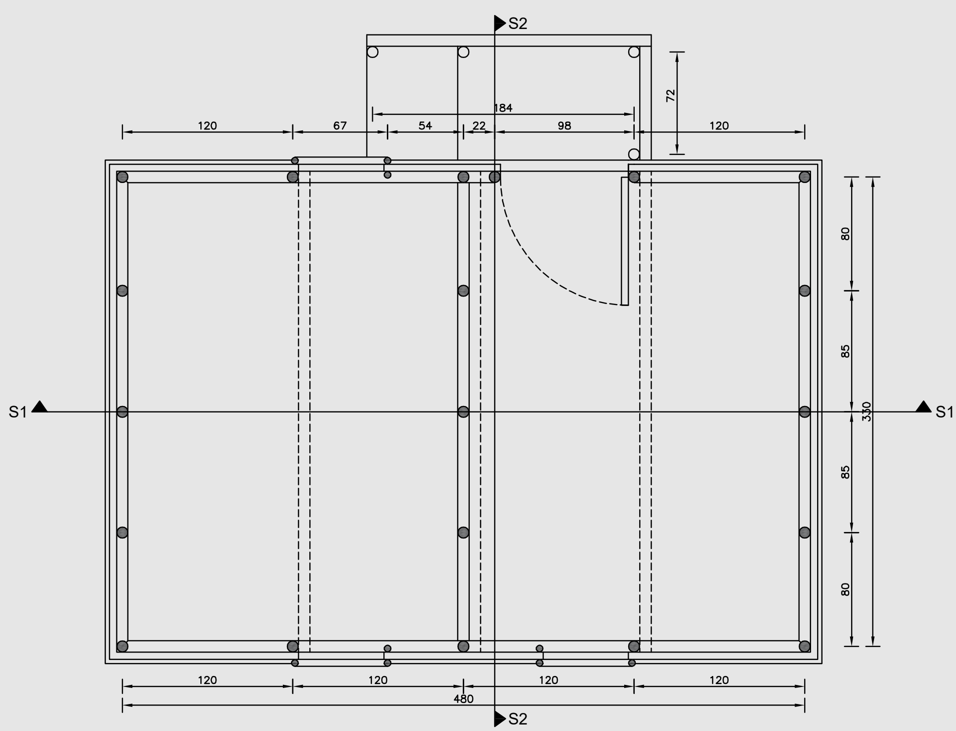
Technical drawings

All measures in cm

0 0.5 1
meters



Floor plan

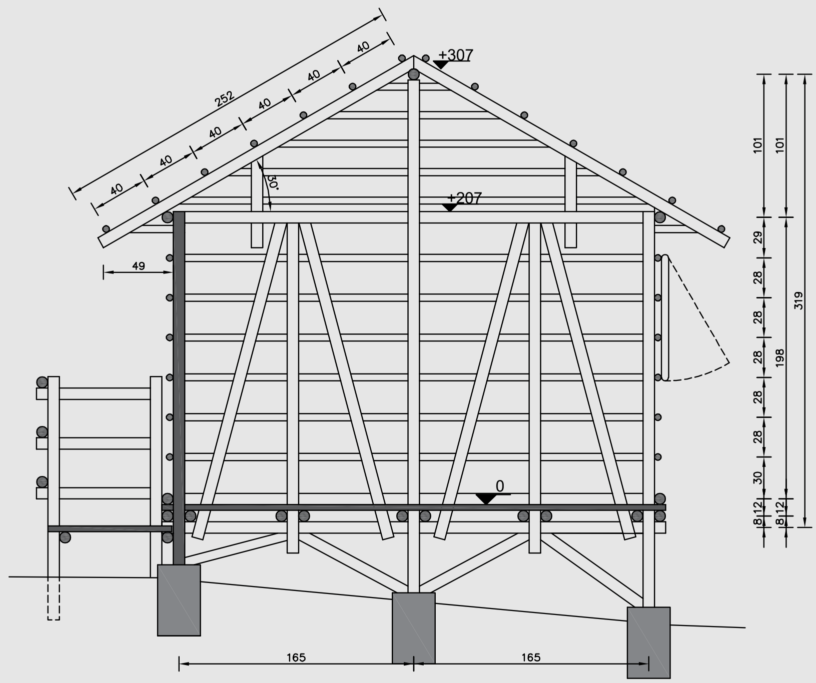


Section S1

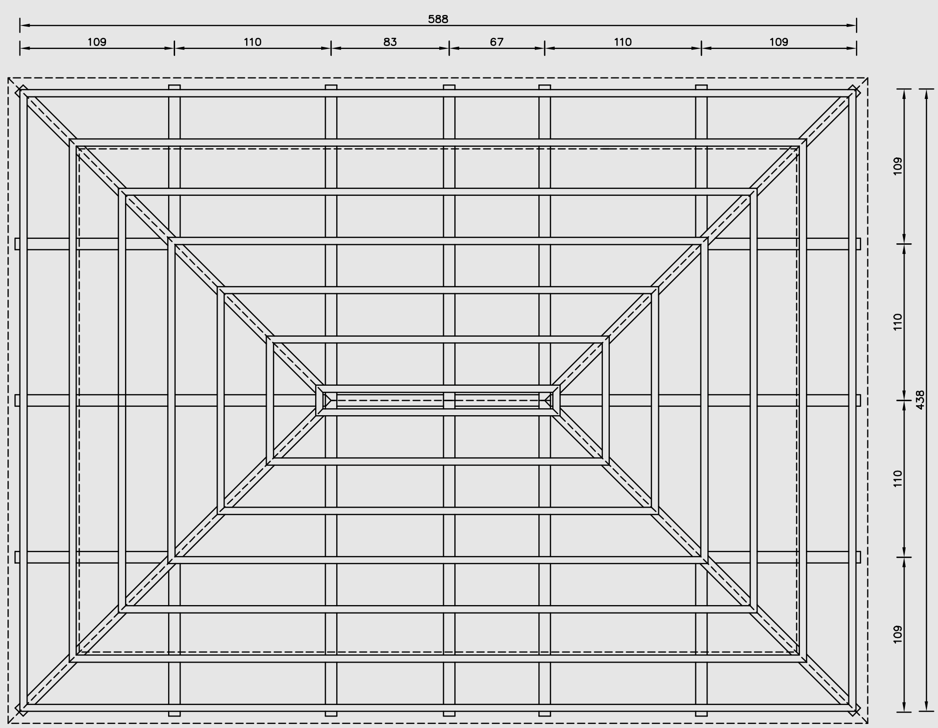
Technical drawings

All measures in cm

0 0.5 1
meters



Section S2



Roof plan

Bill of Quantities

Section	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Fundations	Earthwork & excavation of foundation trenches	m^3	0.6	1.8	1.1
	Foundation pad with cement ratio mix 0.45:1:2:4	m^3	0.7	112.2	76.3
	Steel flat bar, dimesions 850x50x 5mm	pieces	9	3.4	30.2
	Plain Nut Bolt, ø 6 mm, 16 cm long	pieces	18	0.9	17.1
Super Structure	Borrak bamboo for columns, beams & rafters				
	ø 75 mm, 12.2 m long	m length	329.4	0.6	197.6
	Polyvinyl / Nylon rope, ø 6-8 mm	kg	10	1.4	14.1
	Polyvinyl / Nylon rope, ø 3-4 mm	kg	8	1.4	11.3
	Galvanized iron wire, 18 BWG	kg	3	1.3	3.9
	Muli bamboo for purlins, mats, openings & fence				
	ø 30-40 mm, 4 m long	pieces	300	0.6	180
	Plastic rope for purlins, mats, openings & fence	kg	2	1.4	2.8
	UNHCR plastic tarpaulin, sheet 4 x5 m	pieces	3	12	36
	Nails 4 cm long	kg	1	3	3
Labour	2 unskilled worker	day	8	7.5	**120**
	1 skilled worker	day	3	15	45
					574 + 165
	Total				**739**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

- Tree protection
- C02 emission mitigation
- Material efficiency
- Technical performance
- Shelter habitability
- Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

Variation B

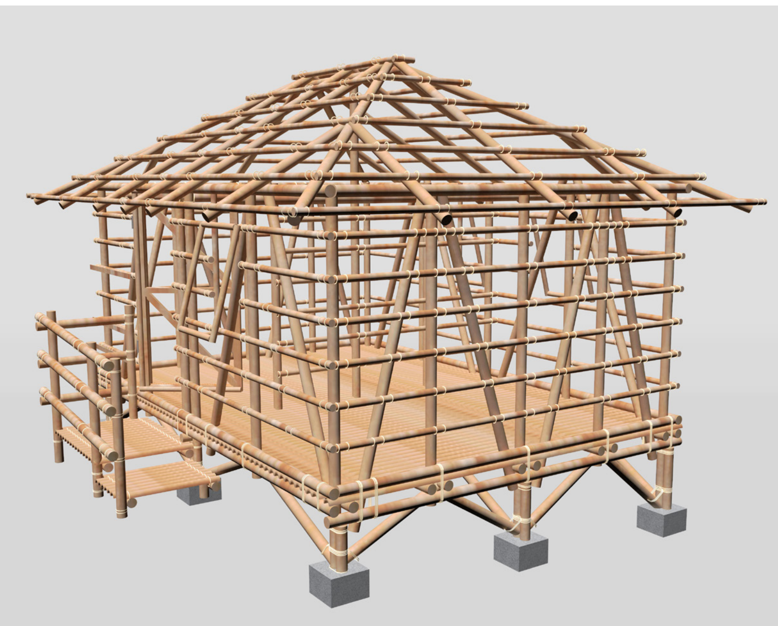
Structure	treated bamboo frame
Walls	woven bamboo mats
Roof	corrugated iron sheets
Footing	pre-cast reinforced concrete posts
Floor	woven bamboo mats on bamboo poles
Openings	1 door [90 x 200cm] 3 windows [60 x 100cm], bamboo ventilation lattice under each eave

+35ºC +10ºC — Suggested temperature range

Number of people required for setup

8 DAYS — Time required for setup[5*]

10 YEARS — Average life span of the shelter



Environmental impacts

Raw materials used[3*]	bamboo	7.9 m³
	water[1*]	74 100 liters
Manmade materials used	plastic (rope)	20 kg
	steel (nails, wire)	105 kg
	cement	210 kg
	sand	0.32 m³
CO_2 emissions	material production	508 kg
	transportation	55 kg
CO_2 absorption cease	due to deforestation	3260 kg/year
	Total	3 823 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	3 823 kg / 10 years / 17.5 m²	
	= 22 kg of CO_2 / year / m²	
Damage of natural habitat	Deforestation & erosion	
Material reuse	CGI sheets are reusable	
	Structural bamboo elements and tarpaulins can be upcycled	

Technical performance

Wind resistance	complying
Flood mitigation	site and shelter flood mitigation measures
Ventilation	meets minimum vent. requirements
Flammability	meets fire retardant criteria
Thermal comfort[*2]	mitigates extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 5 occupants (Sphere)
Privacy	provides minimum privacy
Natural light	meets minimum light. requirements
Artificial light	no access to artificial lightning
Shelter materials	adapted to local practices
Facilities	communal facilities in the site

Affordability

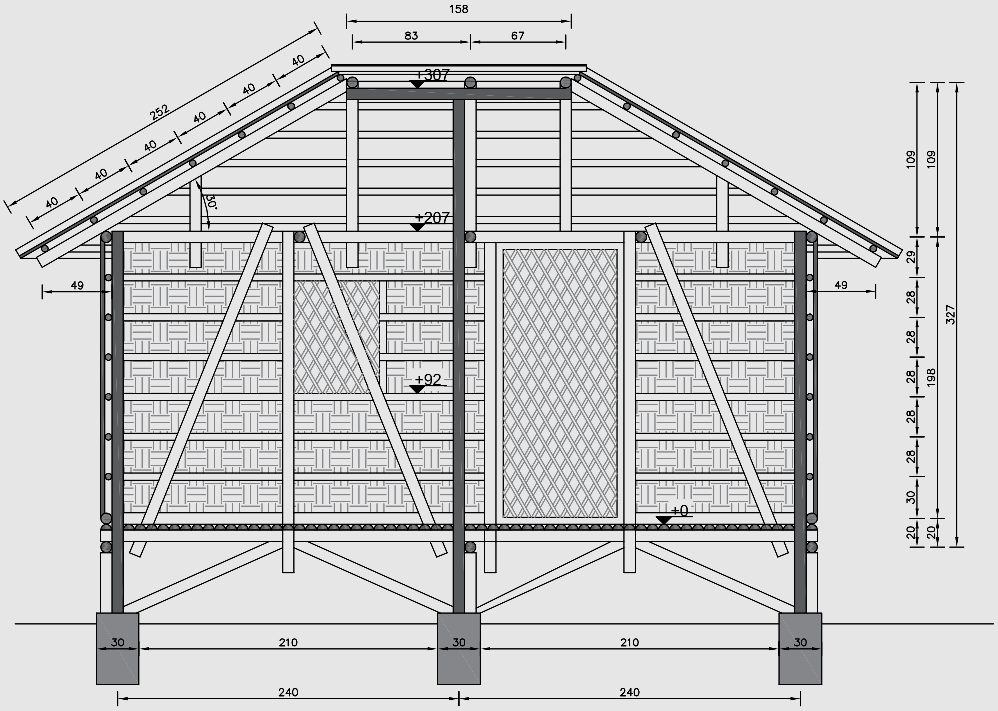
Costs	Cost / Life span / Area
	$ 1 465.1 / 10 years / 17.5 m²
	= $ 8.4 / year / m²

[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

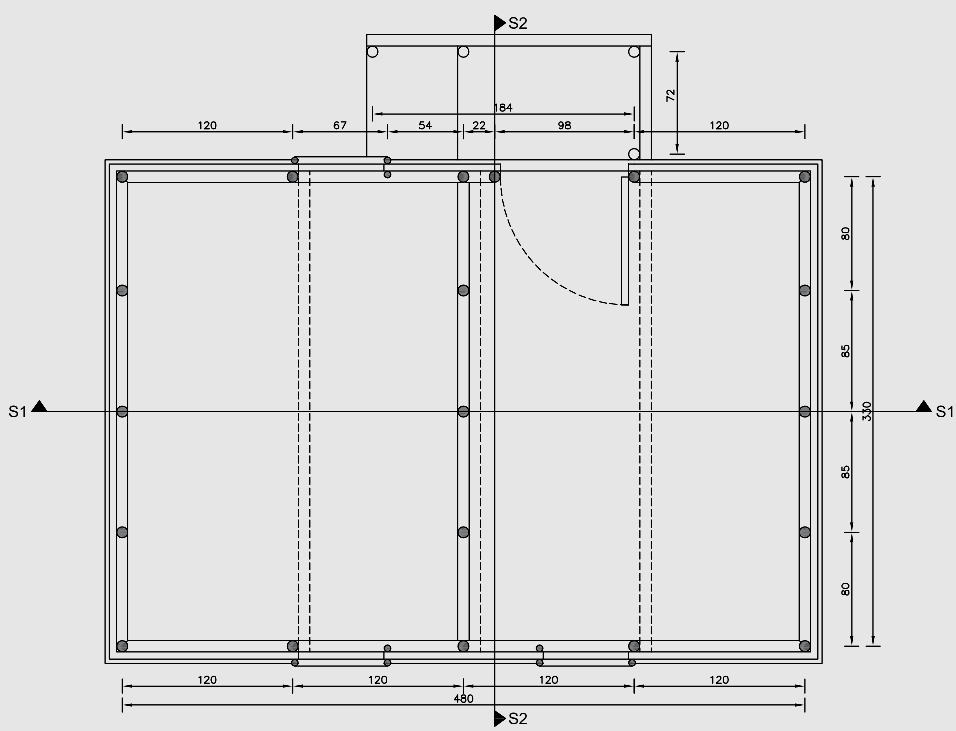
Technical drawings

All measures in cm

0 0.5 1
meters



Floor plan

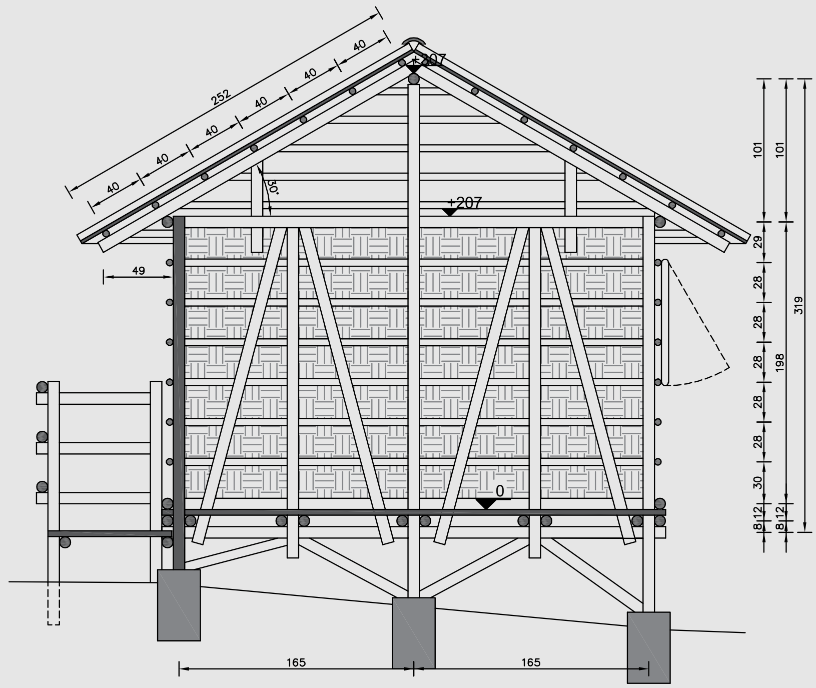


Section S1

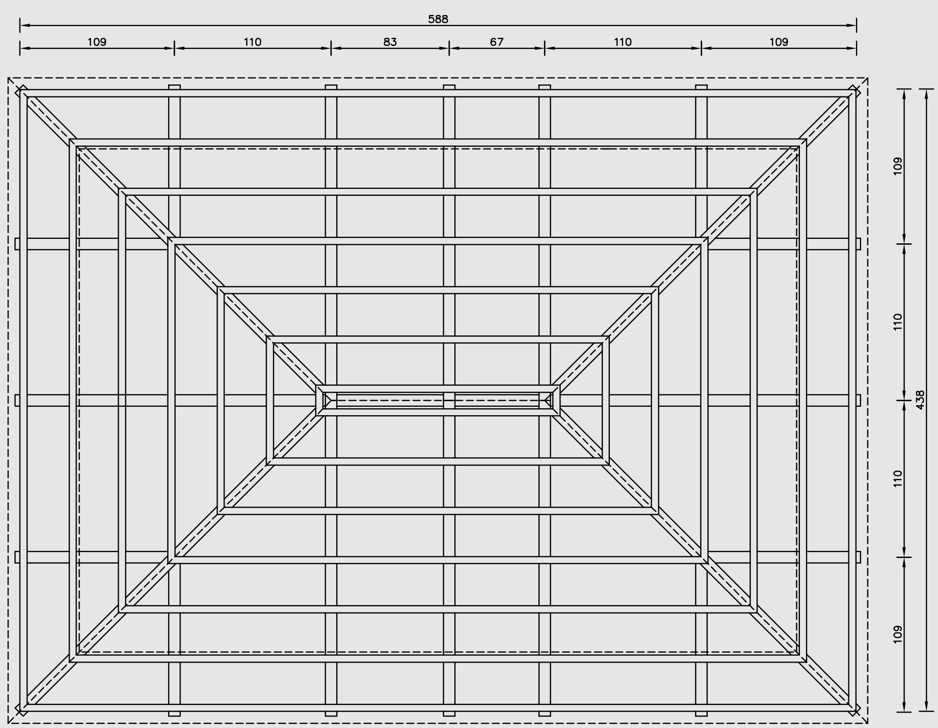
Technical drawings

All measures in cm

0 0.5 1
meters



Section S2



Roof plan

Bill of Quantities

	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Fundations	Earthwork & excavation of foundation trenches	m^3	0.6	1.8	1.1
	Foundation pad with cement ratio mix 0.45:1:2:4	m^3	0.7	112.2	76.3
	Steel flat bar, dimensions 850x50x 5mm	pieces	9	3.4	30.2
	Plain Nut Bolt, ø 6 mm, 16 cm long	pieces	18	0.9	17.1
Super Structure	Borrak bamboo for columns, beams & rafters				
	ø 75 mm, 12.2 m long	m length	329.4	0.60	197.6
	Polyvinyl / Nylon rope, ø 6-8 mm	kg	10	1.4	14.1
	Polyvinyl / Nylon rope, ø 3-4 mm	kg	8	1.4	11.3
	Galvanized iron wire, 18 BWG	kg	3	1.3	3.9
	Muli bamboo for purlins, mats, openings & fence				
	ø 30-40 mm, 4 m long	pieces	1250	0.6	750
	Plastic rope for purlins, mats, openings & fence	kg	2	1.4	2.8
	Iron sheets, gauge 30, dimensions 3.05 x 0.9 m	pieces	10	10	100
	Nails 4 cm long	kg	1	1.6	1.6
	Roofing nails (umbrella type), 5 cm long	kg	2	2	4
	Bamboo treatement	LS	-	90	90
Labour	2 unskilled worker	day	8	7.5	**120**
	1 skilled worker	day	3	15	1 300.1 + 165
	Total				**1 465.1**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

- Tree protection
- C02 emission mitigation
- Material efficiency
- Technical performance
- Shelter habitability
- Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document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4.2 Transitional shelter
Dadaab settlement

Dadaab refugee complex consists of three camps, which went through many displacement influxes over the years. A large part of the residents arrived in Dadaab in the 1990s fleeing the civil war in Somalia. Others had fled atrocities in the Horn of Africa. Most of the refugees live in makeshift shelters called tukuls, the dome-shaped grass-thatched structures used by Somali communities. These shelters provide little shade from the 40°C days and poor protection against the rainy season. UNHCR has recently started a project with the aim to build 1 500 shelters, replacing tukuls with more durable solutions from gum poles and trusses, with iron sheets as roof cover. The settlement was equipped with access to water sources, designated cooking areas within the plots, communal and individual toilets and showers.

Shelter service area
19.8 m² [3.2 m x 6.2m]

Regionally or locally sourced materials
Clayey soil, bricks, sand, aggregates, cement, bamboo

Imported materials
Plastic based items, steel and iron products are generally imported from China. Timber is generally imported form DRC and Tanzania

Climate classification
Desert, hot all year round

Yearly temperatures
Vary from 22°C to 36°C
Rarely below 21°C or above 39°C

Rainy season
October to May with
31 mm of precipitations per month on average

Dry season
June to September with
4 mm of precipitations per month on average

Wind speed
Windiest period from May to October with average wind speeds up to 29 km/h

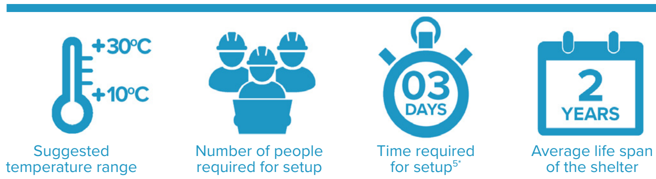
Flood risks
- Areas prone to flash floods
- Sandy soil which easily washes away in rain
- Lack of vegetation cover and erosion

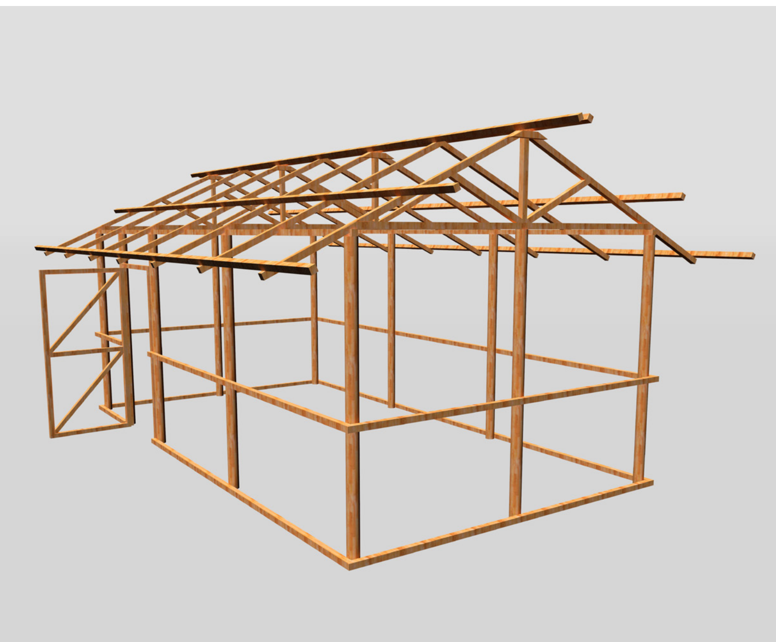
Flood mitigation opportunities
- Dykes across flood prone areas to prevent water reaching the settlement
- Service water drainage in the site

Site level environmental challenges
- Site cleaning (trees and other types of vegetation) due to construction;
- No strategy for a sustainable disposal of fecal and solid waste;
- Firewood collection and open fire cooking.

Variation A

Structure	gable timber frame
Walls	UNHCR plastic tarpaulins
Roof	corrugated iron sheets
Footing	treated poles, 50 cm deep with compacted earth
Floor	hand compacted in two layers
Openings	1 door [100 x 195cm]
	no windows, ventilation under each eave





Environmental impacts

Raw materials used[3*]	gum & cypress trees	0.8 m^3
	water[1*]	95 200 liters
Manmade materials used	plastic (tarpaulins)	0.13 m^3
	steel (nails, CGI)	135 kg
CO_2 emissions	material production	330 kg
	transportation	102 kg
CO_2 absorption cease	due to deforestation	271 kg/year
	Total	703 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	703 kg / 2 years / 19.8 m^2	
	= 18 kg of CO_2 / year / m^2	
Damage of natural habitat	Deforestation & erosion	
Material reuse	Timber elements and tarpaulins can be upcycled	

Technical performance

Wind resistance	complying
Flood mitigation	on plot/site flood mitigation measures
Ventilation	meets minimum vent. requirements
Flammability	meets fire retardant criteria
Thermal comfort	not fit for extreme temperatures[2*]
Personal security	not guaranteeing personal security
Accessibility	adapted for accessibility needs

Habitability

Covered area	suitable for 6 occupants (Sphere)
Privacy	can be upgraded for minimum privacy
Natural light	no natural light
Artificial light	no access to artificial lightning
Shelter materials	not adapted to local practices
Facilities	communal & household facilities in the site

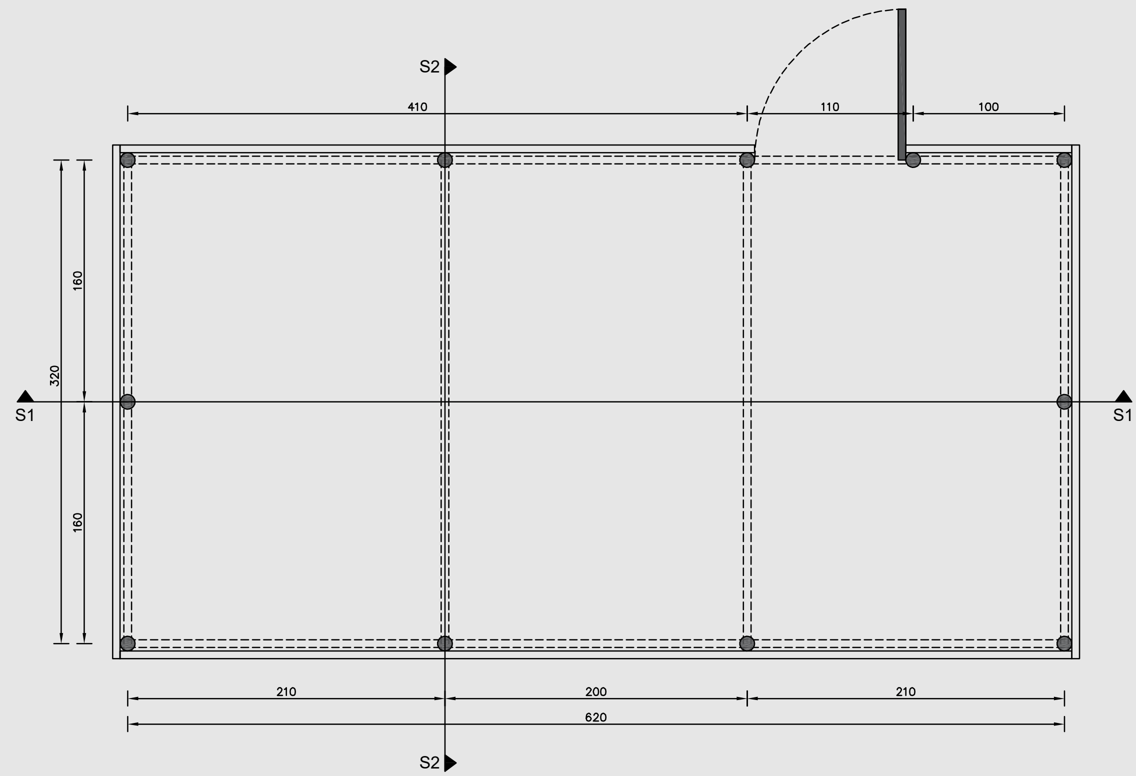
Affordability

Costs	Cost / Life span / Area
	$ 462.4 / 2 years / 19.8 m^2
	= $ 11.7 / year / m^2

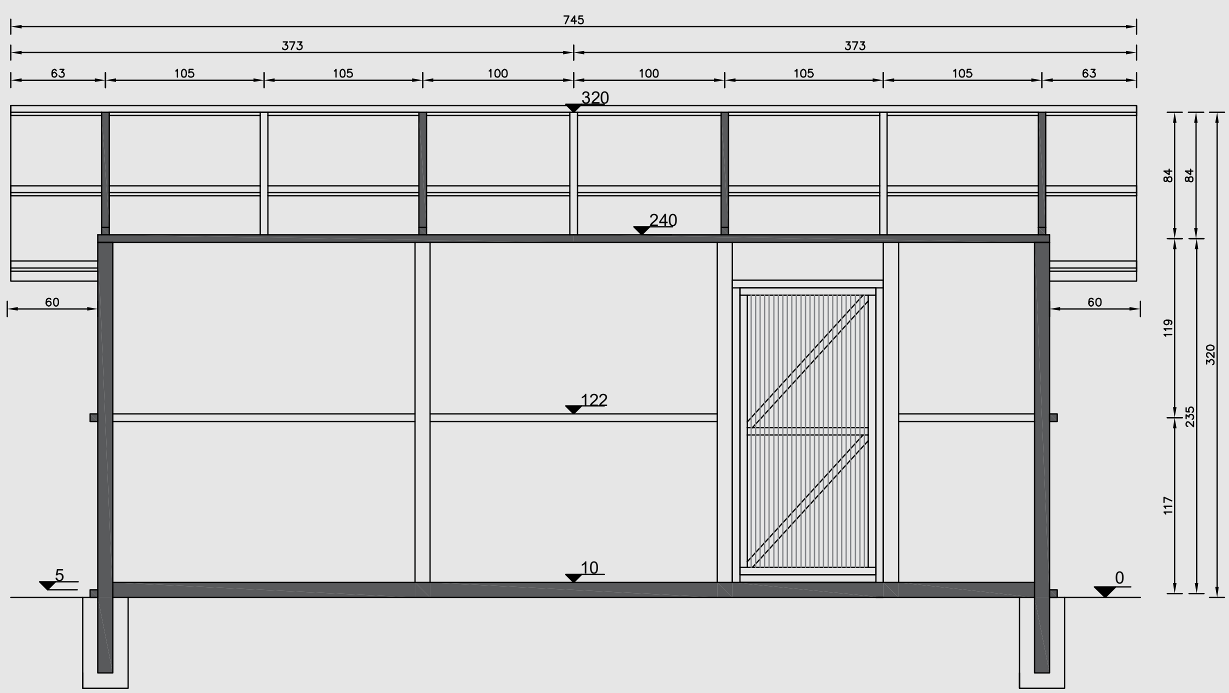
1* The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
2* Temperatures that hover 10 degrees or more above or below the average temperature for the region.
3* The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
5* The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

Technical drawings

All measures in cm



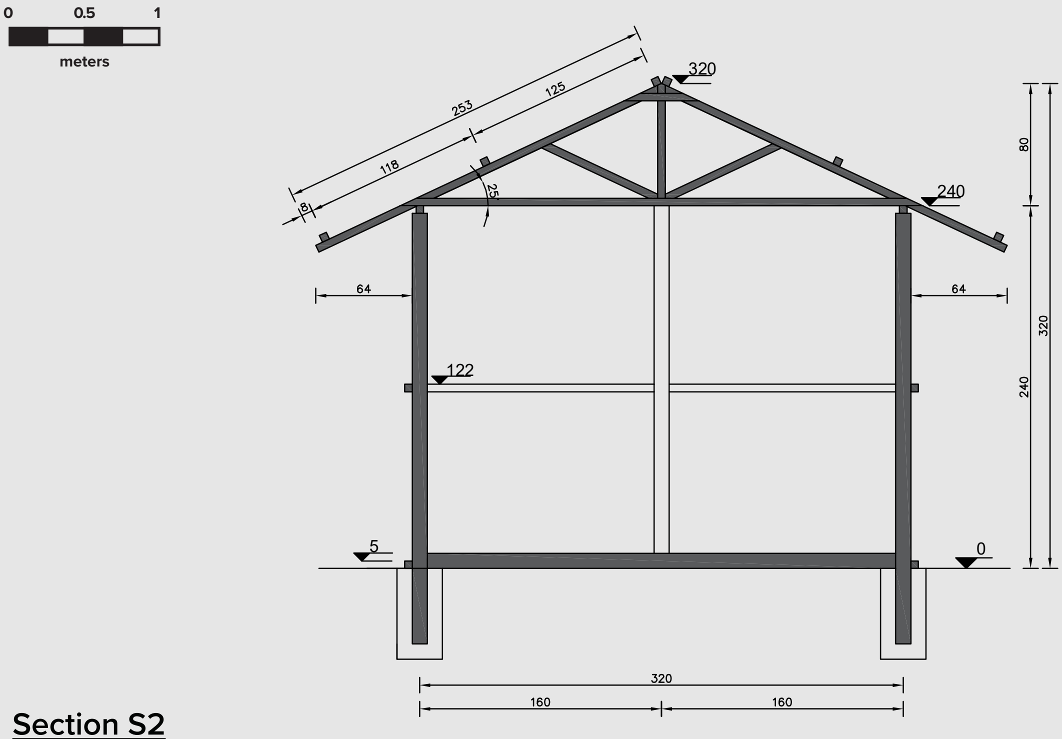
Floor plan



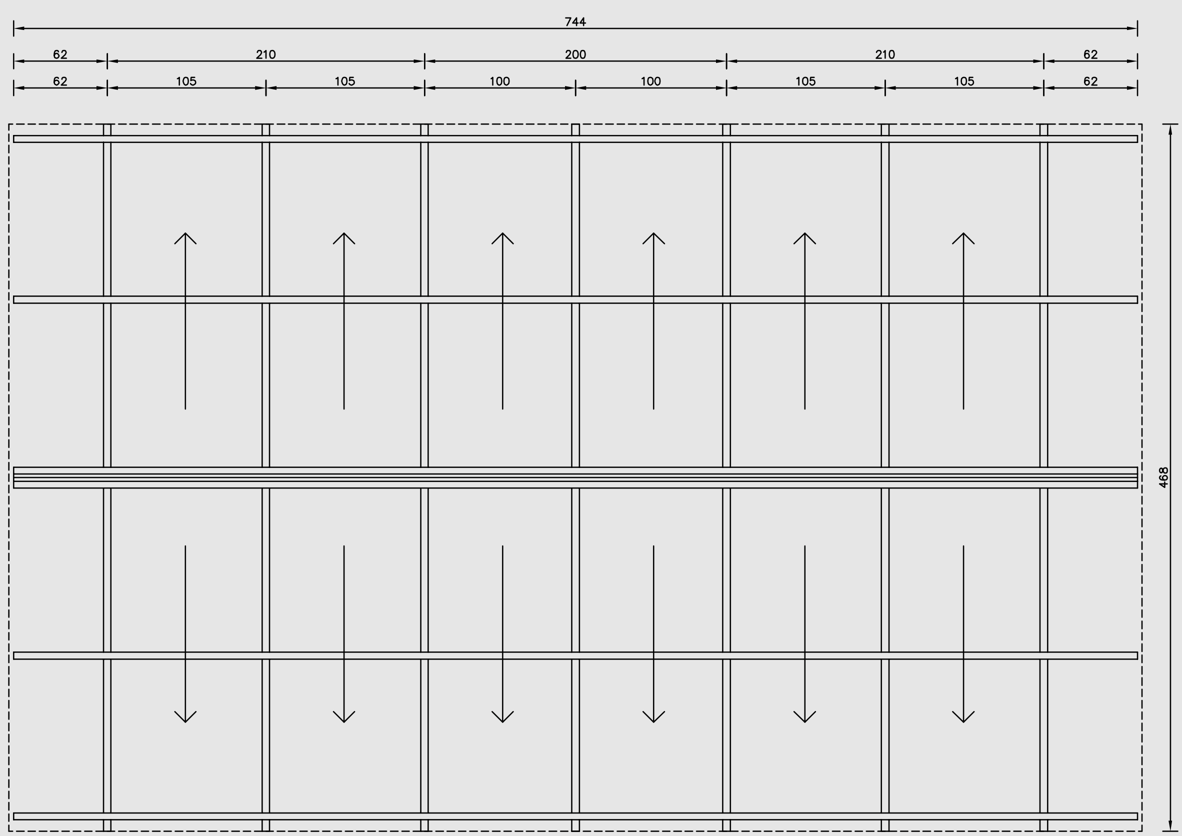
Section S1

Technical drawings

All measures in cm



Section S2



Roof plan

Bill of Quantities

	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Shelter Super Structure	Gum poles with ø 8-10 cm, 3 m long	pieces	11	4	44
	Cypress planks, 5x5 cm, 4.5 m min. length	m	159	1	159
	UNHCR plastic tarpaulin, sheet 4 x5 m	pieces	3	12	36
	Wood preservative	liters	20	0.35	7
	Iron sheets, gauge 30, dimensions 2.5 x 0. 9 m	pieces	18	6.86	123.5
	Nails, 10-11 cm long	kg	5	1.95	9.80
	Nails, 7-8 cm long	kg	2	1.95	3.9
	Nails, 2-3 cm long	kg	1	1.57	1.57
	Nails, 5-6 cm ling	kg	0.25	1.56	0.39
	Roofing nails (umbrella type), 5 cm long	kg	5	1.95	9.75
Openings	Timber door panel, 2x1 m	pieces	1	14	14
	Cypress planks, 5x5 cm, 4.5 m min. length	m	12	1	12
	Door locking system	pieces	1	0.78	0.78
	Door hinges & screws, 10-11 cm	pieces	3	0.25	0.75
Labour	2 unskilled	day	3	5	30
	1 skilled worker	day	1	10	10
					422.44 + 40
	Total				**462.44**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

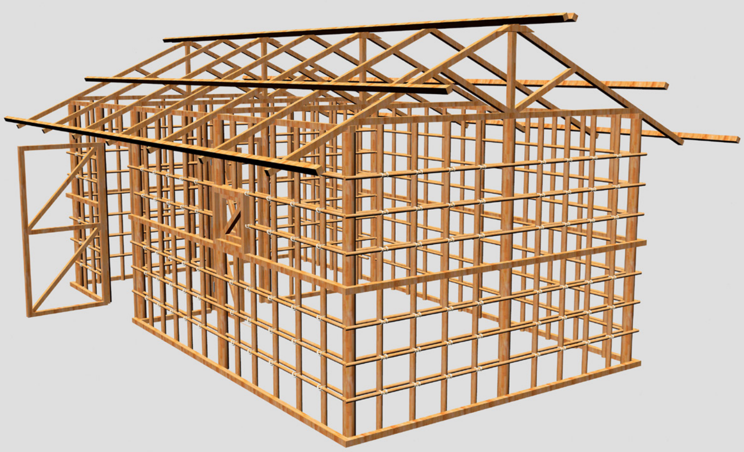
- Tree protection
- C02 emission mitigation
- Material efficiency
- Technical performance
- Shelter habitability
- Shelter affordability

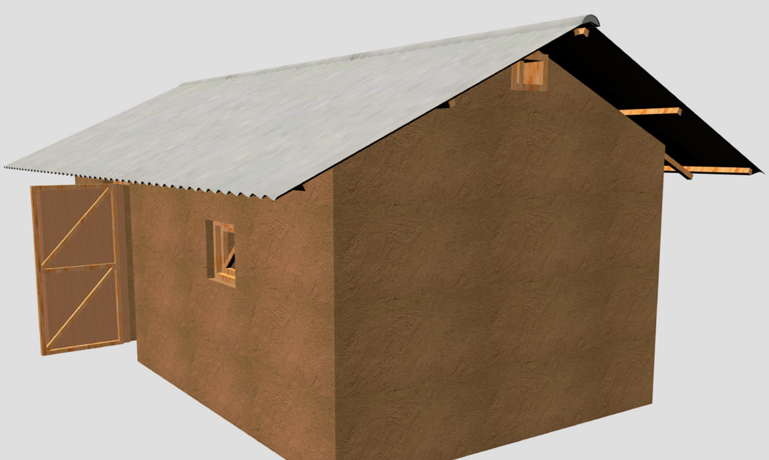
Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

Variation A

Structure	gable timber frame
Walls	wattle & daub with straw reinforced earth
Roof	corrugated iron sheets
Footing	treated poles, 50 cm deep with compacted earth
Floor	hand compacted in two layers
Openings	1 door [100 x 195cm], 2 windows [60 x 55cm]
	2 eave vents & 2 gable vents [50 x 30cm]

Suggested temperature range | Number of people required for setup | Time required for setup[5*] | Average life span of the shelter





Environmental impacts

Raw materials used [3*]	gum & cypress trees	0.9 m^3
	water[1*]	97 700 liters
	bamboo	0.4 m^3
	soil	9 m^3
Manmade materials used	steel (nails, CGI)	133 kg
CO_2 emissions	material production	252 kg
	transportation	114 kg
CO_2 absorption cease	due to deforestation	511 kg/year
	Total	877 kg
	kg of CO_2 / Life span / Area	
CO_2 footprint	877 kg / 6 years / 19.8 m^2 m^2	
	= 7.4 kg of CO_2 / year / m^2	
Damage of natural habitat	Deforestation & erosion	
	Fall through hazards due to soil excavation	
Material reuse	CGI sheets are reusable	
	Structural timber elements and	
	tarpaulins can be upcycled	

Technical performance

Wind resistance	complying
Flood mitigation	on plot/site flood mitigation measures
Ventilation	meets minimum vent. requirements
Flammability	meets fire retardant criteria
Thermal comfort	mitigates extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adapted for accessibility needs

Habitability

Covered area	suitable for 6 occupants (Sphere)
Privacy	provides minimum privacy
Natural light	meets minimum light. requirements
Artificial light	no access to artificial lightning
Shelter materials	adapted to local practices
Facilities	communal & household facilities in the site

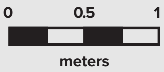
Affordability

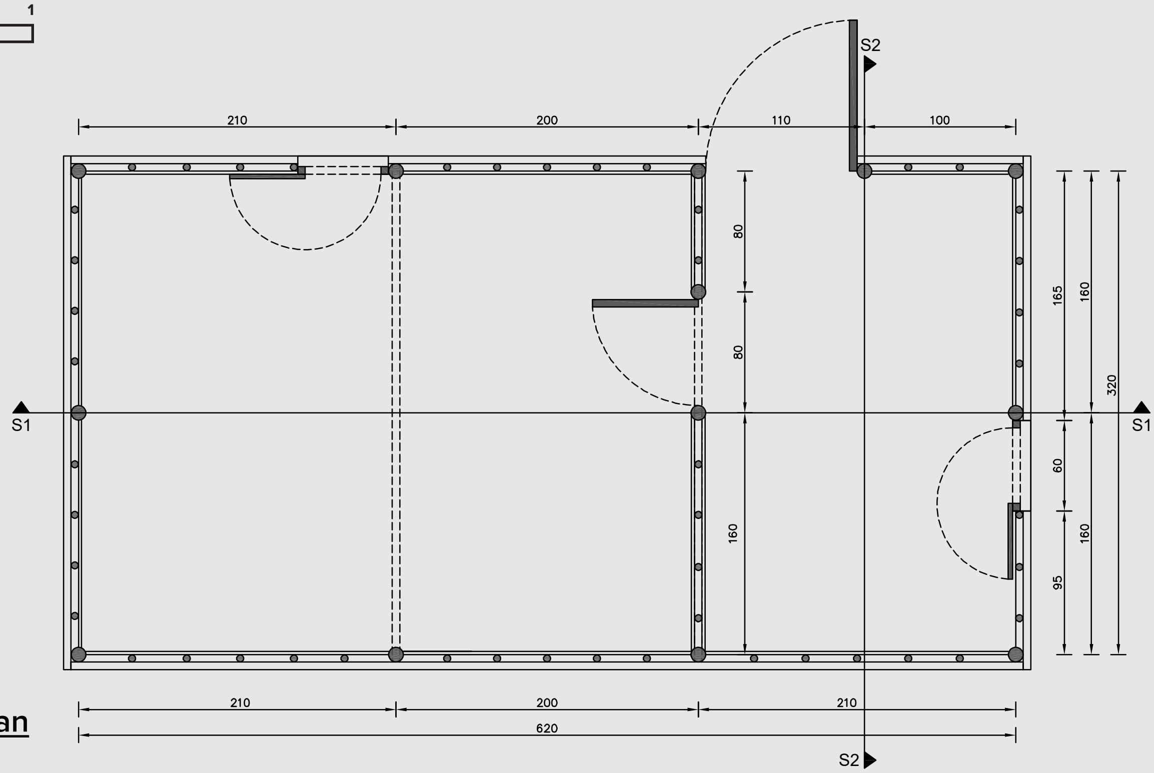
Costs	Cost / Life span / Area
	$ 669.1 / 6 years / 19.8 m^2
	= $ 5.6 / year / m^2

[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

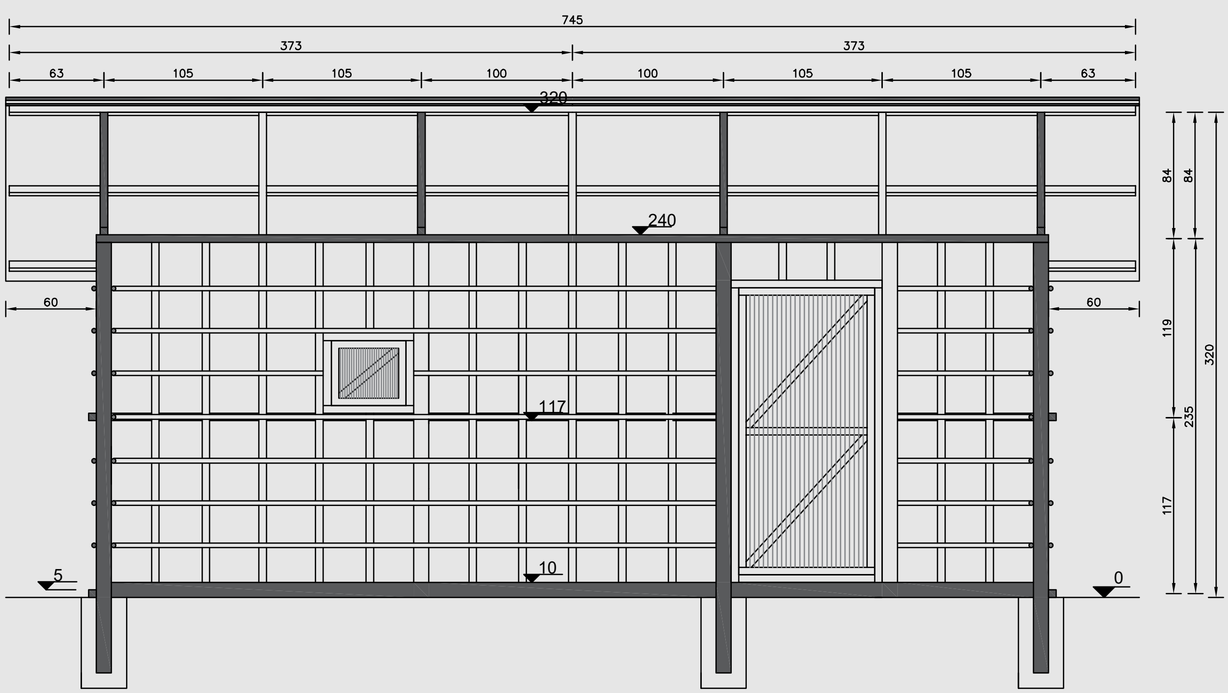
Technical drawings

All measures in cm





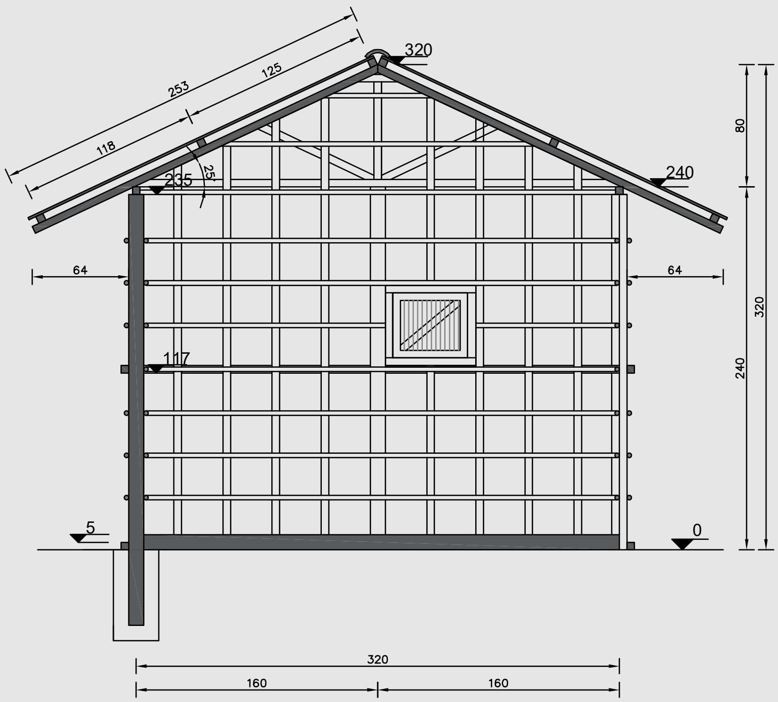
Floor plan



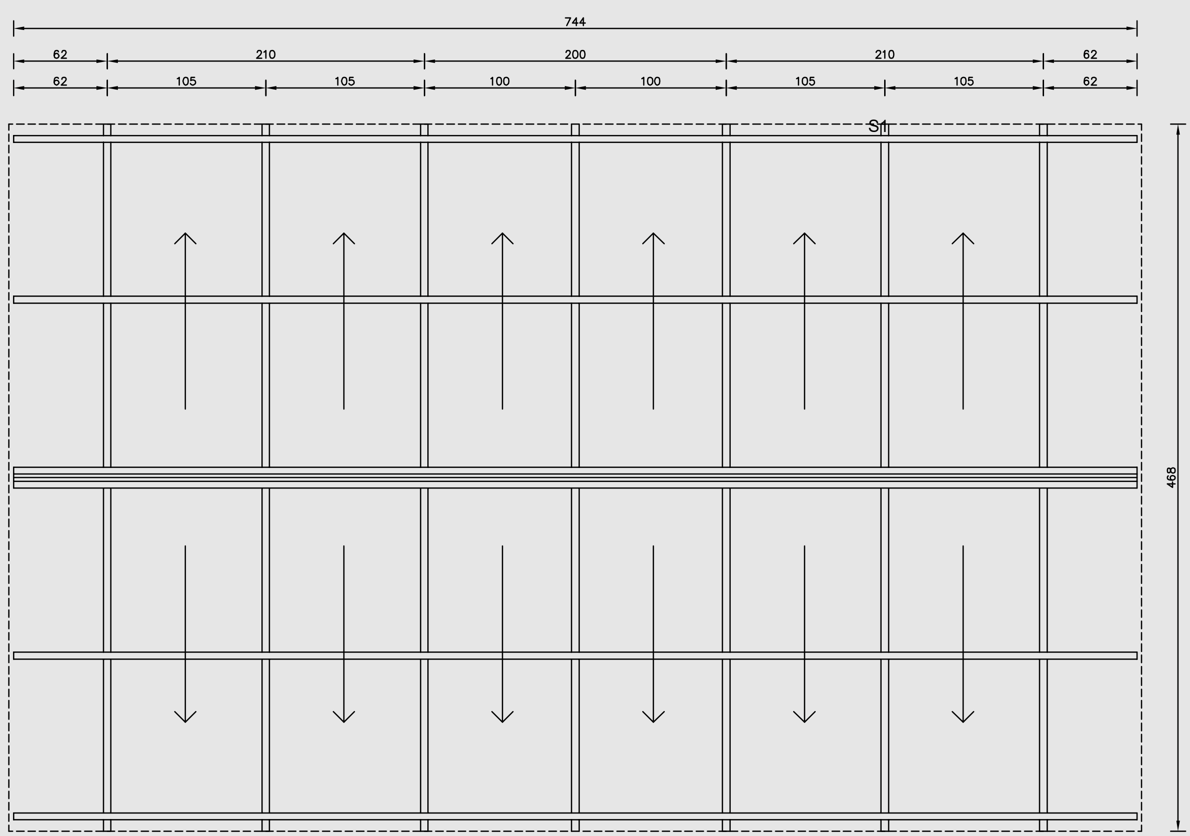
Section S1

Technical drawings

All measures in cm



Section S2



Roof plan

Bill of Quantities

Section	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Shelter Super Structure	Gum poles with ø 8-10 cm, 3 m long	pieces	11	4	44
	Cypress planks, 5x5 cm, 4.5 m min. length	m length	159	1	159
	Bamboo sticks with ø 2-3 cm, 3.5 m long	pieces	64	0.25	16
	Bamboo sticks with ø 4-5 cm, 2.5 m long	pieces	32	0.25	8
	Bamboo sticks with ø 4-5 cm, 3 m long	pieces	16	0.3	4.8
	Soil excavation	m^3	9	1	9
	Lime for the soil mix	kg	450	0.2	90
	Wood preservative	liters	20	0.35	7
	Iron sheets, gauge 30, dimensions 2.5 x 0. 9 m	pieces	18	6.86	123.5
	Nails, 10-11 cm long	kg	5	1.95	9.80
	Nails, 7-8 cm long	kg	1	1.95	3.92
	Nails, 5-6 cm ling	kg	0.25	1.56	0.39
	Roofing nails (umbrella type), 5 cm long	kg	5	1.95	9.75
Openings	Door panel, 2x1 m	pieces	1	14	14
	Cypress planks, 5x5 cm, 4.5 m min. length	m length	12	1	12
	Door locking system, 10-11 cm	pieces	1	0.78	0.78
	Door hinges & screws, 10-11 cm	pieces	3	0.25	0.75
	Window panel, 0.6x0.55 m	pieces	3	5	15
	Cypress planks, 5x5 cm, 4.5 m min. length	m length	9	1	9
	Window locking system, 7-8 cm	pieces	2	0.78	1.56
	Window hinges & screws, 7-8 cm	pieces	4	0.2	0.8
Labour	2 unskilled	day	9	5	90
	1 skilled worker	day	4	10	40
					539.1 + 130
	Total				**669.1**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

Tree protection

C02 emission mitigation

Material efficiency

Technical performance

Shelter habitability

Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

5. Durable shelter solutions

While it may be difficult during an emergency to look beyond the provision of life saving shelter support, it is imperative to keep in mind that persons of concern to UNHCR should be supported to reach durable shelter solutions. Within, but particularly beyond the emergency and transitional phase, shelters should be adapted and contextualized according to the following elements: climate, cultural practice and habits, local availability of skills, access to adequate construction materials and geographical context. Furthermore, standards for durable shelter solutions should be defined based on humanitarian standards and in collaboration with the future shelter users, the shelter partners and in close coordination with government authorities and development partners.

5.1 Durable shelter
Mahama settlement

Mahama refugee settlement, is UNHCR's newest and largest settlement in Rwanda, hosting mainly Burundian refugees. Established in 2015, it has a population of around 60 000 refugees. The settlement is currently in currently in transition from a temporary site into a durable, integrated settlement through an innovative and long term response plan, that promotes refugee self-reliance and integration with the host community. Temporary shelters are being replaced by the more durable, brick alternatives, which were designed as twin structures due to scarce availability of land. One shelter unit can therefore host two households. The settlement was equipped with access to water sources, communal toilets, showers and designated cooking areas within the plots.

Shelter service area
34.6 m² [5.4 m x 6.4 m] - 17.3 m² per household

Regionally or locally sourced materials
Water, timber, straw, clay rich soil, bricks, cement and cement based products, sand, steel, iron and its end products (CGI)

Imported materials
Plastic based items and some steel and iron products are generally imported from China

Climate classification
Tropical savanna

Yearly temperatures
Vary from 19°C to 26°C
Rarely below 10°C or above 32°C

Rainy season
October to December with
383 mm of precipitations per month on average
March to May
320 mm of precipitations per month on average

Dry season
June to August with
67 mm of precipitations per month on average

Wind speed
Winds up to 17 km/hr

Flood risks
- Clay reach soil
- Important volumes of rain water runoff

Flood mitigation opportunities
Site slope 6-18 %

Site level environmental challenges
- Site cleaning (trees and other types of vegetation) due to construction;
- Communal toilets shared among 4 families;
- Refuse pits implemented, solid waste management integrated with the national system;
- Gas fuel cooking.

Variation A

Structure	load bearing walls-non reinforced masonry
Walls	cement plastered sun-dried mud-brick
Roof	corrugated iron sheets
Footing	40 x 70 cm mud-brick foundations
Floor	compacted earth
Openings	2 doors [90 x 200cm], 4 windows [60 x 60cm], 4 gable vents [50 x 30cm]

+45ºC
+7ºC
Suggested temperature range

Workforce required for setup

10 DAYS
Time required for setup[5*]

10 YEARS
Average life span of the shelter

Environmental impacts

Raw materials used[3*]	gum trees	1 m³
	water[1*]	126 600 liters
	soil	21.5 m³
	quarry stones	10 m³
Manmade materials used	plastic (damp course)	0.02 m³
	steel (nails, CGI, bars)	174 kg
	cement	405 kg
	sand	6 m³
CO_2 emissions	material production	696 kg
	transportation	33 kg
CO_2 absorption cease	due to deforestation	204 kg/year
	Total	933 kg

CO_2 footprint	kg of CO_2 / Life span / Area
	933 kg / 10 years / 34.6 m²
	=2.7 kg of CO_2 / year / m²
Damage of natural habitat	Deforestation & erosion
	Fall through hazards due to soil excavation
Material reuse	CGI sheets are reusable
	Timber and tarpaulins can be upcycled

Technical performance

Flood mitigation	plot & shelter adapted to mitigate risks
Ventilation	meets minimum vent. requirements
Flammability	meets fire resistant criteria
Thermal comfort[*2]	mitigates extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 5 occupants (Sphere)
Privacy	provides minimum privacy
Natural light	meets minimum light. requirements
Artificial light	artificial lightning in communal areas
Shelter materials	adapted to local practices
Facilities	communal facilities in the site

Affordability

Costs	Cost / Life span / Area
	$ 1 061.66 / 10 years / 34.6 m²
	= $ 3.1 / year / m²

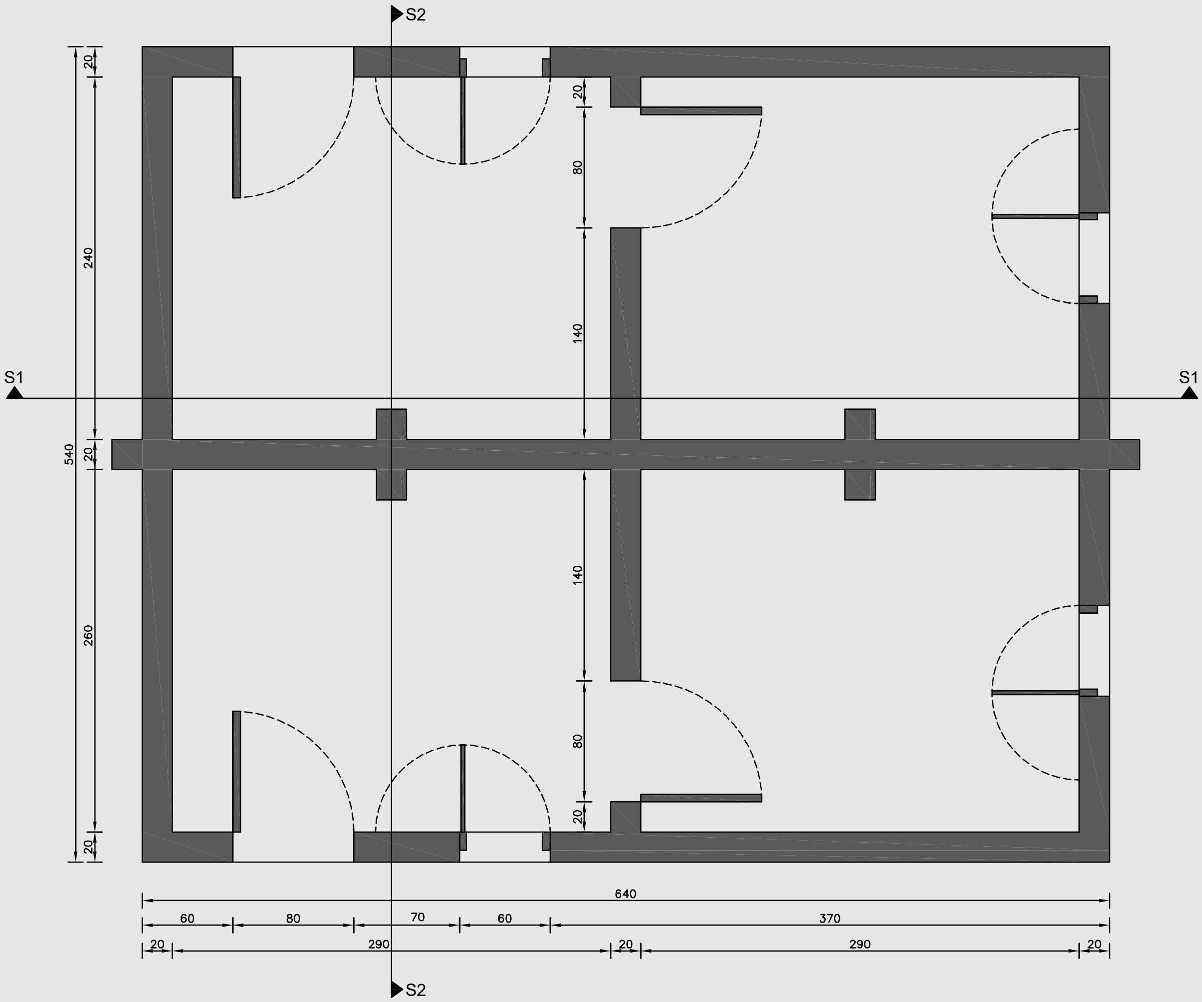
[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

Technical drawings

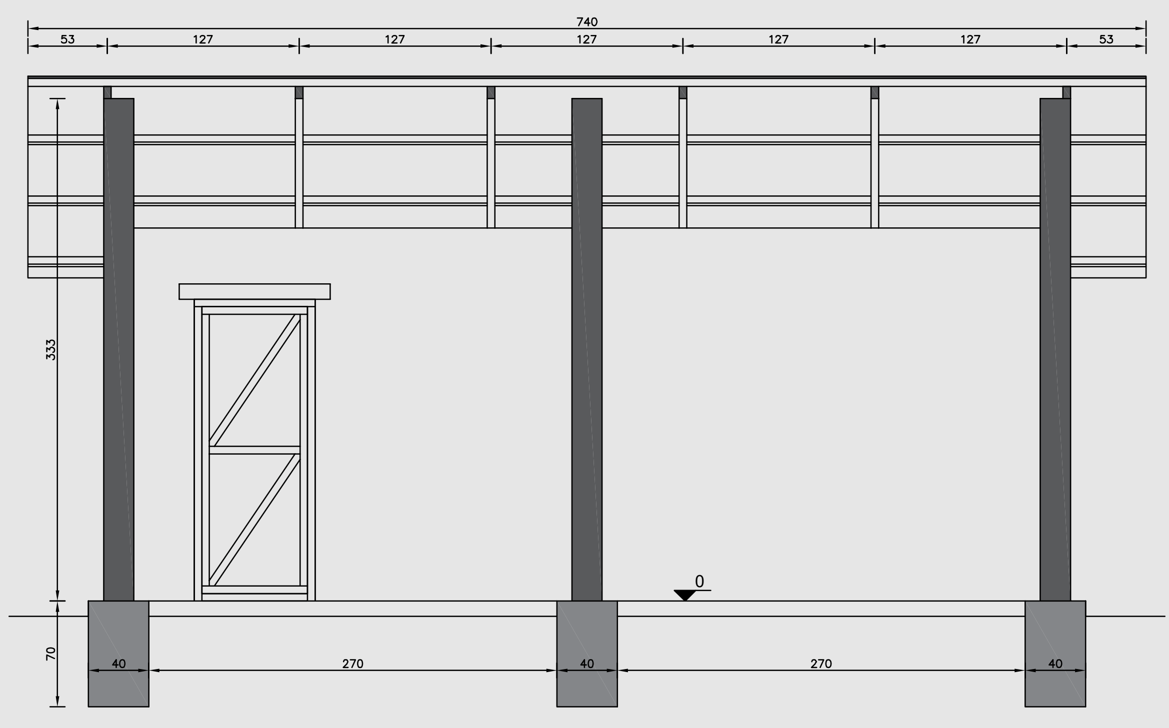
All measures in cm

0 0.5 1
meters

Floor plan



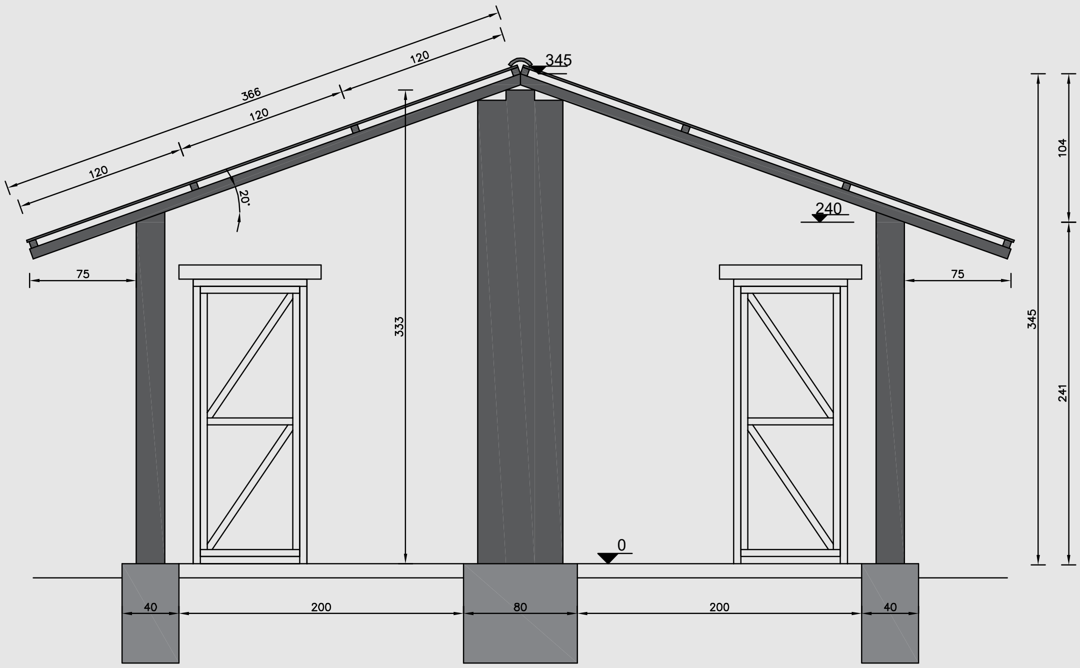
Section S1



Technical drawings

All measures in cm

0 0.5 1
meters



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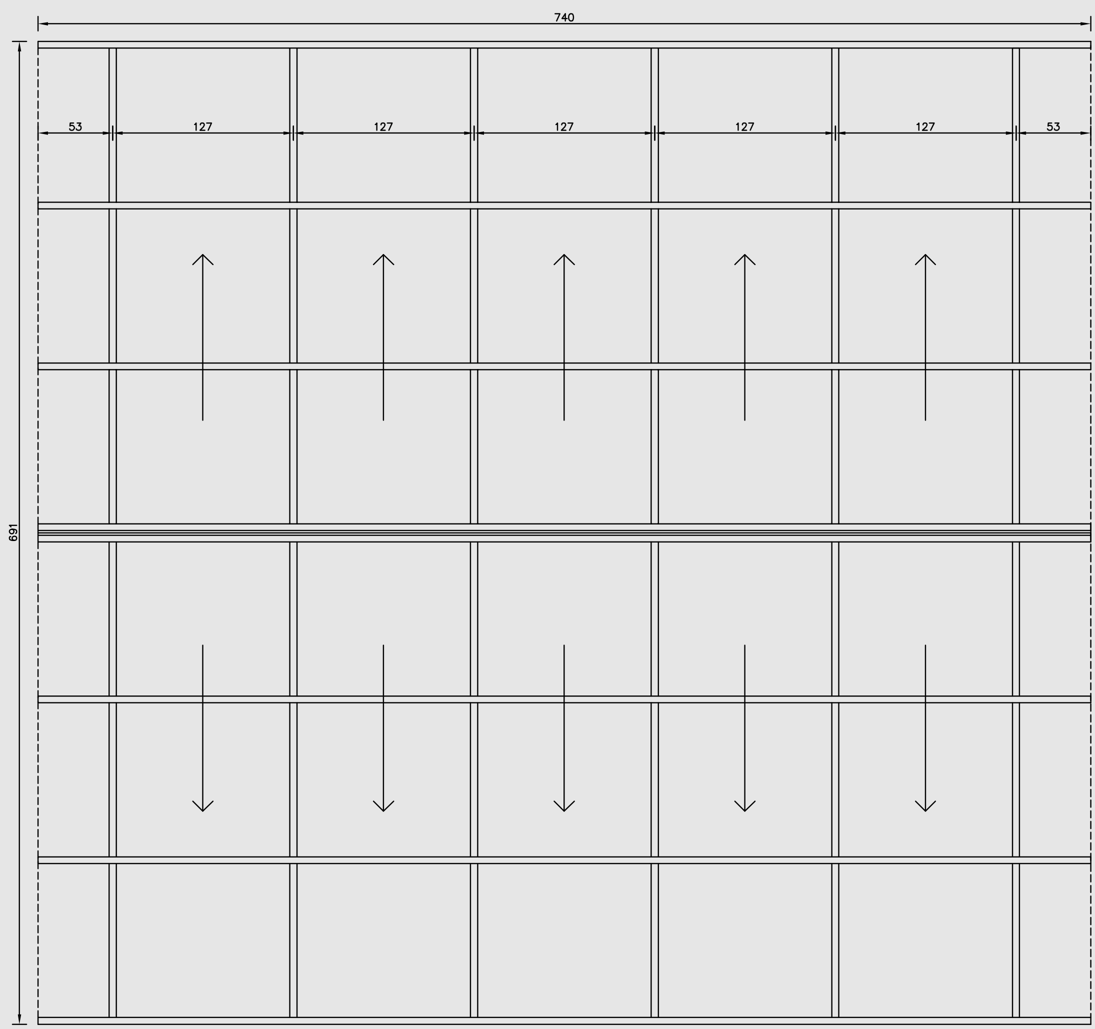


Roof plan

Bill of Quantities

Section	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Fundations	Quarry stones	m^3	10	5.43	54.35
	Big River sand	m^3	5	10.87	54.35
	Portland cement, (50kg bag)	pieces	3	10.87	32.61
Super Structure	Clay bricks, dimensions 40x20x20 cm	pieces	1 200	0.16	195.65
	Soil for joints mortar	m^3	5	1.2	8.4
	Gum rafters, 7.5 x 5cm section, 4m long	pieces	12	4.57	54.78
	Gum purlins, 5x5cm section, 4m long	pieces	22	3.48	76.52
	Gum poles for scaffold	pieces	32	1.63	52.17
	Iron sheets, gauge 30, dimensions 3.65 x 0. 9 m	pieces	16	10.65	170.43
	Iron bar, ø 6 mm, 12m long	pieces	2	2.72	5.43
	Roofing nails (umbrella type)	kg	3	2.17	6.52
	Orindary nails, 12 cm long	kg	4	1.63	6.52
	Ordinary nails, 10 cm long	kg	2	1.63	3.26
	Ordinary nails, 8 cm long	kg	1	1.63	1.63
	Ordinary nails, 5 cm long	kg	0.5	1.63	0.82
	Portland cement for plaster (50kg bag)	pieces	5	10.87	54.35
	Sand for plaster	m3	1	10.87	10.87
Openings	Door panel, 0.8 x 2 m and frame, 0.10 m	pieces	4	14	56
	Door hindges	pieces	8	1.5	12
	Window panel, 0.6 x 0.6 m and frame, 0.10 m	pieces	4	6	24
	Window hindges	pieces	8	1	8
	Tower bolts	pieces	8	0.75	6
	Pad bolts	pieces	4	0.5	2
Labour	2 unskilled worker	day	10		100
	1 skilled worker	day	4		65
					896.66 + 165
	Total				**1 061.66**

4* Prices according to the 2019 local market assessment.

Sustainability Score Card

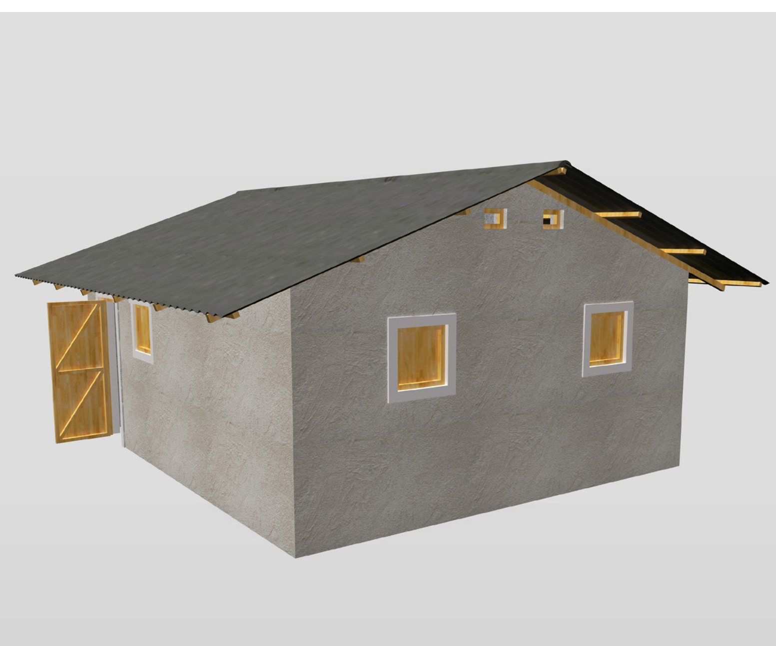
- Tree protection
- C02 emission mitigation
- Material efficiency
- Technical performance
- Shelter habitability
- Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

Variation B

Structure	load bearing walls-non reinforced masonry
Walls	cement plastered blocks
Roof	corrugated iron sheets
Footing	40 x 70 cm quarry stone foundations
Floor	compacted earth
Openings	2 doors [90 x 200cm], 4 windows [60 x 60cm], 4 gable vents [25 x 30cm]

Suggested temperature range | Number of people required for setup | Time required for setup[5*] | Average life span of the shelter



Environmental impacts

Raw materials used[3*]	gum trees	1 m³
	water[1*]	127 200 liters
	quarry stones	10 m³
Manmade materials used	steel (nails, CGI, bars)	174 kg
	cement	4 805 kg
	sand	14 m³
CO_2 emissions	material production	4 656 kg
	transportation	132 kg
CO_2 absorption cease	due to deforestation	204 kg/year
	Total	4 992 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	4 992 kg / 25 years / 34.6 m²	
	=5.8 kg of CO_2 / year / m²	
Damage of natural habitat	Deforestation & erosion	
Material reuse	CGI sheets and cement blocks are reusable	
	Timber elements can be upcycled	

Technical performance

Flood mitigation	plot & shelter adapted to mitigate risks
Ventilation	meets minimum vent. requirements
Flammability	meets fire resistant criteria
Thermal comfort[*2]	partially mitigates extreme temperatures[2*]
Personal security	guaranteeing personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 5 occupants (Sphere)
Privacy	provides minimum privacy
Natural light	meets minimum light. requirements
Artificial light	artificial lightning in communal areas
Shelter materials	adapted to local practices
Facilities	communal facilities in the site

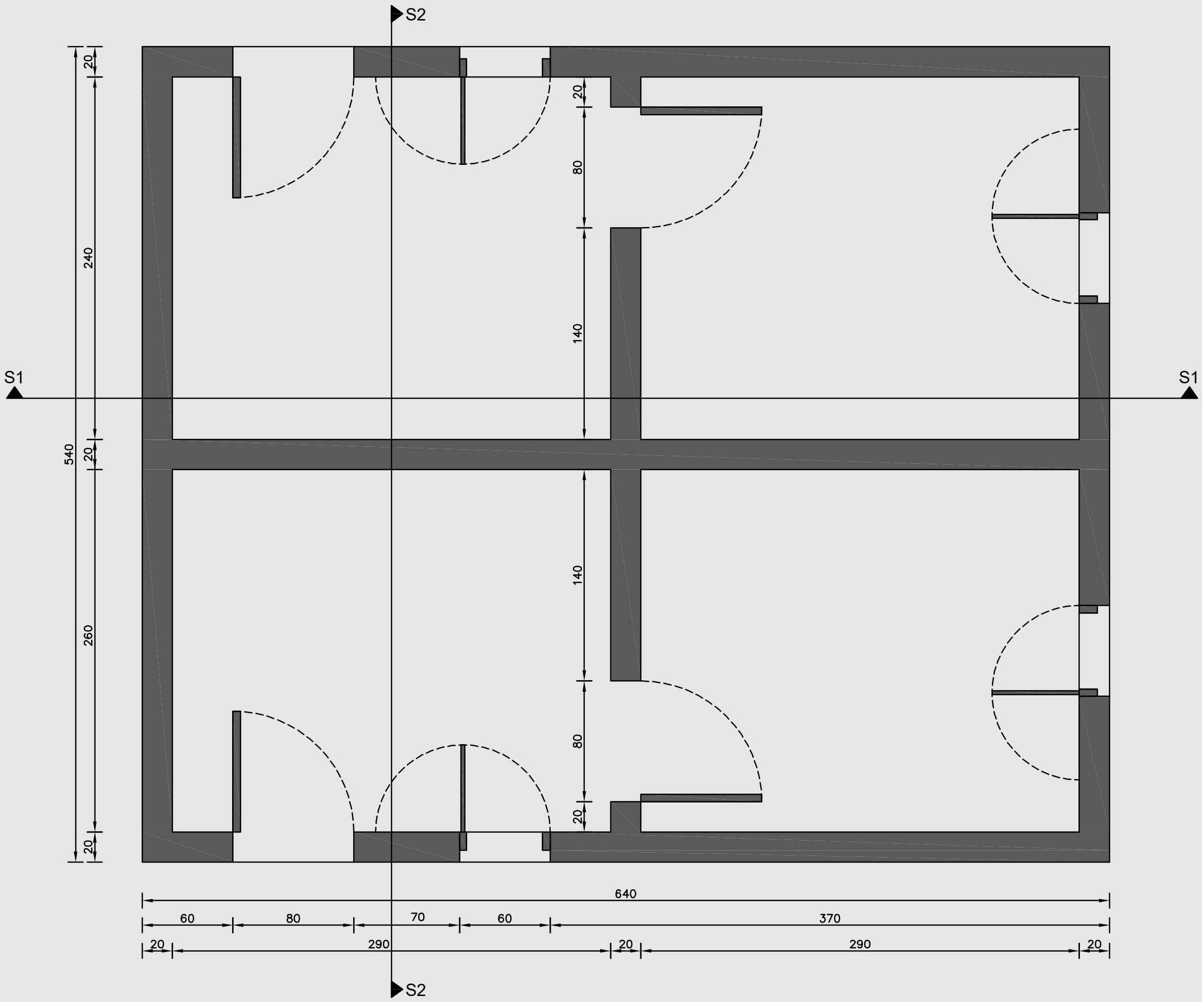
Affordability

Costs	Cost / Life span / Area
	$ 1 558.7 / 25 years / 34.6 m²
	= $ 1.8 / year / m²

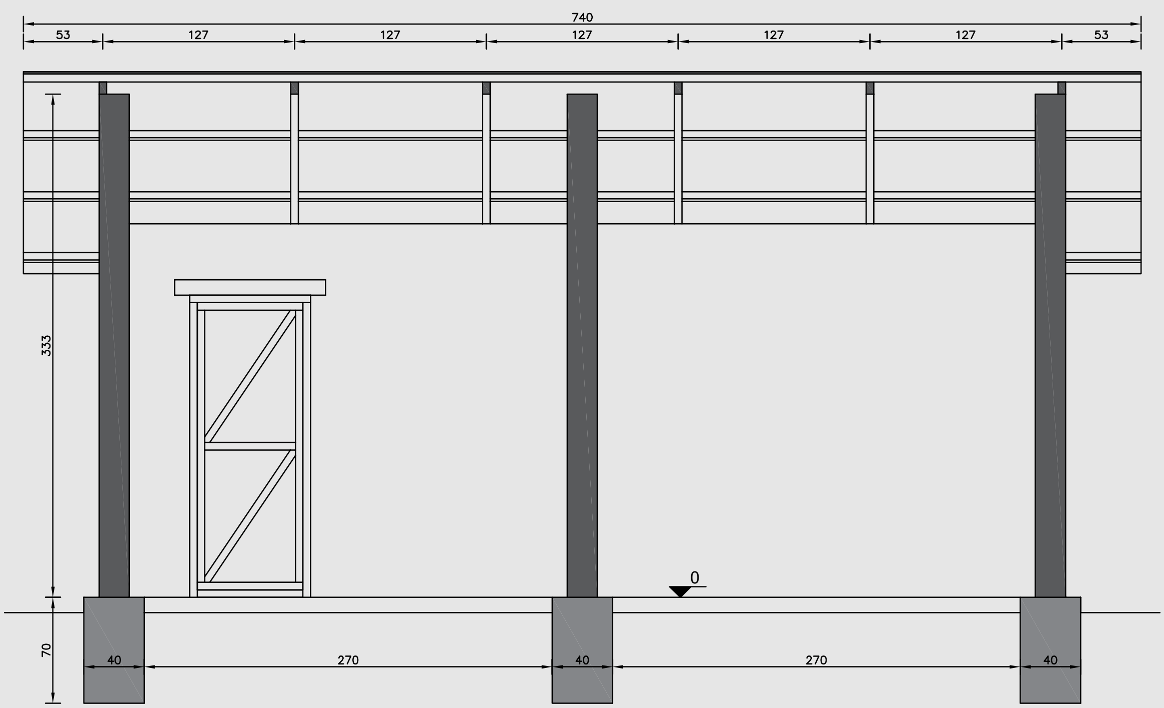
[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

Technical drawings

All measures in cm



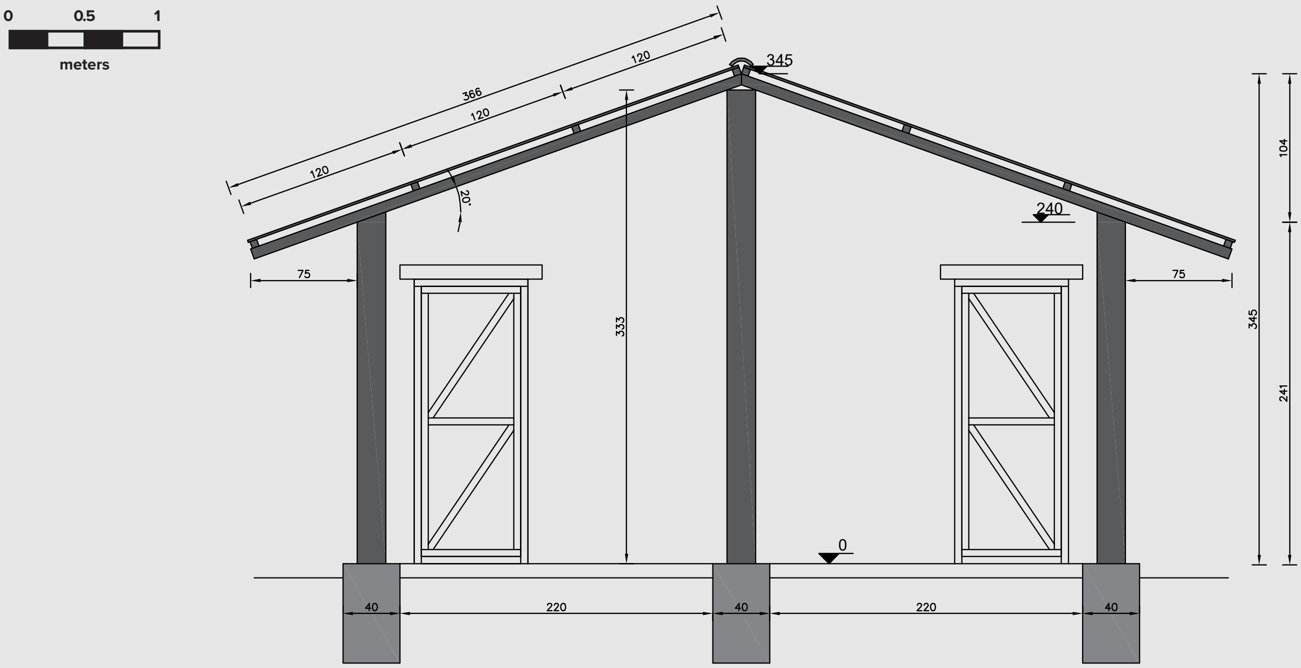
Floor plan



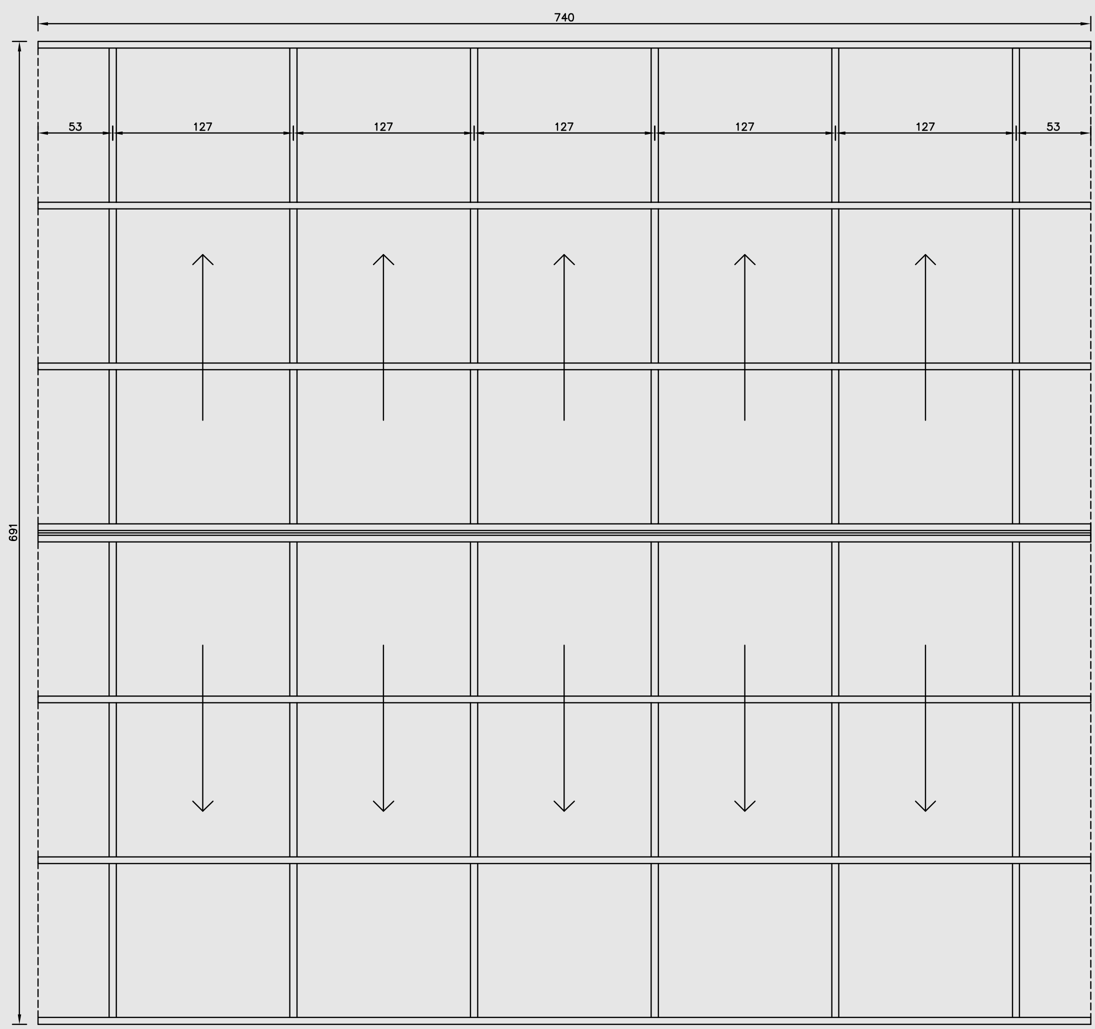
Section S1

Technical drawings

All measures in cm



Section S2



Roof plan

Bill of Quantities

	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Fundations	Quarry stones	m^3	10	5.43	54.35
	Big River sand	m^3	5	10.87	54.35
	Portland cement, 42.5 or 53 (50kgs bag)	pieces	3	10.87	32.61
Super Structure	Concrete blocks dimensions 40x20x20 cm	pieces	1 200	0.5	600
	Gum rafters, 7.5 x 5cm section, 4m long	pieces	12	4.57	54.78
	Gum purlins, 5x5cm section, 4m long	pieces	22	3.48	76.52
	Gum poles for scaffold	pieces	32	1.63	52.17
	Iron sheets, gauge 30, dimensions 3.65 x 0. 9 m	pieces	16	10.65	170.43
	Iron bar, ø 6 mm, 12m long	pieces	2	2.72	5.43
	Roofing nails (umbrella type)	kg	3	2.17	6.52
	Orindary nails, 12 cm long	kg	4	1.63	6.52
	Ordinary nails, 10 cm long	kg	2	1.63	3.26
	Ordinary nails, 8 cm long	kg	1	1.63	1.63
	Ordinary nails, 5 cm long	kg	0.5	1.63	0.82
	Portland cement for plaster & mortar (50kgs bag)	pieces	13	10.87	141.31
	Sand for plaster & mortar	m3	2.3	10.87	25
Openings	Door panel, 0.8 x 2 m and frame, 0.10 m	pieces	4	14	56
	Door hindges	pieces	8	1.5	12
	Window panel, 0.6 x 0.6 m and frame, 0.10 m	pieces	4	6	24
	Window hindges	pieces	8	1	8
	Tower bolts	pieces	8	0.75	6
	Pad bolts	pieces	4	0.5	2
Labour	2 unskilled worker	day	10		100
	1 skilled worker	day	4		65
					1 393.7 + 165
	Total				**1 558.7**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

- Tree protection
- C0₂ emission mitigation
- Material efficiency
- Technical performance
- Shelter habitability
- Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

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5.2 Durable shelter

Nyarugusu settlement

The current three settlements of Kigoma region were established in the mid-1990s to welcome Congolese refugees and were later reopened for the new influx of Burundians in 2015. The refugees are provided with emergency shelters on individual plots upon their arrival. The shelter strategy is focused on the provision of durable solutions - built from mud bricks and covered with iron sheets. The implementation is undertaken with the local authorities through a community-based approach. The strategy involves community participation and capacity building enabling the refugees to develop the technical skills in the construction of their own shelters. The settlement was equipped with access to water sources, individual toilets and communal showers. The cooking area is integrated in the shelter design.

Shelter service area
20.8 m² [3.3 m x 6.3 m]

Cooking area
4.9 m² [1.6 m x 3.1 m]

Regionally or locally sourced materials
Water, timber, straw, clay rich soil, bricks, sand, cement as well as cement based products

Imported materials
Plastic based items are generally imported from China whereas steel as well as iron and its end products are generally imported from South Africa

Climate classification
Tropical savanna

Yearly temperatures
Vary from 11°C to 29°C
Rarely below 9°C or above 32°C

Rainy season
October to April with
95 mm of precipitations per month on average

Dry season
May to September
7.6 mm of precipitations per month on average

Wind speed
Winds up to 18 km/hr

Flood risks
- Clay reach soil
- Important volumes of rain water runoff

Flood mitigation opportunities
- Site slope 6-18 %

Site level environmental challenges
- Site cleaning (trees and other types of vegetation) due to construction;
- Individual pit latrines, but no measures in place for a sustainable disposal of fecal waste;
- Refuse pits implemented, but without strategy for long term solid waste management;

Variation A

Structure	load bearing walls-non reinforced masonry
Walls	mud plastered sun dried mud-brick
Roof	corrugated iron sheets
Footing	40 x 60 cm sun-dried mud brick foundations
Floor	compacted earth
Openings	2 doors [90 x 200cm], 3 windows [65 x 60cm], 4 gable vents [25 x 30cm]

Suggested temperature range | Workforce required for setup | Time required for setup[5*] | Average life span of the shelter

Environmental impacts

Raw materials used[3*]	gum trees	0.6 m³
	water[1*]	143 600 liters
	soil	18.2 m³
Manmade materials used	plastic (damp course)	2 kg
	steel (nails, CGI, bars)	195 kg
	lime	50 kg
CO_2 emissions	material production	426 kg
	transportation	188 kg
CO_2 absorption cease	due to deforestation	192 kg/year
	Total	806 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	806 kg / 10 years / 25.7 m²	
	= 3.1 kg of CO_2 / year / m²	
Damage of natural habitat	Deforestation & erosion	
	Fall through hazards due to soil excavation	
Material reuse	CGI sheets are reusable	
	Timber can be upcycled	

Technical performance

Flood mitigation	plot & shelter adapted to mitigate risks
Ventilation	meets minimum vent. requirements
Flammability	meets fire resistant criteria
Thermal comfort[*2]	mitigates extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 5 occupants (Sphere)
Privacy	provides minimum privacy
Natural light	meets minimum light. requirements
Artificial light	artificial lightning in communal areas
Shelter materials	adapted to local practices
Facilities	household facilities in the plot

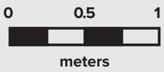
Affordability

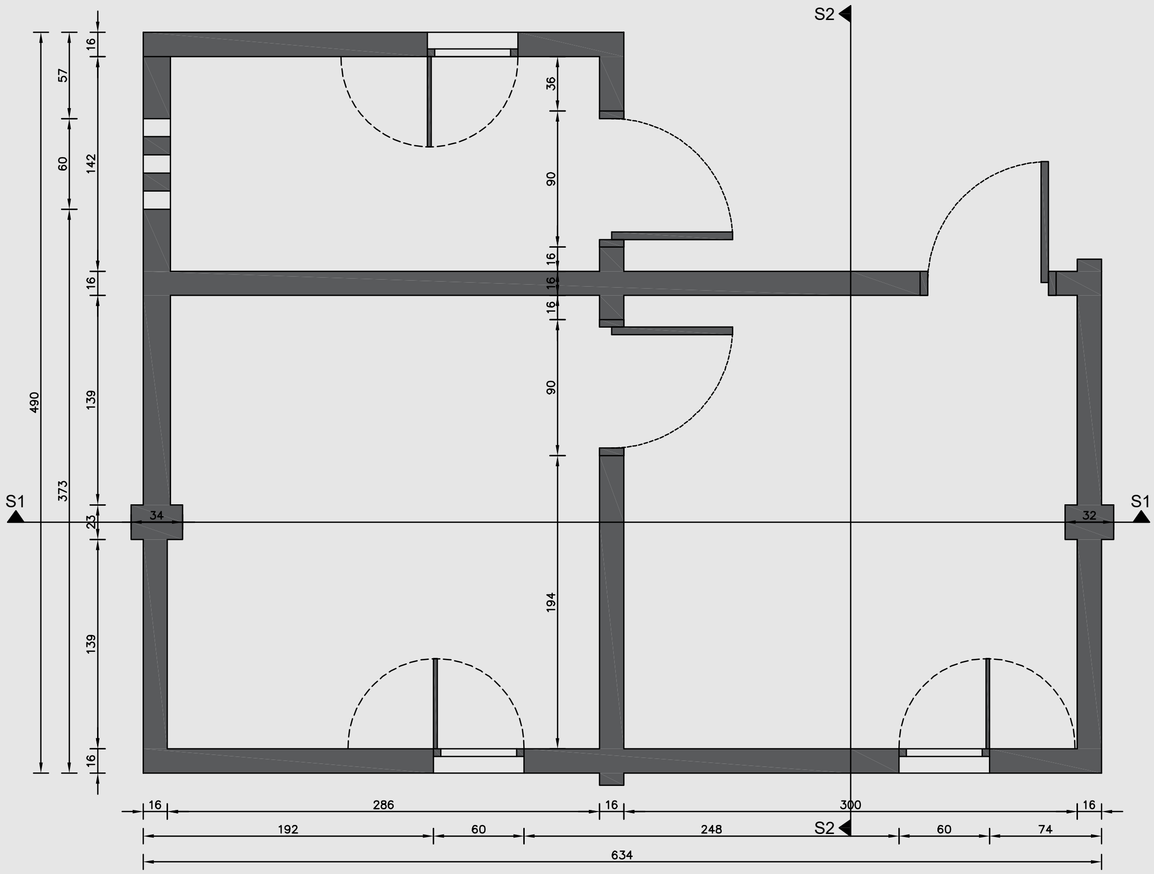
Costs	Cost / Life span / Area
	$ 793.92 / 10 years / 25.7 m²
	= $ 3.1 / year / m²

[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

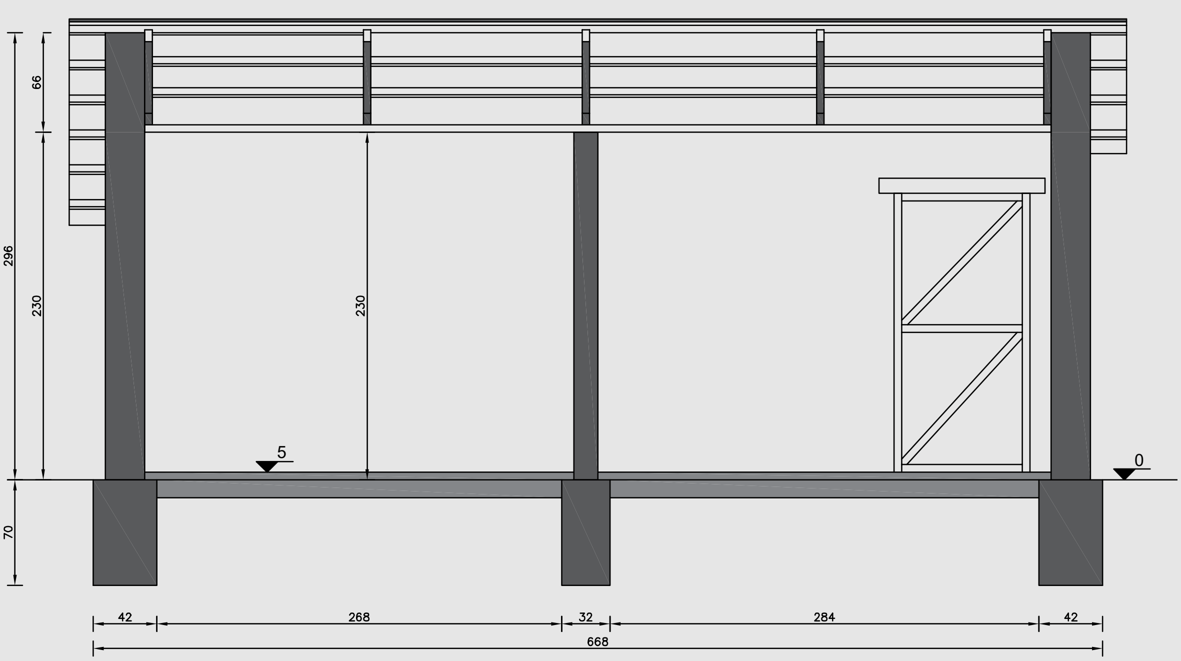
Technical drawings

All measures in cm





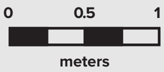
Floor plan

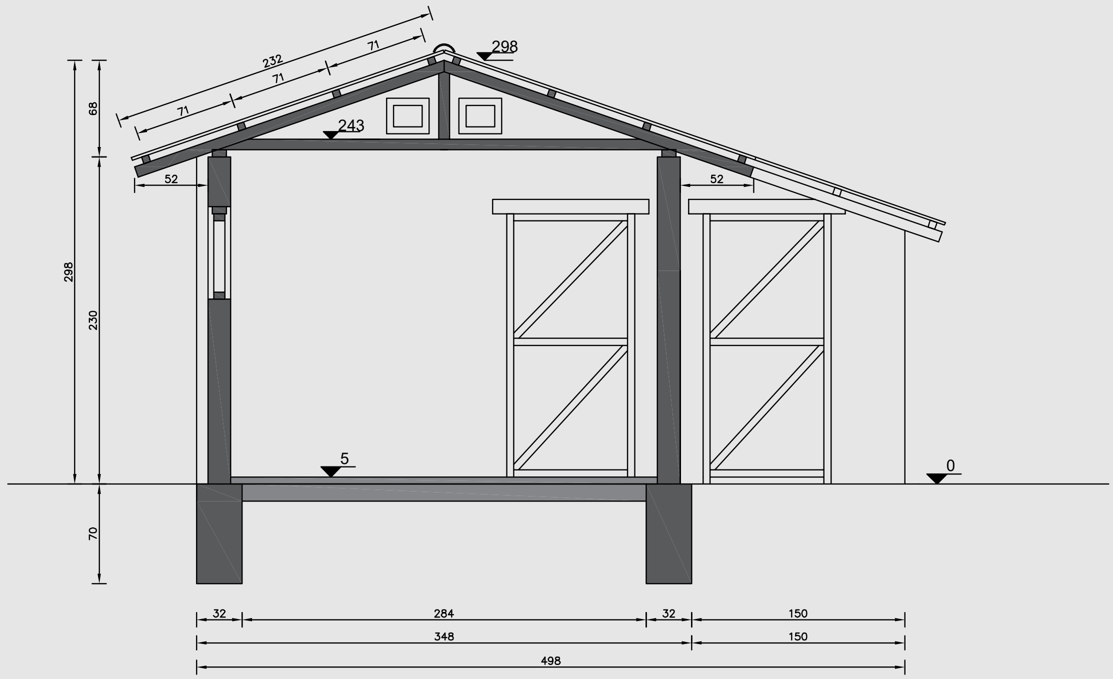


Section S1

Technical drawings

All measures in cm





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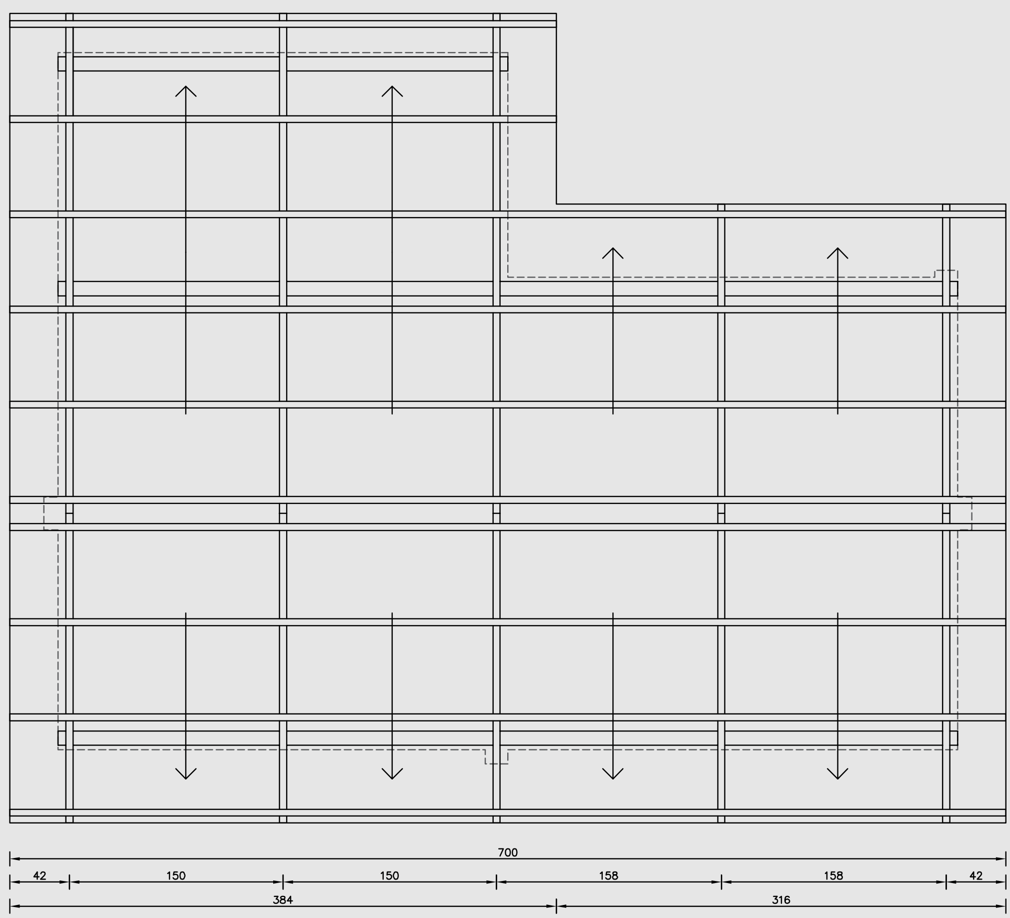


Roof plan

Bill of Quantities

	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Super Structure	Clay bricks, dimensions 16x30x12 cm	pieces	2 300	0.16	368
	Soil excavation for joints mortar and plastering	m^3	5	1.2	6
	Gum plates, 10 x 5cm section,	m length	18	0.8	14.4
	Gum purlins, 5x5 cm, min 4 m length	m length	64	0.5	32
	Gum planks, 5x7.5 cm, min 3.7 m length	pieces	15	2.5	37.5
	Iron sheets, gauge 32, dimensions 3 x 0. 9 m	pieces	21	7	147
	Iron hoop, gauge 20, 2.5 cm	kg	1	4.5	4.5
	Damp proof course (polythene), width 30cm	m length	28	0.13	3.7
	Manilla rope, ø 1.5mm (50m roll)	pieces	1	0.4	0.4
	Roofing nails (umbrella type)	kg	3	2.3	6.9
	Ordinary nails, 7-8 cm long	kg	1.5	1.3	1.95
	Ordinary nails, 5-6 cm long	kg	2.5	1.3	3.25
	Ordinary nails, 10-11 cm long	kg	3.5	1.3	4.55
	Lime (25kg bag)	pieces	2	2.15	4.3
	Anti-termite protection (wood preservative)	liters	2.5	1.1	2.75
Openings	CGI door panel, 32 gauge, 0.9 x 2 m	pieces	2	6	12
	Door hindges	pieces	6	0.42	2.52
	CGI window panel, 32 gauge, 0.6 x 0.6 m	pieces	3	2	6
	Window hindges	pieces	6	0.34	2
	Gum planks for frames 5x10 cm, 3.6 m length	pieces	7.5	2.16	16.2
	Tower bolts	pieces	6	0.5	3
	Pad bolts	pieces	2	1.5	3
Labour	2 unskilled worker	day	10	4	80
	1 skilled worker	day	4	8	32
					681.92 + 112
	Total				**793.92**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

Tree protection

C02 emission mitigation

Material efficiency

Technical performance

Shelter habitability

Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

Variation B

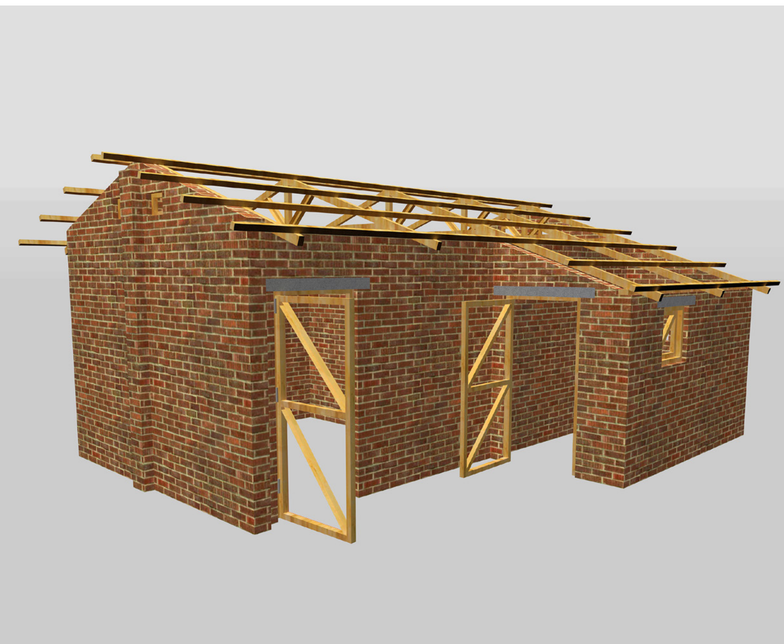
Structure	load bearing walls-non reinforced masonry
Walls	cement plastered burned clay brick
Roof	corrugated iron sheets
Footing	40 x 60 cm burned clay brick foundations
Floor	compacted earth
Openings	2 doors [90 x 200cm], 3 windows [65 x 60cm], 4 gable vents [25 x 30cm]

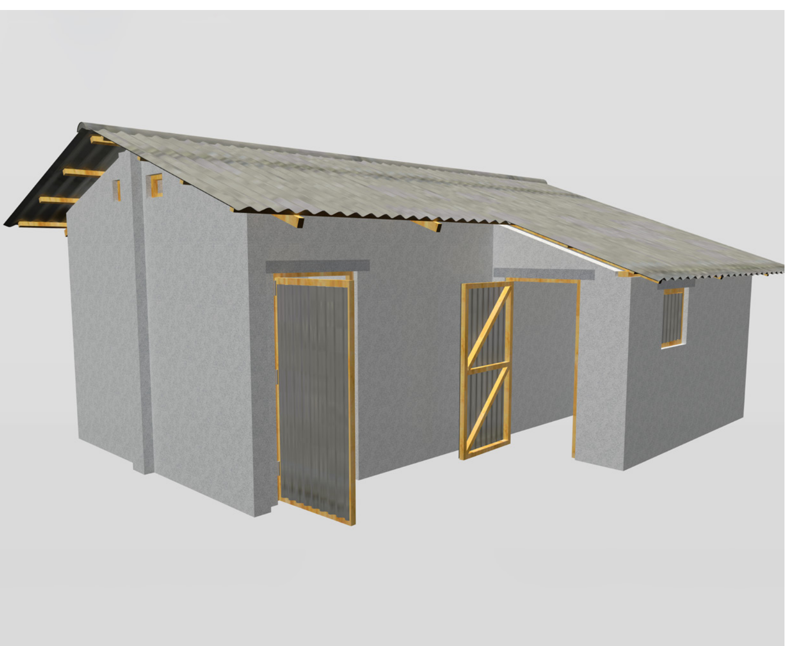
+45ºC
+7ºC
Suggested temperature range

Workforce required for setup

10 DAYS
Time required for setup[5*]

25 YEARS
Average life span of the shelter





Environmental impacts

Raw materials used[3*]	gum trees	0.6 m³
	water[1*]	142 300 liters
	soil	11.2 m³
Manmade materials used	plastic (damp course)	2 kg
	steel (nails, CGI, bars)	195 kg
	cement	1580 kg
	sand	5.4 m³
CO_2 emissions	material production	7 243 kg
	transportation	1 840 kg
CO_2 absorption cease	due to deforestation	192 kg/year
	Total	9 275 kg

CO_2 footprint	kg of CO_2 / Life span / Area
	kg / 25 years / 25.7 m²
	= 14.4 kg of CO_2 / year / m²
Damage of natural habitat	Deforestation & erosion
	Fall through hazards due to soil excavation
Material reuse	CGI sheets and bricks are reusable
	Timber can be upcycled

Technical performance

Flood mitigation	plot & shelter adapted to mitigate risks
Ventilation	meets minimum vent. requirements
Flammability	meets fire resistant criteria
Thermal comfort[*2]	mitigates extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 5 occupants (Sphere)
Privacy	provides minimum privacy
Natural light	meets minimum light. requirements
Artificial light	artificial lightning in communal areas
Shelter materials	adapted to local practices
Facilities	household facilities in the plot

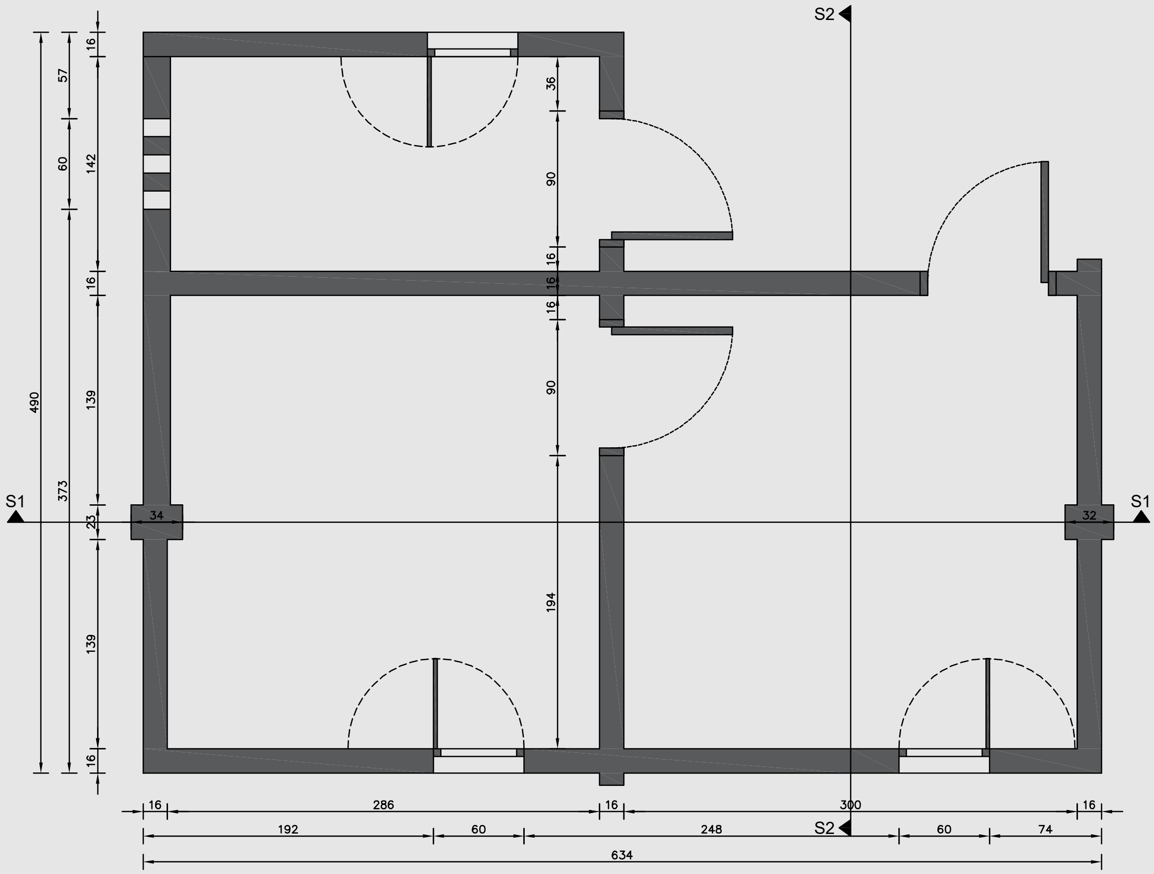
Affordability

Costs	Cost / Life span / Area
	$ 1 500.9 / 25 years / 25.7 m²
	= $ 2.9 / year / m²

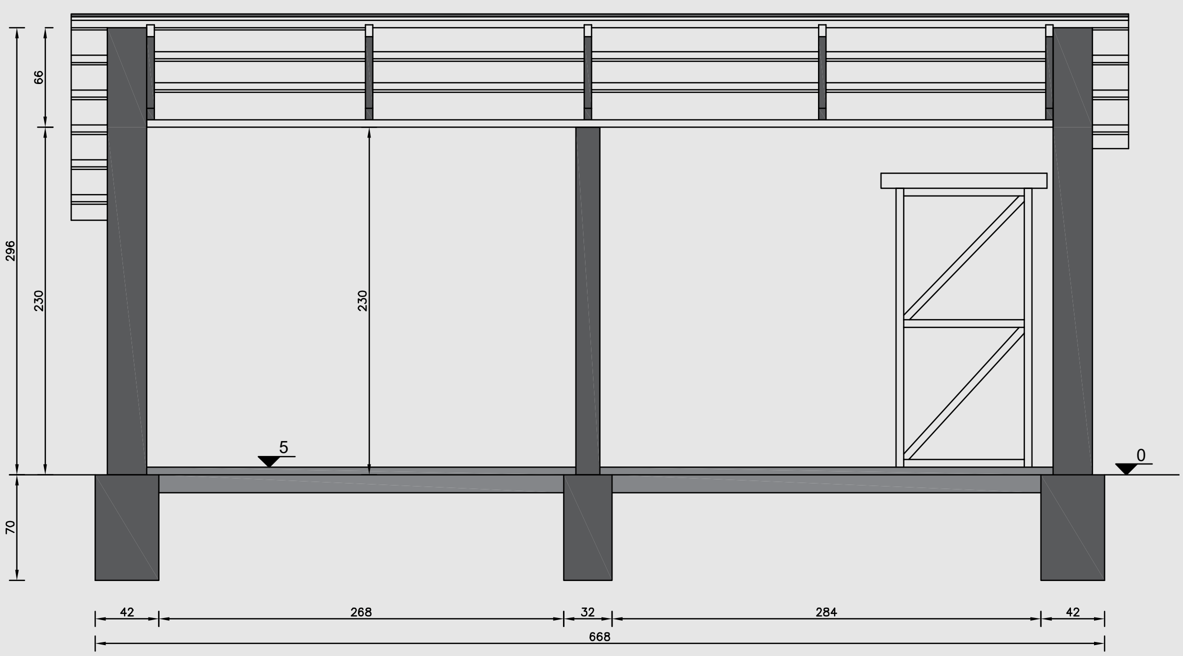
[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

Technical drawings

All measures in cm



Floor plan

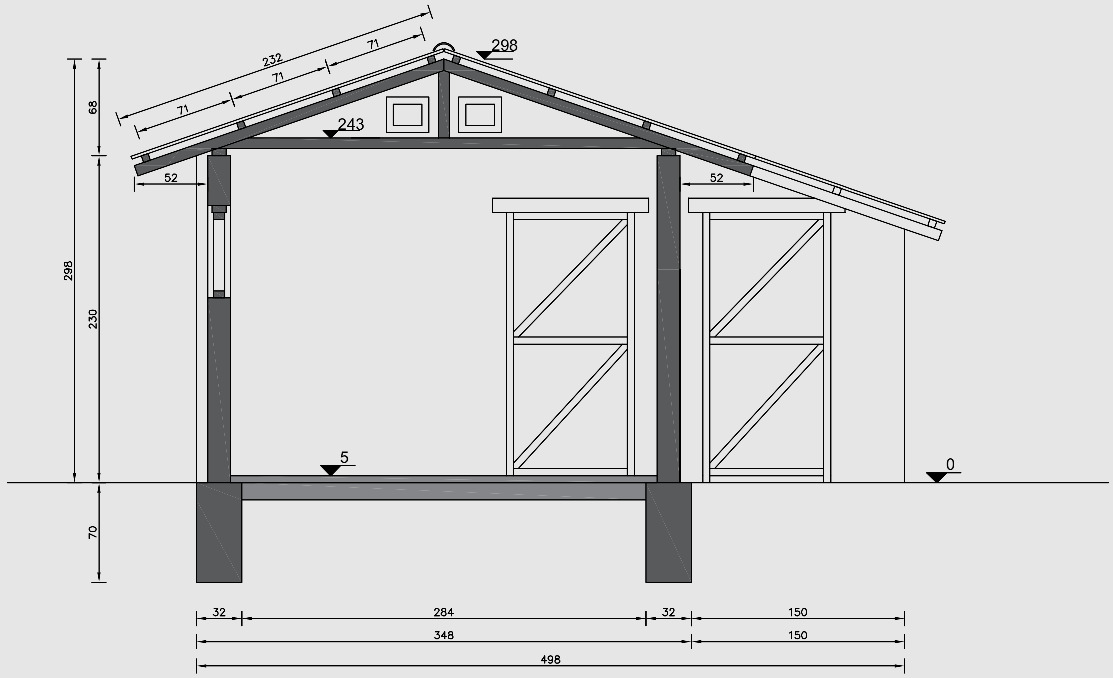


Section S1

Technical drawings

All measures in cm

0 0.5 1
meters



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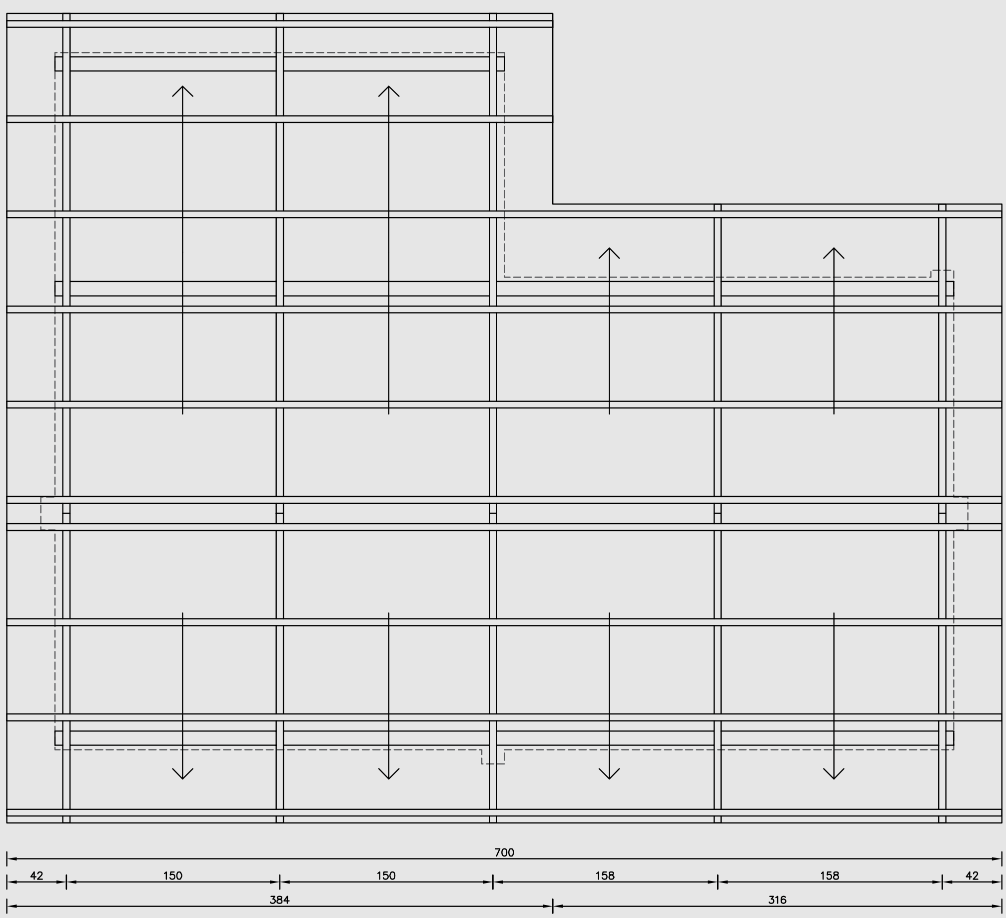
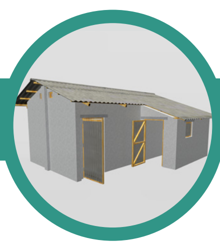


Roof plan

Bill of Quantities

Section	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Super Structure	Clay burned bricks, dimensions 22.2 x 10.6 x 7.3 cm	pieces	6500	0.10	650
	Lintel block with cement ratio mix 0.45:1:2:4	m^3	0.1	120	12
	Gum plates, 10 x 5cm section,	m length	18	0.8	14.4
	Gum purlins, 5x5 cm, min 4 m length	m length	64	0.5	32
	Gum planks, 5x7.5 cm, min 3.7 m length	pieces	15	2.5	37.5
	Iron sheets, gauge 32, dimensions 3 x 0. 9 m	pieces	21	7	147
	Iron hoop, gauge 20, 2.5 cm	kg	1	4.5	4.5
	Damp proof course (polythene), width 30cm	m length	28	0.13	3.7
	Manilla rope, ø 1.5mm (50m roll)	pieces	1	0.4	0.4
	Roofing nails (umbrella type)	kg	3	2.3	6.9
	Ordinary nails, 7-8 cm long	kg	1.5	1.3	1.95
	Ordinary nails, 5-6 cm long	kg	2.5	1.3	3.25
	Ordinary nails, 10-11 cm long	kg	3.5	1.3	4.55
	Portland cement for plaster and mortar (50kg bag)	pieces	31	12	372
	Sand for plaster and mortar	m^3	5.4	9.5	51.3
	Anti-termite protection (wood preservative)	liters	2.5	1.1	2.75
Openings	CGI door panel, 32 gauge, 0.9 x 2 m	pieces	2	6	12
	Door hindges	pieces	6	0.42	2.52
	CGI window panel, 32 gauge, 0.6 x 0.6 m	pieces	3	2	6
	Window hindges	pieces	6	0.34	2
	Gum planks for frames 5x10 cm, 3.6 m length	pieces	7.5	2.16	16.2
	Tower bolts	pieces	6	0.5	3
	Pad bolts	pieces	2	1.5	3
Labour	2 unskilled worker	day	10	4	80
	1 skilled worker	day	4	8	32
					1 388.9 + 112
	Total				**1 500.9**

[4*] Prices according to the 2019 local market assessment.



Sustainability Score Card

Tree protection

C02 emission mitigation

Material efficiency

Technical performance

Shelter habitability

Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent

The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

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5.3 Durable shelter

Kandahar urban area

Since 2002, nearly 5.3 million Afghan refugees have returned to their country under UNHCR's facilitated Voluntary Repatriation program and shelter remains one of the most pressing need in this context. Through UNHCR's cash for shelter project, vulnerable returnee households receive cash grants that enable them to build their own shelter with the technical support from UNHCR and partners. Beneficiaries are provided with cash in three installments linked to three phases of construction. Training and technical expertise is provided to guide the construction process. A total of 600 households were targeted in the eastern, southern and western regions of Afghanistan. The housing units include a kitchen and toilet, and the households have access to the public water distribution system.

Shelter service area
40 m^2

Regionally or locally sourced materials
Timber, bricks, sand, cement and cement based products

Imported materials
Plastic based items, steel as well as iron and its end products are generally imported from China

Climate classification
Arid steppe – very cold in winter, very hot in summer

Yearly temperatures
Vary from 1°C to 40°C
Rarely below -3°C or above 43°C

Rainy season
December to April with
21 mm of precipitations per month on average

Dry season
May to November
5 mm of precipitations per month on average

Wind speed
Winds up to 25 km/hr

Flood risks
- Areas prone to flash floods
- Sandy soil which easily washes away in rain
- Lack of vegetation cover and erosion

Flood mitigation opportunities
- Service water drainage in the plot
- Shelters elevated on platforms

Site level environmental challenges
- Site cleaning (trees and other types of vegetation) due to construction;
- Solid waste management integrated with the national system;
- Toilets with septic tanks;
- Charcoal/kerosene heating stove;
- Charcoal/kerosene fuel cooking.

Variation A

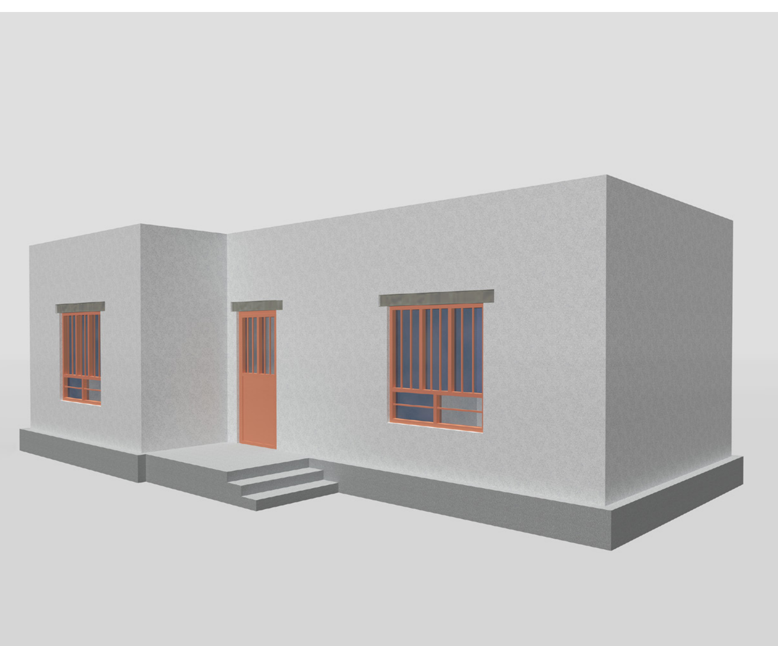
Structure	load bearing walls-non reinforced masonry
Walls	cement plastered burned brick
Roof	flat roof - I section steel profiles with brick infill
Footing	50 x 80 cm quarry stone foundations
Floor	PCC flooring on compacted hard core filling
Openings	2 doors [100 x 210cm], 2 windows [150 x 150cm], 1 toilet vent [80 x 80cm]

+45°C / +7°C — Suggested temperature range

Workforce required for setup

30 DAYS — Time required for setup[5*]

25 YEARS — Average life span of the shelter



Environmental impacts

Raw materials used[3*]	straw	321 kg
	water[1*]	2 984 100 liters
	soil	20.3 m³
	quarry stones	22 m³
Manmade materials used	plastic (damp course)	14 kg
	steel (doors, profiles)	4 218 kg
	cement	5 150 kg
	sand	24 m³
	gravel	2 m³
	glass	41 kg
CO_2 emissions	material production	22 851 kg
	transportation	8 119 kg
	due to deforestation	0 kg/year
CO_2 absorption cease	Total	30 970 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	30 970 kg / 25 years / 40 m²	
	= 31 kg of CO_2 / year / m²	
Material reuse	Bricks are reusable	

Technical performance

Flood mitigation	shelter adapted to mitigate risks
Seismic resistance	withstands moderate (5-5.9 Richter) events
Ventilation	meets minimum vent. requirements
Flammability	meets fire resistant criteria
Thermal comfort[*2]	mitigates extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 10 occupants (Sphere)
Privacy	provides minimum privacy
Natural light	exceeds minimum light. requirements
Artificial light	shelter equipped with artificial lightning
Shelter materials	adapted to local practices
Facilities	shelter equipped with facilities

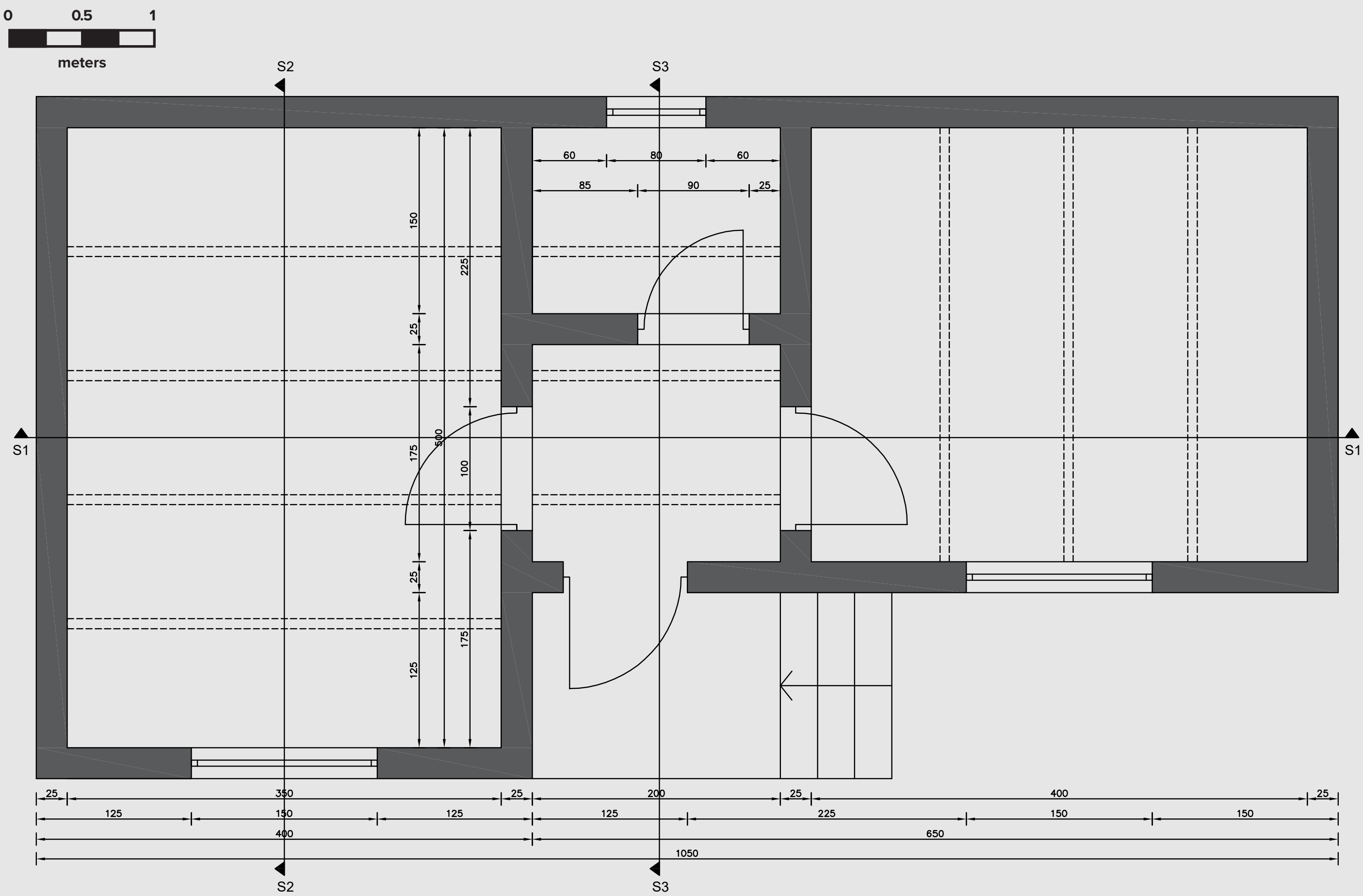
Affordability

Costs	Cost / Life span / Area
	$ 3 550.4 / 25 years / 40 m²
	= $ 3.6 / year / m²

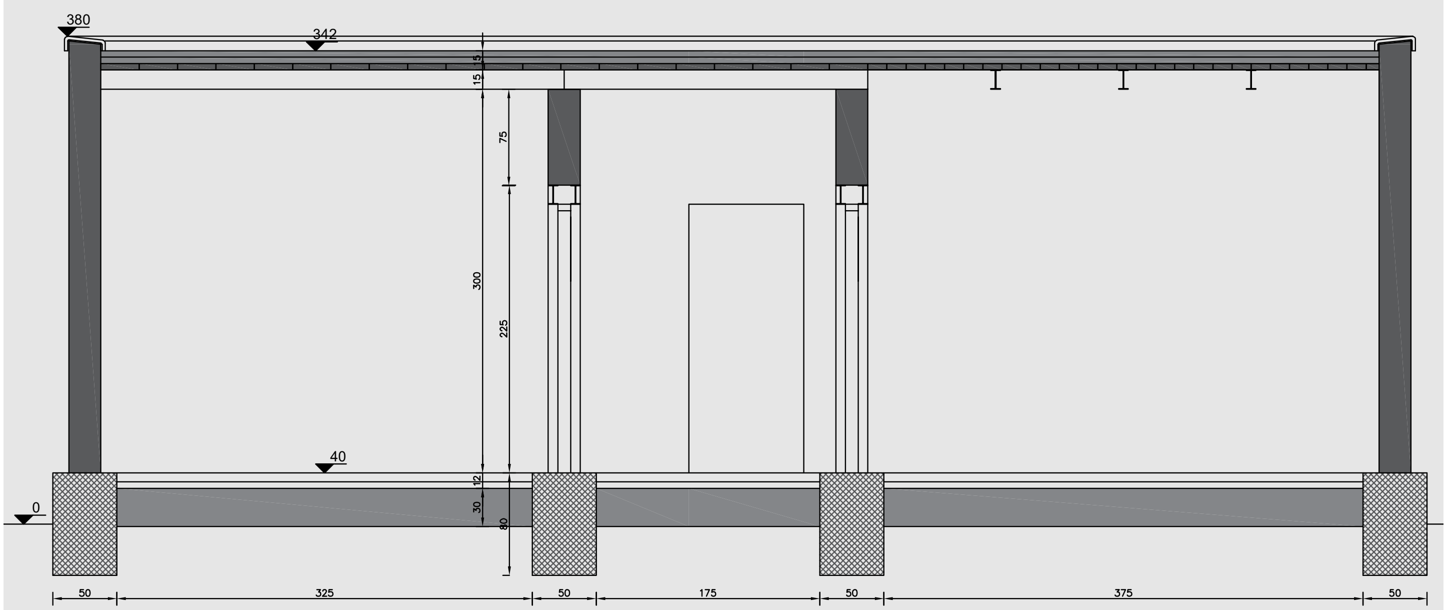
[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

Technical drawings

All measures in cm



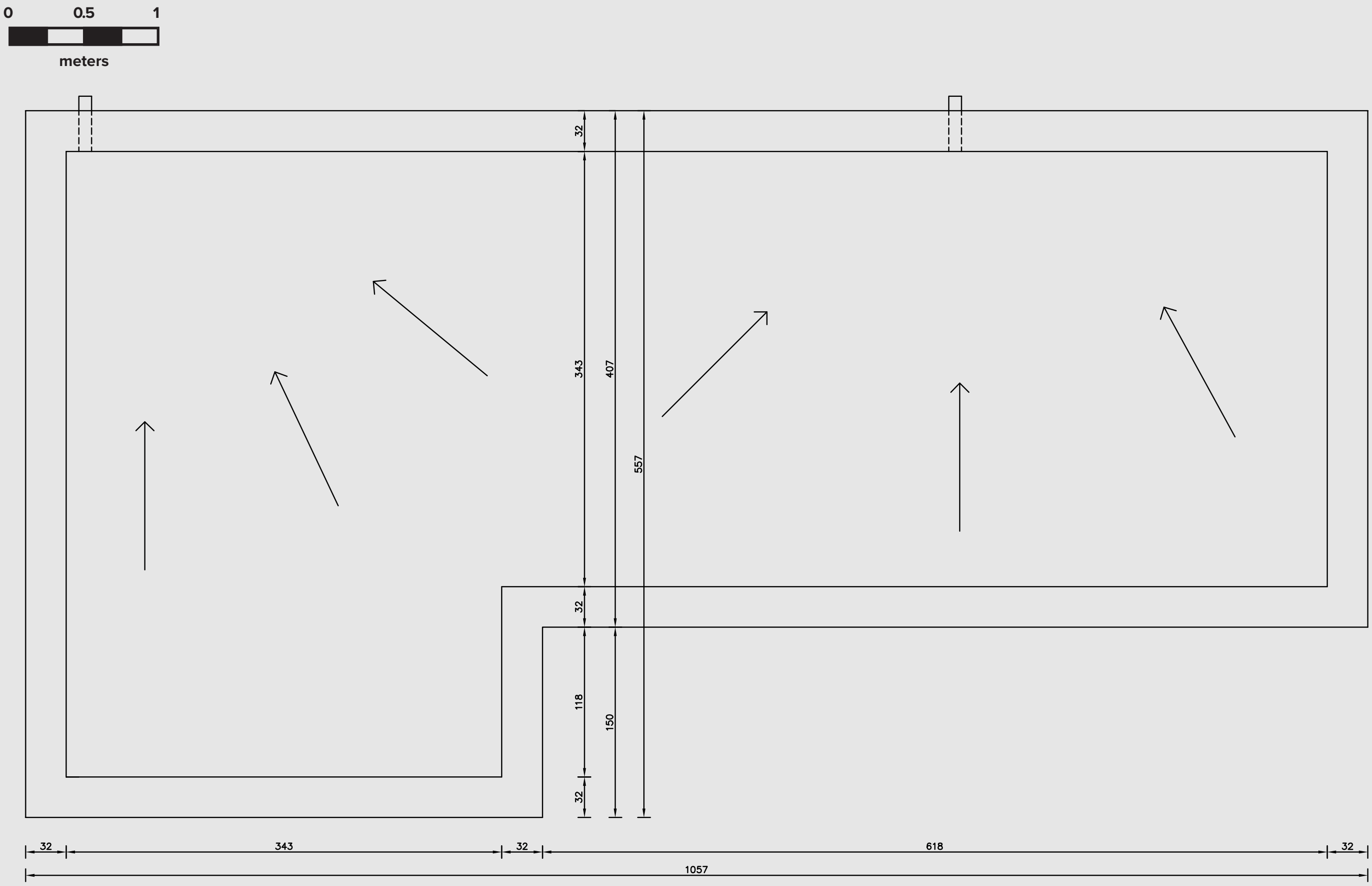
Floor plan



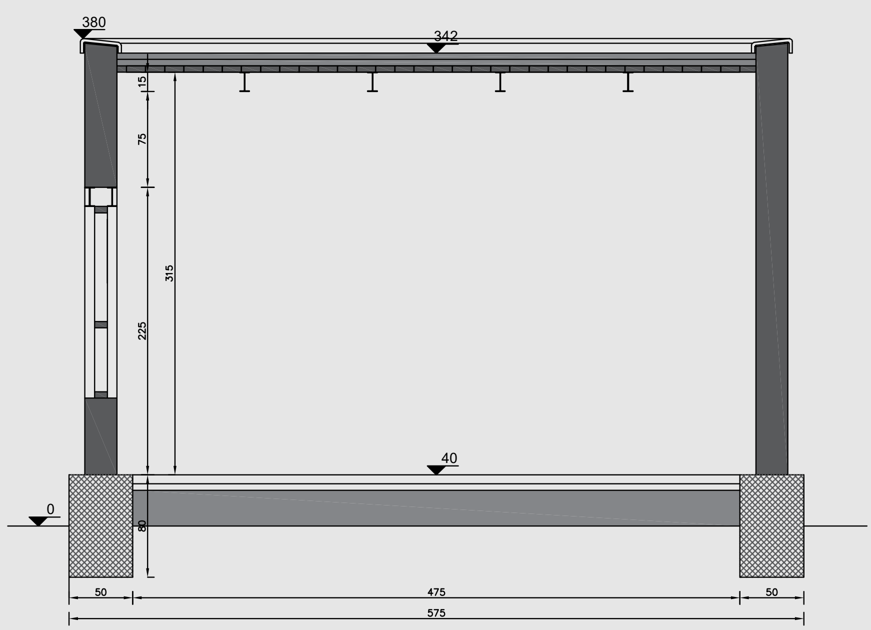
Section S1

Technical drawings

All measures in cm



Roof plan

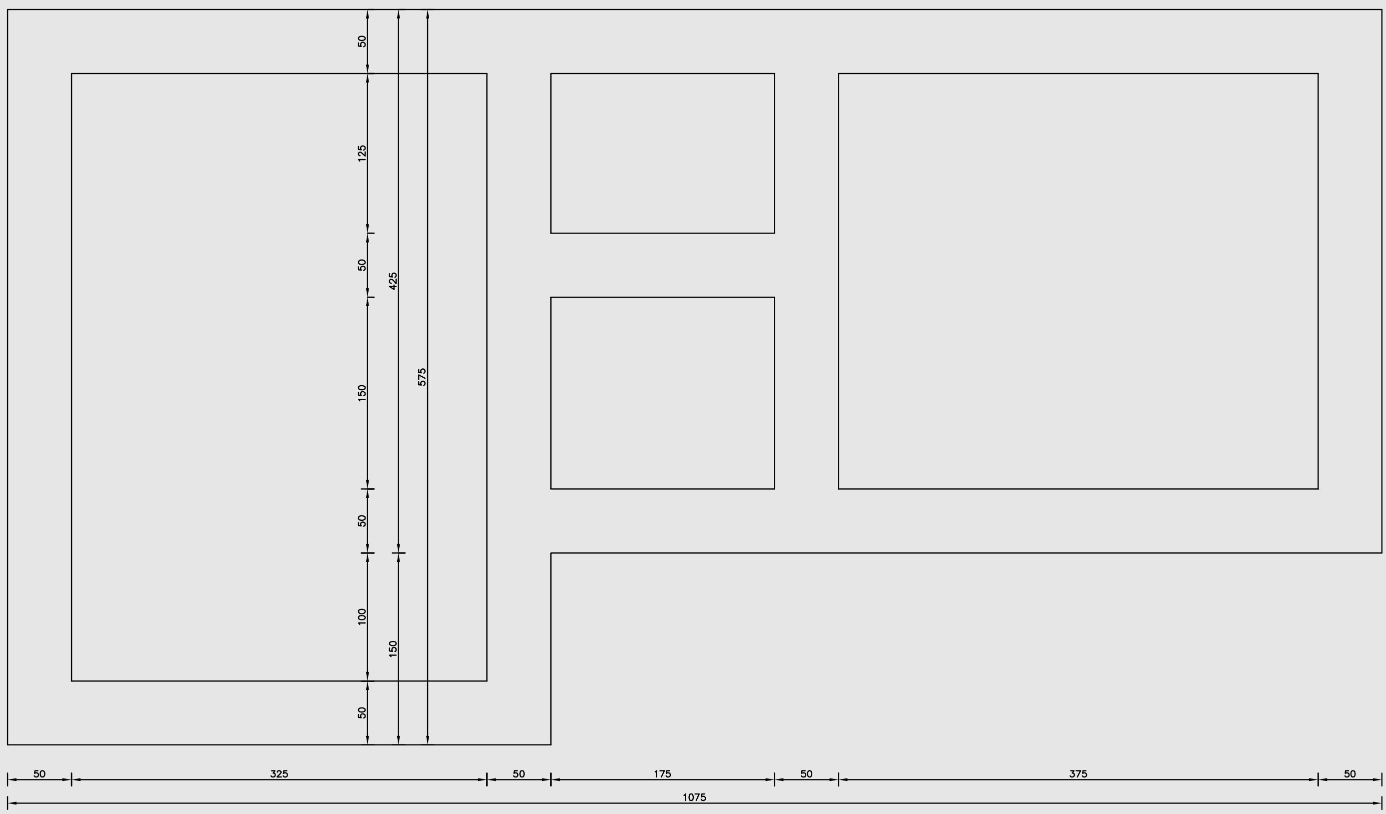


Section S2

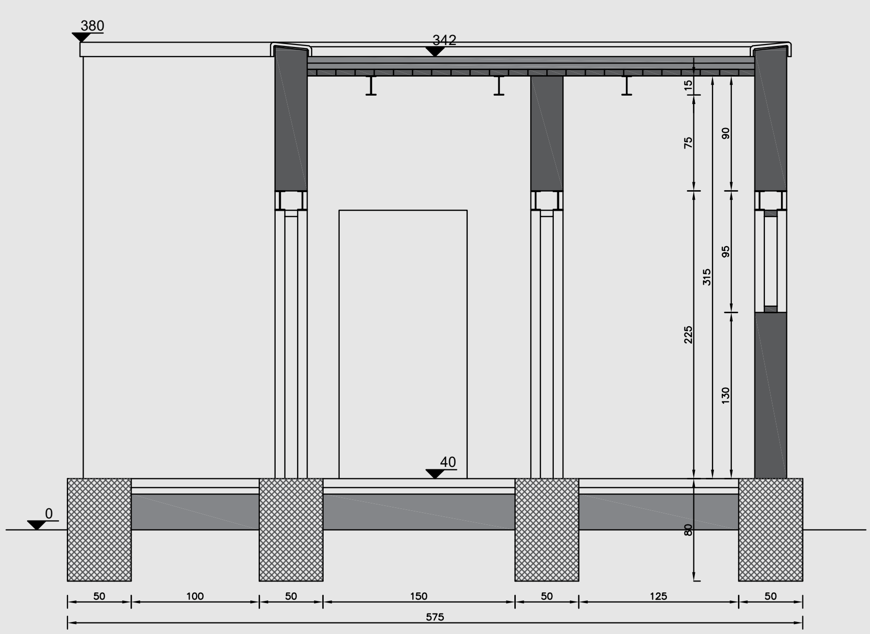
Technical drawings

All measures in cm

0 0.5 1
meters



Foundation plan

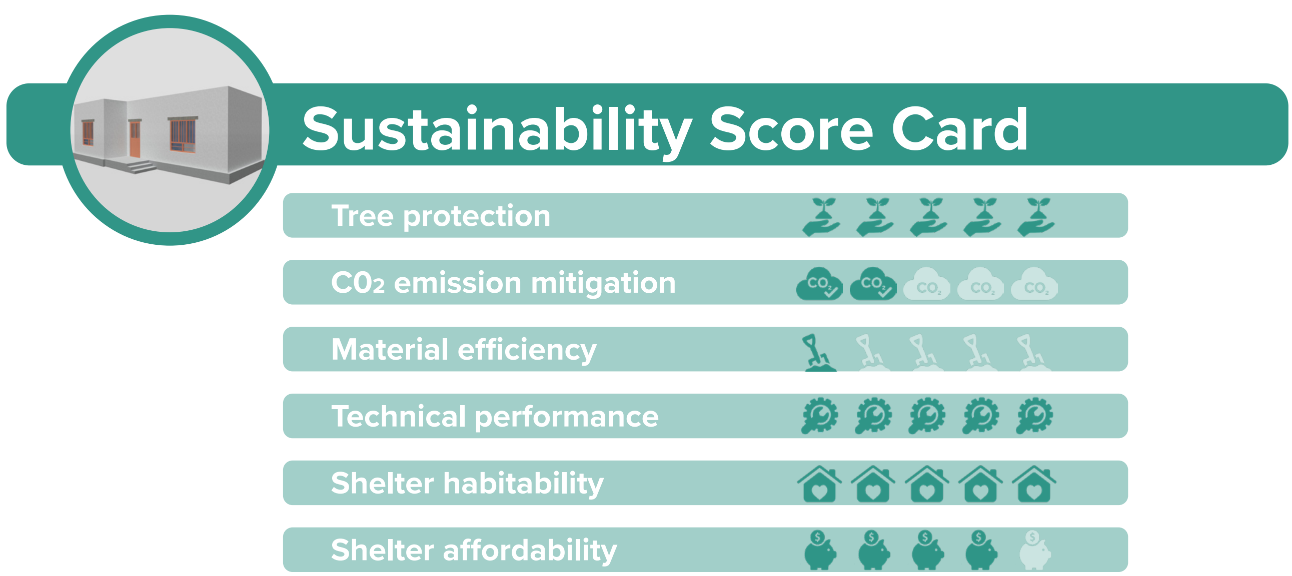


Section S3

Bill of Quantities

	Item specification	Unit	Quantity	Unit cost in USD[4*]	Total cost in USD[4*]
Fundations	Quarry stones	m^3	22	6.1	134.2
	Sand	m^3	7	5.3	37.1
	Portland cement, (50kg bag)	pieces	33	6.5	214.5
	Plastic tarpaulin, 0.12 mm thick, as dump proof course over ceiling and foundation walls	m^2	70	0.5	35
Super Structure	Burned bricks, dimensions 22x11x7 cm	pieces	11 900	0.1	1190
	Portland cement for masonry (50kg bag)	pieces	41	6.5	266.5
	Sand for masonry	m^3	11	5.3	58.3
	I-Beams, dimensions 15x7.5x0.5 cm	m length	135	1.1	148.5
	T-Iron, dimensions 5x0.5 cm	m length	578	0.3	173.4
	Burned bricks, dimensions 30x15x0.5 cm (ceiling)	pieces	1150	0.1	115
	Straw mixed with mud plaster (flat roof infill)	m^2	51	1	51
	Portland cement for plaster (50kg bag)	pieces	17	6.5	110.5
	Sand for plastering	m^3	5	5.3	26.5
	Portland cement for flooring (50kg bag)	pieces	12	6.5	78
	Sand for flooring	m^3	1	5.3	5.3
	Gravel for flooring, size 120-160 mm	m^3	2	5.2	10.4
Openings	Complete metal door, 1 x 2.1 m	pieces	3	41.6	124.8
	Complete metal door, 0.9 x 1.8 m	pieces	1	41.6	41.6
	Complete metal window, 1.5 x 1.5 m	pieces	2	36.4	72.8
	Complete metal window, 0.8 x 0.8 m	pieces	1	10.4	10.4
	Plain window glass, 4mm thick as per window design	m^2	4.1	0.4	1.64
Labour	2 unskilled worker	day	30	4.5	270
	1 skilled worker	day	30	12.5	375
					2 905.4 + 645
	Total				**3 550.4**

[4*] Prices according to the 2019 local market assessment.



Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

Variation B

Structure	load bearing walls-non reinforced masonry
Walls	cement plastered burned brick
Roof	flat roof - I section steel profiles with brick infill
Footing	50 x 80 cm quarry stone foundations
Floor	PCC flooring on compacted hard core filling
Openings	2 doors [100 x 210cm], 2 windows [150 x 150cm], 1 toilet vent [80 x 80cm]

+45ºC / +7ºC — Suggested temperature range

Workforce required for setup

30 DAYS — Time required for setup[5*]

25 YEARS — Average life span of the shelter

Environmental impacts

Raw materials used[3*]	straw	321 kg
	water[1*]	2 658 900 liters
	soil	20.3 m^3
	quarry stones	22 m^3
Manmade materials used	plastic (damp course)	14 kg
	steel (doors, profiles)	3 756 kg
	cement	5 840 kg
	sand	24.9 m^3
	gravel	3.4 m^3
	glass	41 kg
CO_2 emissions	material production	22 595 kg
	transportation	8 226 kg
	due to deforestation	0 kg/year
CO_2 absorption cease	Total	30 821 kg
CO_2 footprint	kg of CO_2 / Life span / Area	
	30 821 kg / 25 years / 40 m^2	
	= 31 kg of CO_2 / year / m^2	
Material reuse	Bricks are reusable	

Technical performance

Flood mitigation	shelter adapted to mitigate risks
Seismic resistance	withstands strong (6-6.9 Richter) events
Ventilation	meets minimum vent. requirements
Flammability	meets fire resistant criteria
Thermal comfort[*2]	mitigates extreme temperatures[2*]
Personal security	guarantees personal security
Accessibility	adaption measures necessary

Habitability

Covered area	suitable for 10 occupants (Sphere)
Privacy	provides minimum privacy
Natural light	exceeds minimum light. requirements
Artificial light	shelter equipped with artificial lightning
Shelter materials	adapted to local practices
Facilities	shelter equipped with facilities

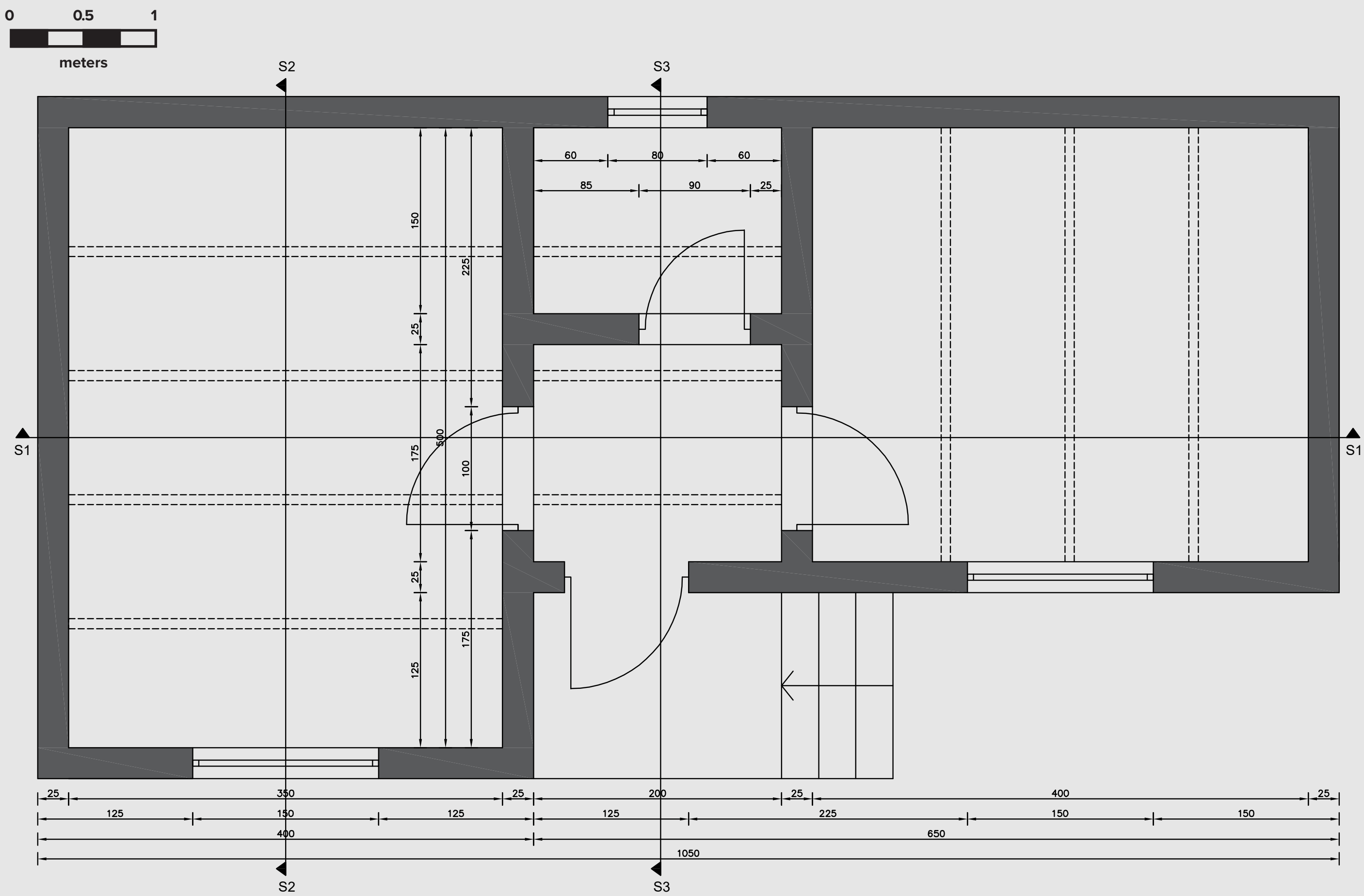
Affordability

Costs	Cost / Life span / Area
	$ **3 615.5** / 25 years / 40 m^2
	= $ 3.6/year/m^2

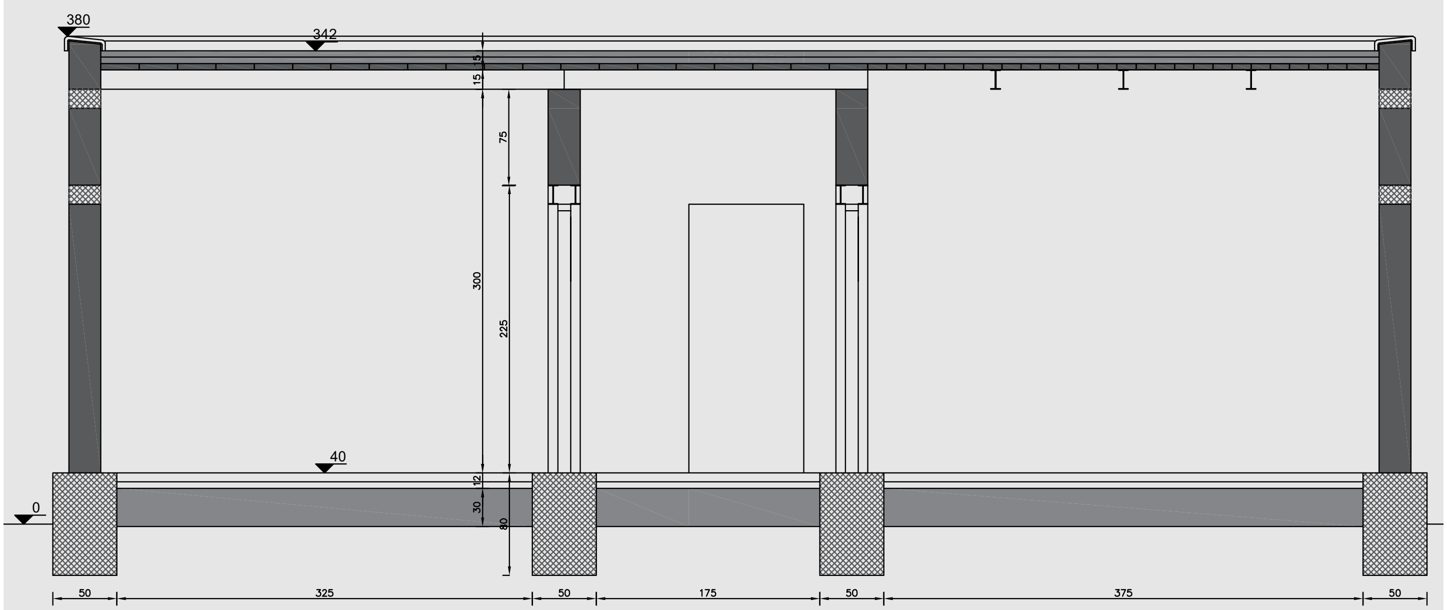
[1*] The water consumtion is calculated for all the man made materials and products used to build the shelter. The water consumed by naturally grown materials is not taken into account (e.g. trees, thatch, bamboo).
[2*] Temperatures that hover 10 degrees or more above or below the average temperature for the region.
[3*] The calculation takes into consideration the resources needed for the construction of one shelter unit. It does not reflect the resources used for the preparation and maintenance of the settlement.
[5*] The construction set up time considers the time necessary to build the shelter with all necessary building material ready to use.

Technical drawings

All measures in cm



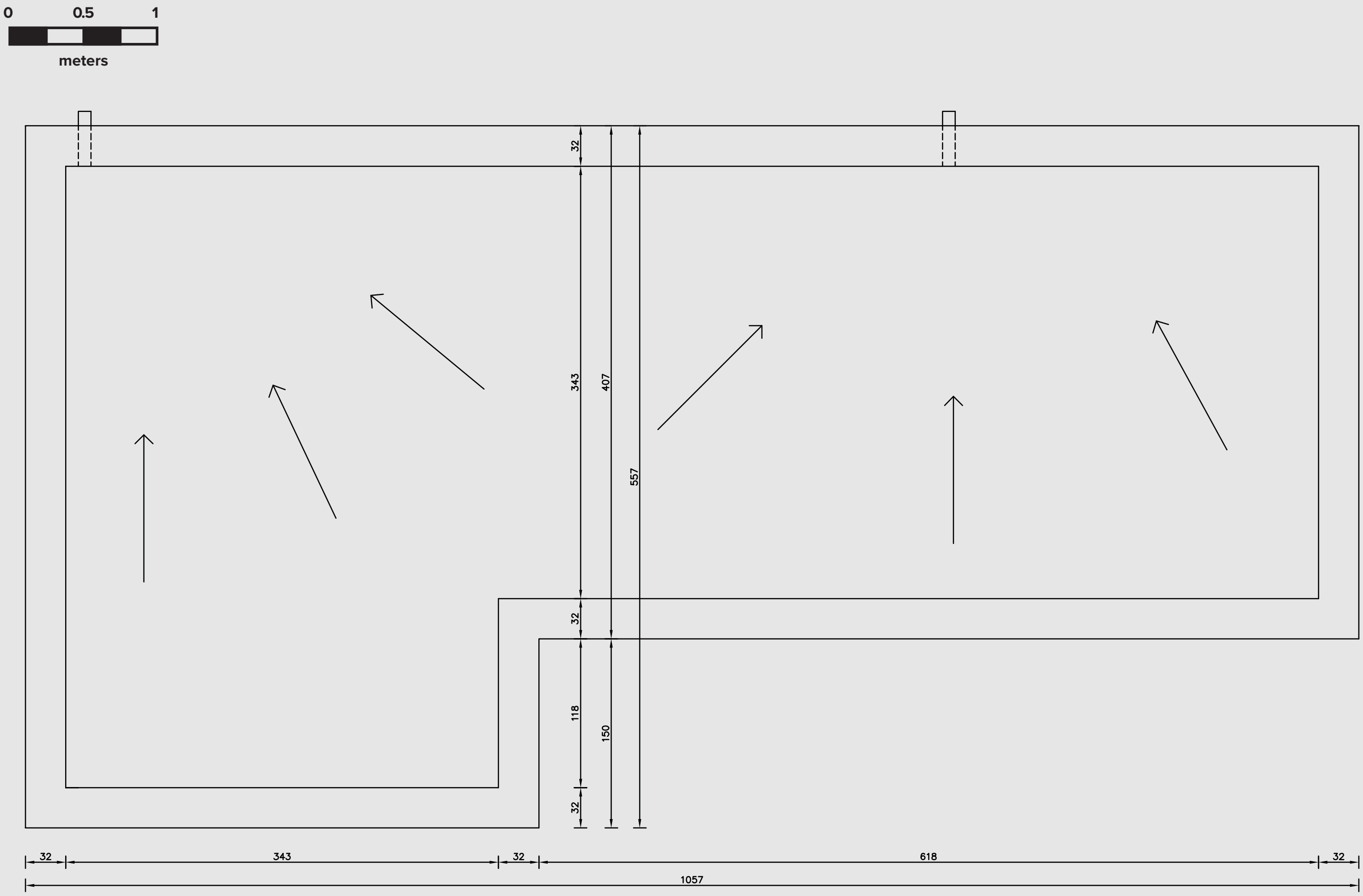
Floor plan



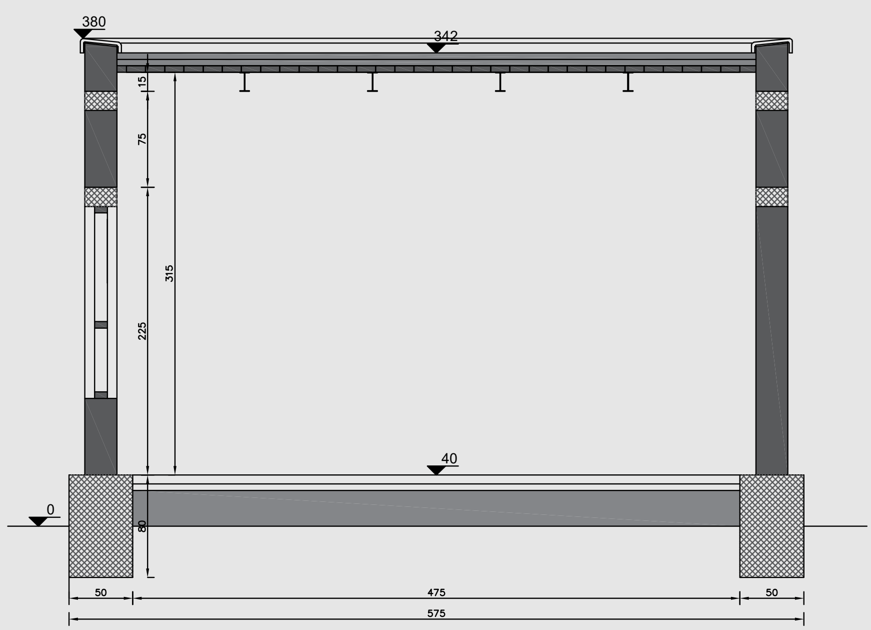
Section S1

Technical drawings

All measures in cm



Roof plan

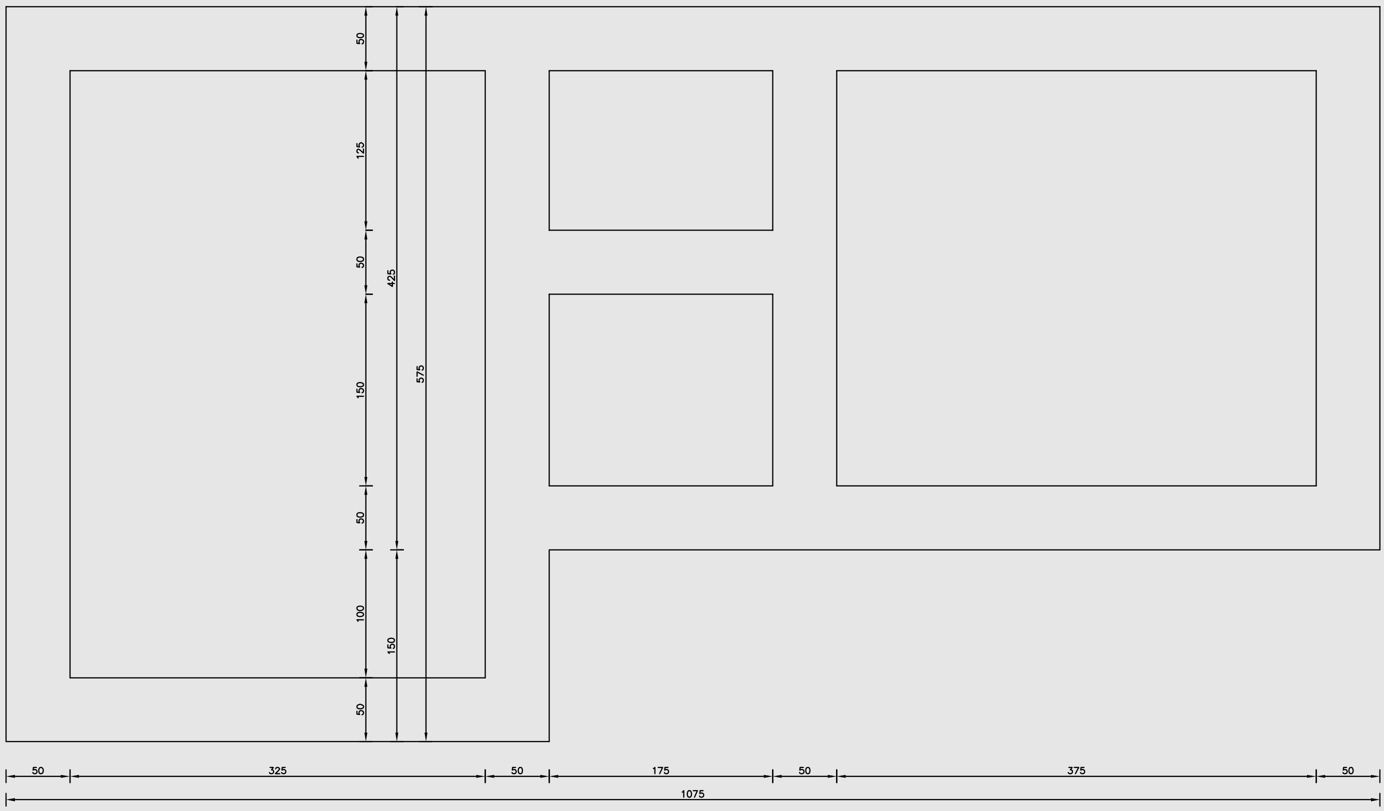


Section S2

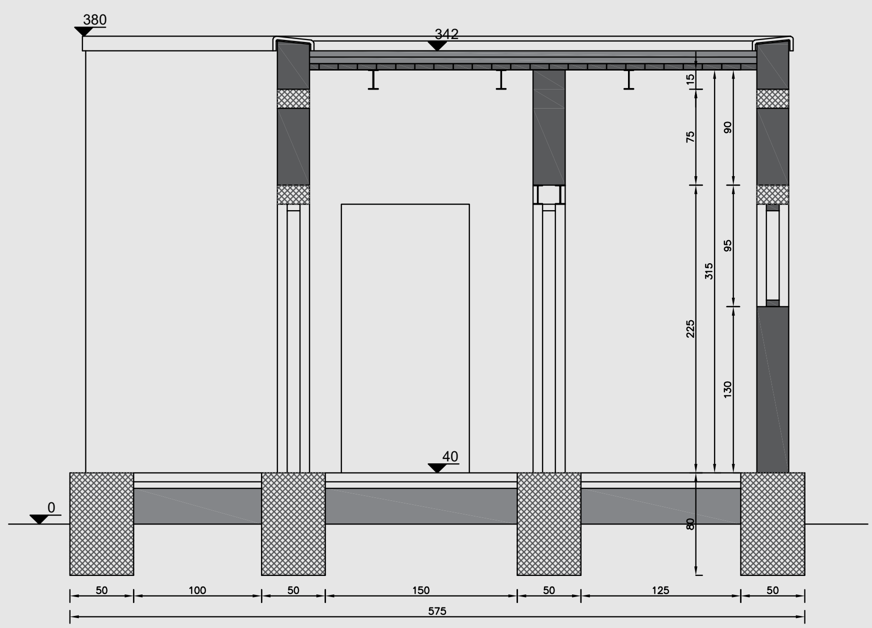
Technical drawings

All measures in cm

0 0.5 1
meters



Foundation plan



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	Portland cement for flooring (50kg bag)	pieces	12	6.5	78
	Sand for flooring	m^3	1	5.3	5.3
	Gravel for flooring, size 120-160 mm	m^3	2	5.2	10.4
	Portland cement for beam ring (50kg bag)	pieces	14	6.5	91
	Sand for flooring for beam ring	m^3	0.9	5.3	4.8
	Gravel for for beam ring	m^3	1.5	5.2	7.8
Openings	Complete metal door, 1 x 2.1 m	pieces	3	41.6	124.8
	Complete metal door, 0.9 x 1.8 m	pieces	1	41.6	41.6
	Complete metal window, 1.5 x 1.5 m	pieces	2	36.4	72.8
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					2 970.5 + 645
	Total				**3 615.5**

[4*] Prices according to the 2019 local market assessment.

Sustainability Score Card

Tree protection

C02 emission mitigation

Material efficiency

Technical performance

Shelter habitability

Shelter affordability

Score interpretation*: 1 = poor, 2 = fair, 3 = average, 4 = good, 5 = exellent
The criteria for the evaluation was established based on the overall performance of the shelters presented in this document

6. Environmental tips for shelter materials

Environmental impacts for shelter construction are typically divided into: i) embodied impacts, which are associated with the pre- and post-use phases of Life Cycle Sustainability Assessment (LCSA), when raw materials are harvested and turned into construction materials, transported to the site and assembled into the finished shelter, as well as the end-of-life impacts, and ii) use impacts, which are associated with energy consumption and other operational and maintenance impacts. Material related decisions in a construction project are not all made at one time. Different issues on material selection, sourcing, procurement, storage, use and disposal emerge at different stages of the project cycle. Life Cycle Sustainability Assessment's strength lies in the fact that it also considers what happens before and after the final shelter is used and allows for the measurement of long-term environmental impacts. The life cycle of materials and ultimately of a shelter consists of four interconnected steps: raw material extraction stage, production phase and transporting, installation/use and maintenance phase and finally end-of-life stage.

Material	Natural forest and plantation timber	Bamboo
Raw material extraction stage	• Unsustainable or inappropriate forest timber extraction can cause forest destruction, soil erosion, landslides, land degradation, habitat destruction, and can increase flood risk. • Forest management for timber production can be combined with biodiversity conservation and ecosystem services such as landslide prevention and water supplies. • In the case of timber plantations, mono culture timber plantations can cause land degradation, habitat and biodiversity loss, and hydrological problems. • Transport of woods/logs can damage forests and rural roads. • Source timber from forests where it has been logged sustainably following local approved forest management plans.	• Bamboo can be extracted from natural or farmed bamboo groves. • Uncontrolled bamboo extraction may cause habitat destruction, riverbank erosion. • Bamboo grows fast, does not need replanting and it is renewable, therefore it can be a valid substitute for timber. • Bamboo should be sourced from well managed sources which do not damage other natural areas (bamboo plantations replacing natural forests). • Employing bamboo may support local livelihoods and traditional knowledge.
Production phase and transport	• Wood is processed in timber mills. Mills may cause solid waste pollution, inefficient timber use, and noise and air pollution. • Many types of timber require treatment for pest control and to prevent moist. Using toxic chemicals for treatment causes environmental and health hazards.	• Bamboo can be used directly without any processing. However, it can be processed into high-quality products. Some of these products require energy intensive factory processes, especially if bamboo must be treated for long term use. • Bamboo treatment processes may cause air, water pollution and health hazards, as they can involve chemical treatments. Natural seasoning or non-toxic certified treatment chemicals should be used.
Installation use, maintenance phase (in humanitarian contexts)	• To avoid excessive waste and inefficient use of timber proper structural design for timber structures should be prepared and timber quantity and quality calculated according to needs. • Use timber profile that minimize off-cuts. • If timber is susceptible to insect attack it should be treated with preferably sustainable or natural surface treatments to ensure longer term durability. • Timber should be stored properly to avoid damaging and waste.	• Bamboo should be used only when sustainable harvesting is possible. • Bamboo should be treated for long-term durability. • Borax or boric acid treatment is common; though should be carried out with care and training, as both chemicals have proven health hazards. • To support local communities, bamboo should be from local industries. • Bamboo should be stored properly, to avoid damage and waste.
End-of-life stage	• Timber reuse and recycling from debris should be encouraged (e.g. door and window frames, roof members etc.)	• Bamboo reuse and recycling from debris should be encouraged

Adobe bricks	Clay/burned bricks	Wattle & daub (reinforced mud wall)
• Adobe bricks require important amounts of clayey soil. • Soil extraction may cause natural habitat and farmland destruction, pollutes water bodies, creates ponds where disease vectors can breed, alters local hydrological regime, and may cause soil erosion.	• Burned brick production requires important amounts of clay. • Clay mining may cause natural habitat and farmland destruction, pollutes water bodies, creates ponds where disease vectors can breed, alters local hydrological regime, and may cause soil erosion.	• This type of walling technique requires high/large amounts of soil. • Soil extraction can cause habitat destruction, landslides, erosion, fouling of water bodies and hydrological alteration. It creates ponds and extraction holes where disease vectors can breed. • -For the construction of walls, a wooden or bamboo framework/ structure is needed which put pressure on timber/bamboo resources and may cause uncontrolled
• No air pollution is produced during the production/ installation phase, as the bricks are sun dried. • The earth excavation and production occur in-situ or near the construction site, diminishing in this way transportation needs. • The production site requires a lot of space for drying and excavation purposes. • Brick-manufacturing is an intensive water-consuming industry that requires a sustainable and integrated water management strategy to reduce reliance on freshwater consumption.	• Burned bricks are manufactured in wood or coal fired kilns in most of the fields. Burning coal and wood releases high amounts of C02 - kilns cause severe air pollution. • Firewood demands threaten forests and can cause deforestation and erosion. • Additionally, transportation may contribute to C02 release and air pollution. • To minimize pollution during brick production improved technology in kilns should be promoted.	• The walls are built on the spot; transportation needs are therefore reduced. • This type of walling solutions does not cause air pollution and do not require energy resources or quarried materials; however, it requires water. • The technique should only be used in areas where soil can be extracted without causing hazards or environmental impacts and should be accompanied by strategies for the reestablishment of the area of soil extraction, to prevent accidents and water accumulation (vector control) in the excavation areas.
• Adobe brick structures are not suitable in wet areas without proper protection from the rain and flood mitigation strategies in flood prone areas.	• To minimize pollution during the construction phase, standard lengths and optimal wall thicknesses should be used. • Good loading practices during transport should be adapted to avoid losses.	
• Possible uses of down-cycled clay construction material: filling and stabilizing material for roads and aggregates for concrete or mortar.	• If a brick structure is decommissioned the reuse or down-cycling of bricks should be encouraged.	• A decommissioned mud wall can be used to form substrates for growing plants.

Material	Corrugated galvanized iron	Plastic sheets	Thatching material
Raw material extraction stage	• CGI sheets are sheets of hot-dip galvanized mild steel, cold-rolled to produce a linear corrugated pattern. • Manufacturing processes require large quantities of steel, zinc and other metals and cause social and environmental impacts due to mining.	• Crude oil is the main raw material used for production of polyethylene products. • Using recycled polyethylene reduces dependence on petroleum needs as raw material.	• Thatching material is harvested from natural or farmed vegetation: palm leaves, reed, grasses. • Harvesting may destruct natural habitats and cause erosion.
Production phase and transport	• CGI sheets are protected from corrosion by a zinc coating (or galvanized) applied to the steel sheet and are manufactured using energy and water intensive processes, often with carbon emissions from fossil fuel energy sources. • Manufacturing plants cause severe air and water pollution by releasing toxic heavy metals into the environment. • Large quantities of water are used in steel production, with losses mostly attributable to evaporation during cooling.	• The production processes are energy intensive especially because the transformation of PE into fibers involves extremely hot processes which release toxic chemicals and require important amounts of energy and water. • The vast majority of PE products are produced in Asia, therefore the transportation impacts of worldwide export of these products in terms of Co2 emissions, but also direct pollution especially linked to sea and air freight transportation.	• Thatching material is harvested and processed on a household or small-scale industrial scale. • Its processing may cause water pollution if not properly managed. • Thatching does not require additional materials, nor energy sources for its processing. • Thatching techniques can support community led and traditional livelihood opportunities and be part of sound grassland management.
Installation use, maintenance phase (in humanitarian contexts)	• CGI sheets should not be used in corrosive environments. • The quantity of the sheets should be carefully measured, avoiding unnecessary waste.		• Only thatching material that can be obtained locally and without environmental damage should be used. • As the material needs to be seasoned, thatch cannot be accessible all year round. • Thatch should be treated for longer-term durability of the products.
End-of-life stage	• Reuse of un-corroded sheets from old buildings should be encouraged • The sheets should be stored in a dry place in suitable stack heights to avoid damage and never disposed in a natural environment.	• Polyethylene is not biodegradable, once disposed it can stay in landfills for centuries, therefore the reuse and recycling of old sheets is recommended. • Special care should be taken when disposing – in well managed landfill sites.	

Cement/Concrete	Cement blocks	Quarried materials (sand, rock chips, gravel)
• Cement is manufactured using limestone and other minerals extracted from quarries or mines. Its extraction can cause severe social and environmental impacts due to mining. • Extraction of limestone can cause alteration in pH value / alkalinity of soil, impacting hydro-geology and livelihoods of the host community. • In the case where cement is used to mix concrete, mortar or plaster other materials are associated with its use: quarried material and water.	• Cement blocks require cement, quarried and mined material (sand, rock chips, gravel).	• The extraction of quarried materials involves blasting, which causes noise, dust, air pollution, habitat destruction. • Informally managed rock quarrying can cause landslides and hydro-geological impacts. • Quarried material extraction may cause natural habitat and farmland destruction, it pollutes water bodies, creates ponds where disease vectors can breed, alters local hydrological regime, and may cause soil erosion.
• The production of cement occurs on a huge scale, and the resulting byproducts have large effects on the environment. Approximately 5% of global CO2 emissions originate from the manufacturing of cement. • Cement production requires large quantities of raw materials and energy. The main component of cement is called clinker, the production of which is very resource intensive. • Cement production has high energy requirement which results in carbon emissions if fossil fuels are used and causes severe air pollution and dust. • The cement manufacturing process produces millions of tons of the waste product cement kiln dust each year contributing to respiratory and pollution health risks.	• Cement blocks are manufactured using powered or manually operated pressure molds. • Casting areas can cause dust, noise and silt problems and require a lot of space for drying. • Important quantities of water are needed and released into the ground if the process is poorly managed.	• After extraction quarried material usually needs further processing to uniform the aggregate size. The material is crushed and uniformed in specific plants which cause noise, air pollution, and silting/ polluting of water bodies. • Transport affects local roads.
• To minimize waste during construction, the use of prefabricated concrete items and premixed concrete is advised instead of in-situ mixing and the use of optimum concrete mix/ratios. • Cement should be stored in a dry place in suitable stack heights to avoid damage as well as degradation and never disposed in a natural environment. • Concrete structures have generally low maintenance needs and longer life spans and offer exceptional levels of protection and safety in case of fire.	• Use and transport of cement may have hazardous impact on environment.	
• Reuse or rehabilitation of cement-based elements and structures should always be considered.	• Old blocks can be crushed, and used for filler in Portland cement.	

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The Shelter and Sustainability Overview has been developed by UNHCR's Division of Resilience and Solutions, Technical Support Section.

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