REPORT
Chad environmental impact study of the emergency shelter models

May 2022

croix-rouge luxembourgeoise
Mënschen hëllefen

LUXEMBOURG AID & DEVELOPMENT

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1. Definitions

Carbon neutral means that any greenhouse gases (including but not limited to carbon dioxide) that are released into the atmosphere are balanced by an equivalent amount of greenhouse gases being removed.

Carbon offsetting a way to reduce emissions and to pursue carbon neutrality is to offset emissions made in one sector by reducing them somewhere else.[1]

Carbon positive means that an activity goes beyond achieving zero carbon emissions to create an environmental benefit by removing additional carbon dioxide from the atmosphere[2]

Carbon footprint is a term commonly used which refers to the total greenhouse gas emissions caused by an individual, event, organization, service, place or product, expressed as carbon dioxide equivalent (CO_2 equivalent)[3].

The Climate Risk Index (CRI) indicates a level of exposure and vulnerability to extreme events, which countries should understand as warnings in order to be prepared for more frequent and/or more severe events in the future.

Climate change is a long-term shift in global or regional weather patterns. Usually, the term climate change refers specifically to the increase in global temperatures from the mid-20th century to the present[4].

CO_2 equivalent A carbon dioxide equivalent or CO_2 equivalent (a.k.a. CO_2 eq) is a metric measure used to compare the emissions from various greenhouse gases (GHGs) on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same GWP[5].

Decompose is the process by which dead organic substances are broken down into simpler organic or inorganic matter such as carbon dioxide, water, simple sugars and mineral salts.[6]

Embodied carbon comes from the embodied energy consumed to extract, refine, process, transport and fabricate a material or product (including buildings). It is often measured from cradle to (factory) gate, cradle to site (of use), or cradle to grave (end of life). The embodied carbon footprint is therefore the amount of carbon (CO_2 or CO_2 emissions) which is generated in order to produce a material[7].

Environment refers to the physical, chemical, and biological surroundings in which communities live and develop their livelihoods. It provides the natural resources that sustain individuals and determines the quality of the surroundings in which they live[8].

Environmental Impact is defined as any change to the environment, whether adverse or beneficial[9], caused by a project, a process, an organism(s) and a product(s), from its conception to its end of life.

Environmental Performance Index (EPI) is a method of quantifying and numerically marking the environmental performance of a state's policies[10].

Environmental sustainability: A state in which the demands placed on the environment can be met without reducing its capacity to allow all people to live well, now and in the future. While environmental sustainability is broader than climate action, limiting climate and environmental impacts can both contribute to mitigating climate change, for instance by reducing emissions and greening practices, and to strengthening people's resilience to climate change[11].

1 *European Parliament*
2 *Fast Company*
3 *Carbon Trust*
4 *National Geographic*
5 *Energy Manager Canada*
6 *Lynch, Michael D. J.; Neufeld, Josh D. (2015). "Ecology and exploration of the rare biosphere"*
7 *Circular Ecology*
8 *NSW Government*
9 *University of Calgary*
10 *Yale Center for Environmental Law & Policy, and Center for International Earth Science Information Network at Columbia University.*
11 *IFRC*

Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gas effect. Global warming is often described as the most recent example of climate change[12].

Greenhouse gas effect a natural phenomenon that causes a rise in the surface temperature of our planet.

IDP (Internally Displaced person) is someone who is forced to leave their home but who remains within their country's borders.[13]

Life cycle refers to the consecutive and interlinked stages of a product or service, from raw material acquisition or generation from natural resource, to design, production, transportation / delivery, use, end-of-life treatment and final disposal[14].

Life cycle assessment (LCA) is a method of evaluating the environmental impact associated with all stages of a product's life, i.e., from the extraction of raw materials, through materials processing, manufacturing, distribution, use, repair and maintenance, to disposal or recycling.

Waste any residue from a production, transformation or use process, any substance, material, product or, more generally, any movable asset disposed of or intended for disposal by its holder[15].

Waste management A set of operations involving the sorting, pre-collection, collection, transport, storage, recycling and disposal of waste, including the monitoring of disposal sites.

12 *NASA*
13 *UNHC*
14 *ISO*
15 *https://assembly.coe.int*

2. General information

Project/mission title: Chad environmental impact study of the emergency shelter models

Country: Chad

Report date: May 2022

Type of operation: Remote consultancy

Requesting Organization: International Aid of the Luxembourg Red Cross

3. Context

The Aide Internationale de la Croix-Rouge luxembourgeoise (AICRL) has been working for several years in the field of emergency shelter and sustainable housing in the Sahel region. AICRL collaborates closely with the IFRC Shelter Research Unit (IFRC-SRU) in the development of shelter models adapted to the climatic conditions and cultural contexts of the Sahel.

Numerous research missions have made it possible to develop shelter models that take into account the specificities of the contexts and the availability of materials at the local level. In the particular case of Chad, the AICRL and the Chadian Red Cross have developed two shelter models. The first model of shelter built in Chad is the Sahel Shelter type developed by AICRL in Niger and Burkina Faso. This emergency shelter was built in southern Chad in 2018 in a refugee camp (Belom camp, Maro department). A second shelter model, Moundou Shelter, has been tested in 2021 as part of the implementation of their emergency projects in the Lac province (Ngouboua Koura and Djourou Kapi) and is based on the traditional architecture of the intervention area.

This experience gained in the field and the feedback collected from targeted populations has helped to evolve the shelter models designed by AICRL and adopted by all humanitarian actors in the different countries of the Sahel. However, one key factor has not been analysed in detail: the comparative environmental impact of the shelter models. This is necessary in order to understand which option is best adapted to the local context, and is in line with the current global trend to improve the environmental sustainability of humanitarian assistance.

The change in weather patterns caused by global warming has happened faster over the past century. Natural disasters, such as floods, droughts, desertification, fires, etc., are increasing due to climate change, and they are contributing to food insecurity, economic losses, population displacements, and are also conflict drivers. People all over the world are facing the reality of climate change, and in many parts of the world this manifest as increased volatility of extreme weather events. Only between 2000 and 2019, over 475 000 people lost their lives worldwide[16] due to them. The 2021 edition of the Climate Risk Index clearly shows that signs of escalating climate change can no longer be ignored, on any continent or in any region. Impacts from extreme-weather events hit the poorest countries hardest as these are particularly vulnerable to the damaging effects of hazards, have a lower coping capacity and may need more time to rebuild and recover[17]. Africa is already one of the continents most affected by climate change, even if is responsible for only 4% of the world's greenhouse gas emissions. The frequency of heavy rainfall and storms has tripled in the Sahel since the 1980s[18]. The area of the Sahel desert has increased by 10% in the last 100 years[19].

Chad is one of the countries at risk from further climate change. Of 186 countries assessed in a 2016 survey of climate vulnerability[20], it was rated the most affected country in the world. The country which suffers numerous humanitarian needs due to its low development, very limited access to basic social services, and its environmental degradation, is

16 *Global Climate Risk Index 2021*
17 *Global Climate Risk Index 2021*
18 *World Meteorological Organization*
19 *University of Maryland*
20 *Climate Change Vulnerability Index*

also exposed to recurring interlinked humanitarian crises; forced displacement due to the regional conflicts (Chad hosts one of the largest number of refugees in the region, putting additional pressure on Chad's already limited resources[21]), food and nutrition insecurity, environmental degradation, such a rapid desertification, natural hazards such a floods and droughts, and epidemics.[22] A combination of all these factors makes the central African nation to be among the most affected by climate change.

Good environmental practices from humanitarian agencies can help protect the local environment, contribute to improve the resilience of communities to natural disasters, and reduce their vulnerability, as well as reduce the contribution made to further climate change. However, in the past a lack of consideration for the environment has led to humanitarian responses having a negative impact on the environment. For instance, huge quantities of relief items have been brought into a country, local natural resources have been overused, and large amounts of unmanaged waste generated, without considering the consequences for the environment. Humanitarian agencies should not contribute to the degradation of the natural resources that affected communities rely on, and should take steps to mitigate climate change. The concept of 'do no harm' should also be extended to the environment. This comparative study of the environment impact of the Sahel Shelter models implemented in Chad is a contribution to the growing body of work on the environmental impact of humanitarian assistance.

4. Outcome and Outputs[23]

Outcome
With the support of the IFRC-SRU, AI-CRL seeks to improve the quality of the shelter response in Chad, and minimise the environmental impact of its operations.

Outputs
- A comparative study of different shelter models in Chad. This individual study is part of a comparative study in four countries in the region (Chad, Burkina Faso, Niger and Mali)
- Recommendations for reducing the environmental impact of AICRL shelter interventions

The scope of this study is limited to the comparative environmental impact of the two shelter models. It does not include aspects relating to the preparation, construction and maintenance of the sites where the shelters were constructed, nor does it include factors relating to cost, functionality, and satisfaction of targeted populations etc.

5. Methodology

This study was conducted remotely, with the support of AICRL field staff (shelter, logistics, other); the Shelter and Non-Food Item Working Group in Chad; environmental experts from the shelter sector; a local organisation working on support to rural development on the environmental initiatives that exist in Chad ; and some international organisations working in Chad[24].

The methodology adopted is summarised by the graphic below.

21 *WFP*
22 *ECHO*
23 *As included in the Terms of Reference for this study.*
24 *Refer to Annex 2 to see the list of people and organisations contacted.*

Desk research and problem definition

- Literature review: programme documentation (including logistics/supply chain); environmental profile of Chad, etc. *(Refer to bibliography).*
- Review of emerging best practice in life-cycle analysis / carbon footprinting tools for the Shelter sector.

Data collection

- Key informant interviews (semi-structured): Refer to Annex 2 to see the list of people and organisations contacted.
- A rapid field assessment of shelters was considered, but was not seen as necessary after reviewing the documentation and interviewing the project team.

Review SMAC tool

- Review the SMAC, a new carbon footprint calculation tool for the shelter sector.
- This study is one of the first to use the SMAC, and feedback has been shared with the developers of the tool to improve it.
- Extended engagement with the focal point for the Shelter Cluster Environmental Community of Practice, regarding using the SMAC.

Set Criteria

- Set criteria to compare the environmental impact of the shelter models:
  - (1) Materials consumed
  - (2) Carbon emissions (using the SMAC tool)
  - (3) Impact on local natural resources
  - (4) Waste management
- Score Card Approach

Analysis

- Comparison of the environmental impact of the two shelter models according to the four criteria, analysing each material across its lifecycle from production to disposal.
- Overall (qualitative) comparison using a score card approach

Report writing, conclusions and recommendations

6. Background information

6.1. Country profile

CHAD

Location

Chad is a large landlocked country spanning north-central Africa. It covers an area of 1,284,000 Km^2. The country is named after the wetlands of Lake Chad, which are the second largest wetlands in Africa.

Geography

It is bordered by Libya to the north, Sudan to the east, the Central African Republic to the south, Cameroon to the south-west, Nigeria to the southwest (at Lake Chad), and Niger to the west.

Population

Chad has a population of 16 million, of which 1.6 million live in the capital and largest city N'Djamena.

Income

A low-income country with limited income-generating opportunities, and restricted access to social services. 42 percent of its population live below the poverty line, it is ranked 187th out of 189 countries in the United Nations 2020 Human Development Index[25].

Political situation[26]

Chad is facing interconnected humanitarian crises in a context of chronic poverty and limited development. The security situation in neighbouring countries is still contributing to the sporadic movement of people to Chad, particularly to the southern part of the country for people coming from the Central African Republic, to the eastern part of the country for people coming from Sudan, and internal displacements in Lac province in the western part of the country. In this context, it is estimated that close to 5.5 million people in the country require humanitarian assistance, roughly 33% of the population in 2021[27]. Moreover, malnutrition continues to grow as a result of the harmful effects of the COVID 19 pandemic, which is contributing to a worsening of the malnutrition situation and is leading to health problems.

Climate[28]

Chad has three distinct weather zones; a desert zone in the north, an arid Sahelian belt in the centre, and a more fertile Sudanian Savanna in the south.

The summer rains, which are brought by the African monsoon, are only present in the centre-south of the country, from June to September, and they are more pronounced as you travel further south. There is a southern rainy season from May to October. There is very little rain in the north all year long. It is often windy and cooler in the evenings during the dry season. The dry season, which lasts from December to February everywhere in the country, is relatively cool, with daytime temperatures in the upper 20s to mid30s degrees, and night time temperatures that drop to -10 degrees. From March onward it becomes very hot until the first heavy rains fall.

Natural disasters[29]

Chad is also prone to natural disasters such as droughts, floods, and locust infestations, all of which contribute to chronic food insecurity, conflict and population displacement.

25 *WFP*
26 *Oxfam*
27 *OCHA*
28 *IPS International*
29 *Intern-Agency Standing Committee Tchad*

6.2. Environmental Challenges in Chad

Environmental Challenges

Climate change

Chad is one of the countries in the world most affected by climate change. It is ranked 172 out of 180 countries in terms of environmental performance.[30] In 2016, of 186 countries assessed in the Climate Change Vulnerability Index (CCVI)[31] Chad was rated the nation most at risk of effects of climate change.

Increasing Temperature

Temperatures in the Sahel rise 1.5 times faster than the global average. The Sahel is expected to warm by 3°C to 5°C by 2050. This unparalleled warming has implications for the environment, human health, and livelihood dynamics[32]. Chad is among the Sahel countries most likely to have fatal extreme heat on its warmest days, limiting the region's habitability and survivability.[33] The temperatures are extreme during the dry season in the North.[34]

Floods

Floods are a recurring natural hazard in Chad that are likely to become worse with climate change.[35] In 2020 rainy season was marked by record rainfall in most of Chad and across the Sahel. Floods affected 20 out of 23 provinces and 388,000 people, mainly in the central, eastern and southern provinces.[36]

Droughts

Chad is part of the sahelo-sahariane band which is periodically affected by an endemic drought cycle.[37] One of the primary causes of droughts in the Sahel is temperature rise, in addition to land degradation and dust feedbacks. Droughts, in turn, have contributed to fire frequency and biodiversity loss.[38]

Desertification

Declining productivity and soil structure in the Sahelian zones of Chad is exacerbated by unpredictable rainfall and drought, resulting in extreme degradation and desertification. Chad is currently experiencing the greatest vulnerability to desertification, with 58 % of the area already classified as desert, and 30 % classified as highly or extremely vulnerable[39]. The Sahara Desert, which covers one-thirds of the country, is expanding at a rate of 10% since 1920[40]. In Chad, the desert is advancing at 3 km per year.[41]

Shrinkage of Lake Chad

The surface area of the lake Chad has been reduced from 25,000 km² in 1963 to 1,300 km² today. The lake is shared by Cameroon, Chad, Niger and Nigeria; its basin, which extends as far Algeria, Libya, and Sudan, offers a lifeline to nearly 40 million people[42]. There is no single cause for the drastic

30 *According to the Environmental Performance Index (EPI) of Yale University*
31 *The CCVI analyses 42 social, economic and environmental factors to determine national-level vulnerabilities. Factors evaluated include agricultural dependency, adaptive capacity of the government, and exposure to natural disasters (Climate-ADAPT, 2010).*
32 *Climate Change, Food Security and migration in Chad: A Complex Nexus. American University, IOM Chad and the Chad Food Security Cluster*
33 *Climate Change, Food Security and migration in Chad: A Complex Nexus. American University, IOM Chad and the Chad Food Security Cluster*
34 *Log Cluster https://dlca.logcluster.org/display/public/DLCA/1.1+Chad+Humanitarian+Background*
35 *Climate Change Knowledge Portal*
36 *Climate Change, Food Security and migration in Chad: A Complex Nexus. American University, IOM Chad and the Chad Food Security Cluster*
37 *Log Cluster https://dlca.logcluster.org/display/public/DLCA/1.1+Chad+Humanitarian+Background*
38 *Climate Change, Food Security and migration in Chad: A Complex Nexus. American University, IOM Chad and the Chad Food Security Cluster*
39 *Combating Desertification in Asia, Africa and the Middle East. Hakim Djibril. 2013*
40 *University of Maryland*
41 *PNUD*
42 *UNEP*

shrinkage of Lake Chad: natural fluctuations as part of a long-term cycle, overuse of the water for irrigation, extended drought, deforestation and the impacts of climate change, have all been cited.

Deforestation

The deforestation rate on natural forest resources is approximately 2.5% ha/year (SIDRAT, 2013) [43] From 2000 to 2020, Chad lost 2,220,000 ha of tree cover.[44]

Soil degradation

Around 428,000 km² or 33.43% of the total area of Chad is subject to strong soil degradation. This is due to: overgrazing, wind erosion, water erosion, deforestation and oil exploitation.[45]

Wind erosion

Wind erosion is responsible for silting up and therefore soil infertility throughout the country in general and in the Sahelian and Saharan zone in particular, due to insufficient plant cover (41,777,100 ha).[46]

Soil and Water pollution

Improper waste disposal in rural areas and poor farming practices contribute to soil and water pollution.[47]

Solid waste

The system of waste collection, storage, treatment and disposal is not well functioning. The municipal solid waste generated annually is 1,358,851 tons (2010 est.)[48]

Air Pollution

The air quality in Chad is considered unsafe. The data indicates the country's annual average concentration of $PM_{2.5}$ is 53.01 µg/m^3 [49] which exceeds the recommended maximum of 10 µg/m^3 according to the WHO[50]. Air pollution is the 3rd leading risk factor for premature death, accounting for nearly 10% of deaths, more than 14,000 people in Chad in 2017 alone[51].
Contributors to poor air quality in Chad include the oil, textile, and meatpacking industries, vehicle emissions, waste burning[52] and indoor air pollution from households cooking on open fires.

43 *Evaluation des ressources forestierese mondiales 2020. Rapport Tchad. FAO*
44 *Data from FAO. 2020. Global Forest Resources Assessment 2020: Main report. Rome.https://doi.org/10.4060/ca9825en*
45 *Rapport pays sur la Neutralité de la Dégradation des Terres. UNCCD*
46 *Rapport pays sur la Neutralité de la Dégradation des Terres. UNCCD*
47 *CIA*
48 *CIA*
49 *CIA*
50 *IAMAT*
51 *State of Global Air 2019*
52 *IAMAT*

6.3. Chad Shelter models

SAHEL SHELTER

The Sahel Type is designed as an emergency to transitional shelter solution, adapted to the Sahel region of the western Africa. Built in southern Chad in a refugee camp (Belom camp, Maro department).[53]

Total area
21 m²

Occupancy
6 persons

Construction time
48 hours

Cost
200 euros

Durability
12 to 24 months

Total # Built
505

Dimensions
6.50m x 3.50m

Depth of excavation
Depending on the soil context, with a minimum of 25cm depth to a maximum of 40cm for each pillar.

Structure (wall/roof)
The roof geometry is a dome shape created using arches fixed above the column heads. 12 steel tube columns with a minimum section of 30x30mm, e=2 mm.
Additional use of triangulations in the walls to complete the structural system. The material used is semi-rigid PVC with d=32mm and e=2m.

Cladding walls
The walls are made of 14 woven mats of 1x2m from the doum palm tree, directly sewn to the shelter structure.

Roof covering
The inner layer consists of 14 doum palm mats of 1x2m, sewn together, which cover the entire dome structure. The second layer consists of 2 ICRC plastic sheeting of 4x6m.

Openings
The doors are made of 2 plastic mats sewn together

53 *Please refer to Annex 3 to see the graphics of the shelter.*

Moundou Shelter

This emergency shelter was developed as a basic emergency contextual shelter solution adapted to the Lake Province of Chad (Ngouboua Koura and Djourou Kapi).[54]

Total area
17.65m

Occupancy
5 persons

Construction time
72 hours

Cost
258 euros

Durability
6 to 12 months

Total # Built
1261

To Build
348

Dimensions
4.90m x 3.60m.

Depth of excavation
The depth of the excavation will be according to the soil context, with a minimum depth of 25 cm for each pillar.

Structure (wall/roof)
There are twelve wooden posts consisting of 4 posts of 2.7 m fixed to the central axis and 8 posts of 2.2 m fixed to the ends.
The geometry of the roof is a dome shape created by arches attached to the heads of the posts. The material used is date palm stems (branches) of a varying dimension depending on the season (d = 25-32 mm and e = 2.5 m). The columns are also interconnected transversally by the date palm stems.

Cladding walls
The walls are made of a layer of around 80 branches of 80-85 stems of local straw (common reed), and 1 doum palm woven mat of 1x2m sewn directly onto the shelter structure.

Roof covering
The inner layer consists of 14 doum palm mats of 1x2m, sewn together, which cover the entire dome structure. The second layer consists of 2 ICRC plastic sheeting of 4x6m.

Openings
The door is made of date palm stems sewn together and attached to one side of the poles. The width of the door is 0.90 m and the height varies according to the families.

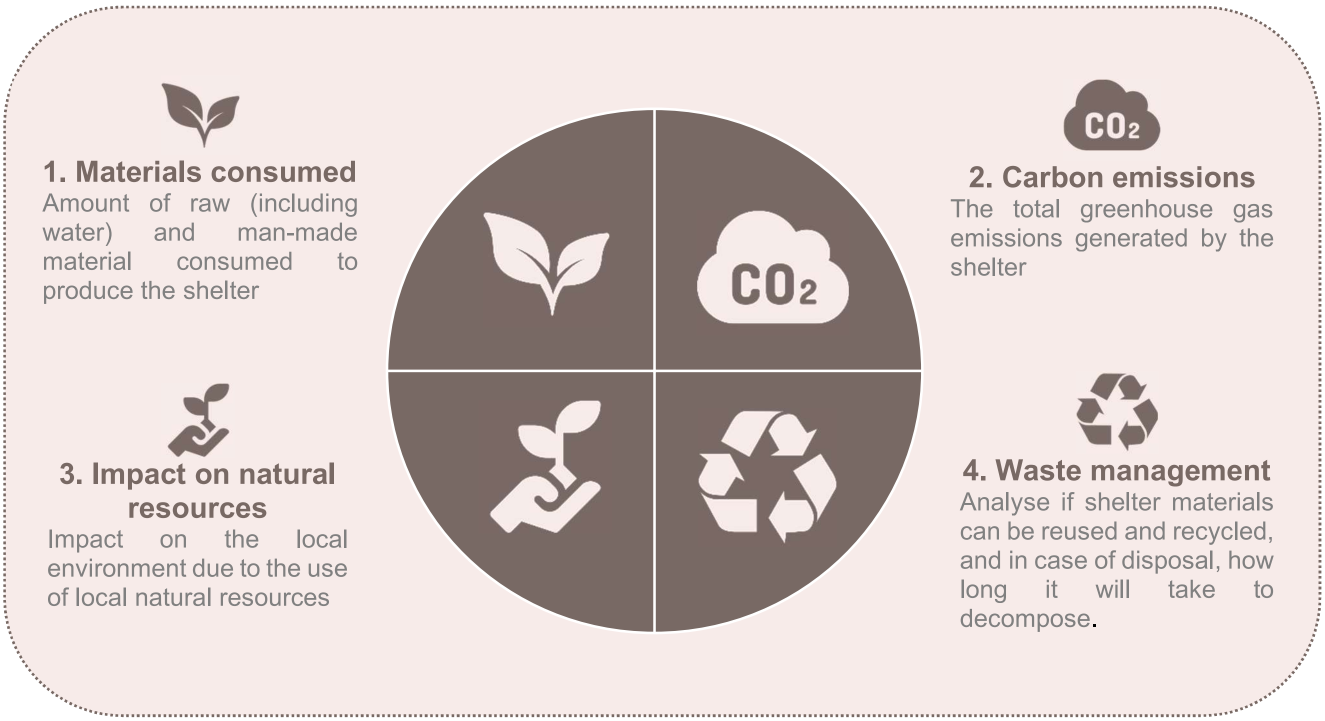
54 *Please refer to Annex 3 to see the graphics of the shelter.*

7. Criteria used to analyse environmental impact

To do a comparative study of the environmental impact of the two shelter models, each material must be analysed across its lifecycle, from production to end of life and disposal. The following criteria were selected to structure this analysis:

1. Materials consumed
2. Carbon emissions
3. Impact on local natural resources
4. Waste management

Each of these is explained in detail below.



7.1. Criteria 1: Materials consumed

The consumption of materials 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, construction and maintenance of the sites where the shelters were constructed. This includes two main groups of materials:

- Natural materials used (in kilograms or litres): any naturally sourced product or physical matter (water, timber, etc.).
- Man-made materials (in kilograms): any product or physical matter that goes through rigorous processing (steel, plastic, etc.).

Water consumption is calculated as an input for all the man-made materials used to build the shelter. The water consumed by the natural growth of the palm trees (date palm and doum palm) and the common reed is not considered.

Any other raw materials which go into the production of the man-made materials are not considered – due to the complexity of this analysis and since data is not readily available.

7.2. Criteria 2: Carbon emissions

What is a carbon footprint?
A carbon footprint is the total greenhouse gas emissions caused by an individual, event, organization, service, place or product, expressed as carbon dioxide equivalent (CO_2 equivalent).

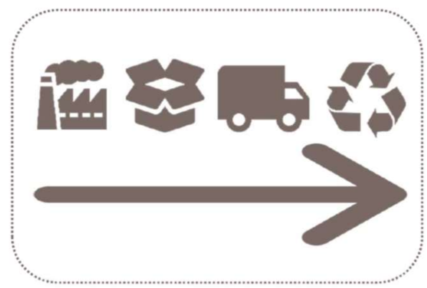
Life cycle analysis (LCA)
LCA is a commonly adopted methodology for quantifying carbon emissions and can be used to help compare shelter options. This 'cradle to grave' assessment evaluates the carbon emissions of the shelter from extraction of raw materials to the end of its life. It is a good starting proxy for a quantitative approach to measuring the environmental footprint of the different shelter options.

Using CO_2 equivalent doesn't cover the entirety of the complex issue of environmental impact, as there can be other more local impacts related to humanitarian shelter and settlement practices, but it provides a useful metric that can inform decision making.

Carbon calculator tool
The carbon calculator tool used in the study is the new SMAC[55] (Shelter Methodology for the Assessment of Carbon) tool. It calculates the CO_2 equivalent for most shelter designs and allows for the comparison of different shelter solutions in terms of their environmental impact over their entire life cycle.

The SMAC allows for comparison of up to 4 different shelter types, in terms of their embodied CO_2 equivalent emissions from the following factors:

1. Production of the component materials
2. Packaging
3. Transport
4. End of Life



7.2.1. Data required to use SMAC

In order to use the tool and calculate a kg CO_2 equivalent figure for the two shelter options, the following data has been compiled:

- A list of the shelter components and materials
- The amount of each material used (in kg) for each shelter
- The type of packaging used for the materials
- The amount of each packaging material used (in kg) for each shelter
- The transportation distances and modes from point of source of materials to point of use and disposal (there is further guidance in the SMAC tool on this if accurate distances are not known).

i) Shelter components and packaging materials

The amount (in kgs) of each raw material used in every shelter component is required.

Refer to Annex 4 to find the information regarding shelter material and quantity in kilograms, packaging components, and origin of the material used in the calculation. All this information was provided by the AICRL team in country, except

55 *SMAC It is a simplified LCA methodology, developed by BRE Trust, the Global Shelter Cluster Environment Community of Practice, and WWF, based on components of shelter options that use CO_2 equivalent emissions as a metric for assessment. Information on SMAC can be found at https://www.sheltercluster.org/community-of-practice/environment*
This study is one of the second to use the SMAC tool, and feedback has been shared with the developers to improve it.

the quantity in kilos of the packaging for the Sahel Shelter model, which was not known, so this data has been excluded from the calculation for both shelters.

ii) Transportation

When calculating the CO_2 equivalent, one of the key factors is the origin of the materials, since transportation can make a big contribution to carbon emissions. Whether a material has been purchased locally or imported, transported from a neighbouring country by road, or produced in a distant country and transported by sea or air, will have a material impact on total carbon emissions.

To calculate the transportation distance, the following distances in kilometres for each product are required.

- Country of origin to point of arrival in country
- Point of arrival to warehouse / store
- Warehouse to construction site
- Construction site to disposal site
- Type of transport used for each phase (truck/road, train, sea or air)

Calculating transport distances

For the purpose of this study, since the exact travel distance and the exact location of each factory are not known, average transport distances have been estimated and can be found in Annex 5. The following assumptions have been made:

- The tool and the analysis here do not include any transportation that may have occurred earlier in the supply chain, for example if part of a product is manufactured in one country and then shipped to another country where production is completed, from where the programme purchases it. The data is not available to include this, and the complexity of such analysis is beyond the scope of the SMAC tool.
- When one material could come from different locations, the average distance has been used.
- The distances in kilometres have been calculated using Google Maps, when it has not been provided by the field team.
- All materials have been transported by road (as per information provided by the field team), except the plastic sheeting and wire that came by boat.
- Plastic sheeting was manufactured in China and transported by boat to Port of Abidjan (Ivory Coast), then to Port of Douala (Cameroon). From Cameroon by road to N'Djamena, as per information provided from the field team.
- Wire was manufactured in Dubai and transported to Port of Douala (Cameron) by boat. From Cameroon by road to N'Djamena, as per information provided from the field team.
- Since the exact location of the Chinese factory wasn't available, the suggested approximate distance baseline provided by the SMAC guidelines from Asia to West Africa has been used: 19,000 kilometres.
- Other sea distances were calculated[56] in nautical miles and converted to kilometres for entry into the tool.
- Since it is not known exactly what happens with disposal, transportation from the site of construction of the shelters for disposal is not included.

iii) End of life

SMAC uses assumptions about the level of recycling and CO_2 eq released at the 'end of life', meaning when the material has reached the end of its useful life, based on standard construction practices for each material. However, the actual portion of each material that is recycled at 'end of life' may be overestimated in the CO2 eq calculation, according to the SMC developers. Meaning that the carbon emissions calculated from 'end of life' are underestimated.

7.2.2. Limitations of the SMAC carbon calculator tool

One of the limitations of the SMAC relates to the types of materials included in the database [57] used by the tool. It was not possible to find Environmental Product Declarations (EPD) for all possible shelter materials that are used in

56 *http://ports.com/sea-route/Ports.com*

57 *The data from the tool has been taken from the Inventory of Carbon and Energy (ICE database), as well as from various environmental product declarations (EPD, such as those found in Eco Platform and Greenbooklive). The ICE database is a collation of aggregated and EPDs. Where data did not exist in ICE, and*

humanitarian operations. As a result, the user must choose a similar material when the precise material is not listed in SMAC's drop-down lists (for example, thatch was selected instead of the doum palm trees, date palm trees and common reed actually used in Chad). Similarly, assumptions are made in the SMAC relating to end of life (recycling options and level of CO_2 released from disposal), where the best data available publicly was used. However, the developers of the SMAC consider both of these limitations to be acceptable, and in line with what they term a "good enough approach".

7.3. Criteria 3: Impact on local natural resources

Going beyond the carbon emissions measured by CO_2 equivalent, which is only one measure of environmental impact, this section looks at impacts on the local environment due to the use of local natural resources. It is important to analyse whether the production or harvesting of natural resources could be causing environmental harm.

For instance, while carbon emissions analysis may indicate that importing wood generates greater emissions than procurement of locally available wood, this local procurement could result in excessive local tree cutting and environmental degradation. Another example is where using locally sourced straw or thatch to roof one house is not an environmental issue, however 1,000 houses may pose some stress on the local eco-system, while roofing 10,000 houses every year could create a major issue in the local area.

The following factors are considered: Deforestation and vegetation removal, soil erosion, and degradation of water quality.

A number of environmental organisations[58] who specialise in the protection of forests and ecosystems in Chad were contacted for this study, but a reply was only received from one. Literature review[59], feedback from the project team and the perspective of this single local organization, has formed the basis for this analysis.

7.4. Criteria 4: Waste Management

One of the challenges of humanitarian action is that more end-to-end thinking about waste isn't common in the largely 'truck and chuck' humanitarian reality. All through the project cycle, any organisation that imports, produces, transports, or generates waste in some way, must think of the waste management implications. The ultimate goal is to generate the minimum amount of waste and extract the maximum benefit from products, keeping them in use for as long as possible.
This section studies if the life cycle of the shelter materials can be prolonged by reusing and recycling, and in case of disposal, how long it will take to decompose.

Waste hierarchy

Reduce, Reuse, Recycle: Commonly referred to as the "3 R's" of the waste hierarchy. Reduce means to minimise the amount of waste created. Reuse refers to using items more than once. Recycle means putting a product to a new use instead of throwing it away. The full waste hierarchy is usually characterised as: Reduce/Prevent; Reuse; Recycle; Recover; Disposal[60]. The different options (in order of preference) are in the illustration.
The levels indicate the progressive order of actions to take to reduce waste. More energy should be spent on the more significant layers at the top of the chart, like redesigning, reducing, and reusing. And to minimize the activities at the bottom, like residual management or landfill.

one EPD was available, that data point was used. Where several EPDs were available, an average was used. All data sources have been referenced within the tool. Data for packaging, end of life and recycled content have been sourced from BRE.

58 *Refer to Annex 2*

59 *Refer to biography*

60 *EU Commission, 2014*

Attempts to identify local private companies, start-ups, etc involved in ecological recycling and waste recovery in the country within the short time allocated to this study were unsuccessful. Literature review[61], feedback from the project team and environmental experts from the shelter sector[62] have been considered for this analysis.

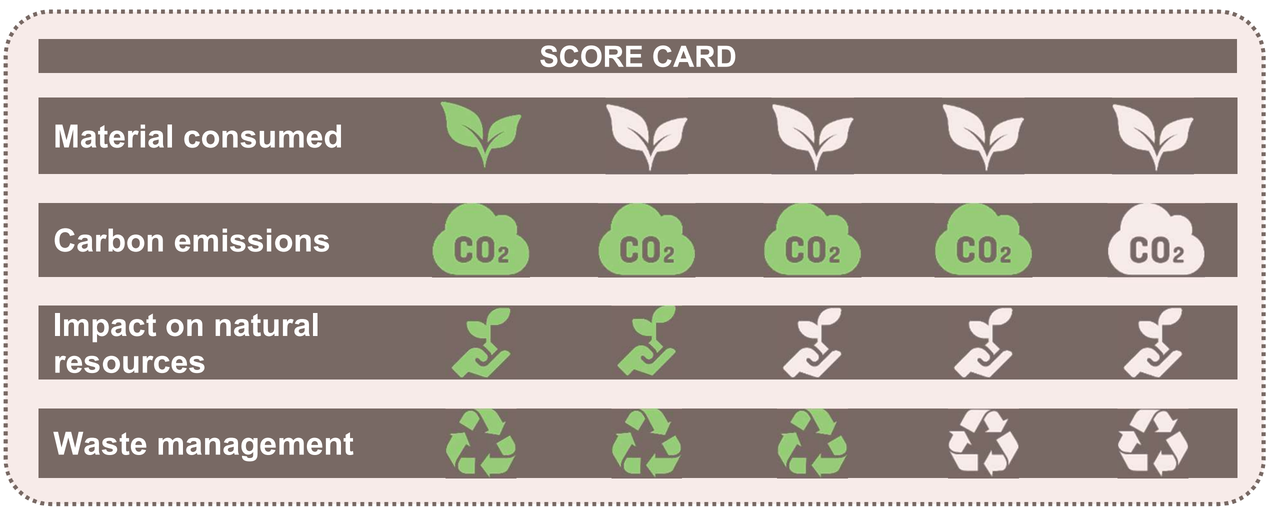
7.5. Score card approach

A simple 'score card' approach is used to compare the two shelter models across the four criteria. This recognises that carbon emissions, while being critical, are not the only factor in environmental impact. A score card also recognises the challenge in applying any kind of numerical weighting for the four criteria in order to arrive at a calculated score. This would require too many assumptions on the relative weight of each category. Instead, a qualitative conclusion will be made based on the score card.

While acknowledging the methodological limitations of this approach, it is the only feasible option in the limited scope and time allotted to this study. A score card allow an explicit inclusion of local factors, and highlights in a simple way what the main environmental issues are for each shelter, thus identifying where mitigating solutions could help to improve the overall environmental impact of the shelter models.

Both shelter models will be scored from 1 to 5 against each of the criteria, to enable comparison.

Example of the score card (noting that a higher score is better, meaning lower environmental impact):



1 poor, 2 average, 3 medium, 4 good, 5 very good

61 *Refer to biography*
62 *Refer to Annex 2 to see the list of people contacted.*

8. Comparison of environmental impact of the shelter models

8.1. Criteria 1: Materials consumed

8.1.1. Overview of the materials used and their general impact on the environment

Plastic Is the term commonly used to describe a wide range of synthetic or semi-synthetic materials that are used in a huge and growing range of applications.[63] Half of all plastics ever manufactured have been made in the last 15 years. Only in 2020, 367 million tons were produced and this is expected to double by 2050.

Types of plastics used in the shelter model

Polyethylene; The poly tarpaulin was invented in 1932. Because polyethylene is such a versatile material, it became the most widely used type of plastic in the market, used to produce everything from shopping bags to plastic containers.

PVC; Polyvinyl Chloride plastic is the world's third most common plastic. It is inexpensive, durable, strong, and chemically and biologically resistant, as well as easy to install and replace. It is widely used in packaging, home furnishings, children's toys, building materials, etc. It is the most environmentally damaging of all plastics.[64]

Nylon; Is composed of polyamides, it is a silk-like thermoplastic generally made from petroleum, that can be melt-processed into fibres, films, or shapes. It was the first fabric made entirely in a laboratory. It became widely available to the general public around the time of World War II, thanks to its strength and durability.[65]

General environmental impacts

Greenhouse effect; the use of fossil fuels and other chemicals in the production of these products is a key contributor to the global warming crisis. Plastic production and incineration currently account for 3.8% of carbon emissions and is estimated to be responsible for 13% by 2050. In 2019 alone 850 million metric tons of carbon dioxide equivalent was released into the atmosphere due to plastic.[66]

Ocean contamination; 10 percent of this plastic ends up in the ocean, where it breaks down into microplastics.[67] By 2050, the world's oceans will contain more plastic than fish (by weight) if current trends continue.

Harm to wildlife; Plastics harm fish, plants, wildlife and the natural environment by leaching toxins into soil, water and air. They poison, injure and kill wildlife.[68]

63 *www.aquapakpolymers.com*
64 *www.greenpeace.org*
65 *https://goodonyou.eco*
66 *Center for International environmental law.*
67 *Greenpeace*
68 *Stopplastic.ca*

Steel is an alloy (a metal combined with two or more metallic elements) made up of iron and a percent of carbon, to improve its strength and fracture resistance. Other elements may be present or added. Iron is the world's third most produced commodity by volume - after crude oil and coal. Over 2,000 million tons of iron is mined a year - about 95 percent is used by the steel industry.[69]

General environmental impacts[70]

Energy consuming; Production of steel is the most energy-consuming in the world.

Pollution; Steel production requires large inputs of coke (a type of coal) which is extremely damaging to the environment. Coke ovens emit air pollution highly toxic and can cause cancer. Wastewater from the coking process is also highly toxic and contains a number of carcinogenic organic compounds.

Greenhouse effect; Steel production is responsible for the emission of 3,3 million tons of CO_2 annually[71]

Tilia americana (basswood) is a species of tree in the family Malvaceae, native to eastern North America but also now found in parts of Africa. The American basswood is a medium-sized to large deciduous tree reaching a height of 18 to 37 m, with a trunk diameter of 1–1.5 m at maturity. It grows faster than many North American hardwoods. Life expectancy is around 200 years, with flowering and seeding generally occurring between 15 and 100 years, though occasionally seed production may start as early as eight years.[72]

Basswood is an important commercial hardwood. Its wood is light, generally straight-grained and fine-textured. Its lumber is used for furniture, millwork, caskets, frames, toys and novelty products.[73]

General environmental impacts

The basswood provides food and shelter for many species of wildlife. Squirrels, chipmunks, mice, rabbits, upland game birds, songbirds, porcupines and foxes eat the seeds or bark of this tree. Trees become dens for many animals.[74]

69 *The world counts*
70 *The world counts*
71 *The world counts*
72 *Wikipedia*
73 *LE TILLEUL D'AMÉRIQUE (lrconline.com)*
74 *LE TILLEUL D'AMÉRIQUE (lrconline.com)*

Doum palm tree

Hyphaene thebaica, is a type of palm tree, Individuals can grow to 25 m.[75] It is a native to the Arabian Peninsula and also to the northern half and western part of Africa,[76] where it is widely distributed and tends to grow in places where groundwater is present. Most of its parts are used by local people, but especially the leaves to make woven mats for walls and roofs of housing.

General environmental impacts[77]

Soil fertility; Palm trees promote soil fertility.

Wind erosion; Palm trees fight against wind erosion and the desertification

Tree extinction: Commercial over-exploitation will lead to the disappearance of the tree

Date palm tree

(Phoenix dactylifera) of the palm family (Arecaceae) cultivated for its sweet edible fruits. The date palm has been prized from remotest antiquity and may have originated in what is now Iraq.[78] The species is widely cultivated across northern Africa, the Middle East, and South Asia, and is naturalized in many tropical and subtropical regions worldwide.[79] The fruit has been the staple food and chief source of wealth in the irrigable deserts of North Africa and the Middle East.[80]

All parts of the date palm yield products of economic value.[81] It has been used as a source of food, for building houses, and landscaping.[82]

General environmental impacts

Preventing soil erosion: Date palms have strong roots that hold well, even in sandy soil. This makes them useful in preventing soil erosion, especially in areas with poor soil quality.[83]

Improving soil properties: Date palm plantations have additional advantage in improving soil physical and chemical properties due to the large amounts of organic materials deposit to the soil after the tree pruning.[84]

Saves on water usage: Date palms are drought resistant as they have been grown in dry areas throughout history.[85]

Reduces temperatures: The tree can decrease the atmospheric temperature of the surrounding air and may help cool down if enough trees are planted.[86]

Pollution control: Date-palms are also great for removing harmful pollutants from the atmosphere, resulting from industrial activities.[87]

75 *www.eol.org*
76 *World Check List of Selected Plant Families (WCSP). Kew Sciences.*
77 *Valoriser les produits du palmier doum pour gérer durablement le système agroforestier d'une vallée sahélienne du Niger et éviter sa desertification. Régis Peltier, Claudine Serre Duhem et Aboubacar Ichaou*
78 *Date palm | Description, Uses, & Cultivation | Britannica*
79 *Wikipedia*
80 *Date palm | Description, Uses, & Cultivation | Britannica*
81 *Date palm | Description, Uses, & Cultivation | Britannica*
82 *The Role of Date Palm Tree in Improvement of the Environment. Kadhim M. Ibrahim*
83 *https://datepalmdubai.com*
84 *The Role of Date Palm Tree in Improvement of the Environment. Kadhim M. Ibrahim*
85 *https://datepalmdubai.com*
86 *The Role of Date Palm Tree in Improvement of the Environment. Kadhim M. Ibrahim*
87 *The Role of Date Palm Tree in Improvement of the Environment. Kadhim M. Ibrahim*

common reed Genus Phragmites, is a broadly distributed wetland grass growing nearly 6 m tall.[88] It commonly forms extensive stands (known as reed beds), which may be as much as 1 km^2 or more in extent. Where conditions are suitable it can also spread at 5 m or more per year by horizontal runners, which put down roots at regular intervals. It can grow in damp ground, in standing water up to 1 m or so deep, or even as a floating mat. The erect stems grow to 2–4 m tall, growing in areas with hot summers and fertile growing conditions.[89]. Reeds were and still are used locally in the construction of walls and roofs of houses.[90]

General environmental impacts

Mitigate environmental pollution: The Common reed has proven ability to mitigate the environmental pollution of its surroundings. It has been a most preferred unique plant system, especially in ecological engineering for improving the quality of wastewater.[91]

Invasive wetland plant: the common reed, is an aggressive, vigorous species which, in suitable habitats, will out-compete virtually all other species and form a totally dominant stand. Its invasive character has been particularly apparent in North America where it has become dominant in a range of wetland habitats replacing native species and biotypes. Bird, fish and insect populations can also be affected.[92]

Water covers 70% of our planet, however, only 3% of the world's water is fresh water.[93] Billions of people worldwide lack access to water. Water is at the core of sustainable development and is critical for socio-economic development, healthy ecosystems and for human survival itself.[94]

Environmental impacts

Water shortage; Water shortages are likely to be the key environmental challenge of this century.[94] More than half the world's wetlands have disappeared. Many of the water systems that keep ecosystems thriving and feed a growing human population have become stressed. Rivers, lakes and aquifers are drying up.

Agriculture; consumes more water than any other source, 70% of the world's accessible freshwater, and wastes 60% of it, much of that through inefficiencies due to leaky irrigation systems, inefficient application methods as well as the cultivation of crops that are too thirsty for the environment in which they are grown.[95]

Water pollution; comes from many sources including pesticides and fertilizers that wash away from farms, untreated human wastewater, and industrial waste.[96]

Climate change; is altering patterns of weather and water around the world, causing shortages and droughts in some areas and floods in others.[97]

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88 *The tall-statured grasses in the genus Phragmites are dominant vegetation in wetlands worldwide and thus play a vital role in ecosystem functioning. Expansive reed populations—alien invasion or disturbed wetlands? Kim Canavan. 2018*
89 *Wikipedia.*
90 *Daphné Durant, Anne Farruggia et Alexandre Tricheur, « Le roseau commun (Phragmites australis) : un capital naturel utilisé en litière pour le logement des vaches allaitantes »*
91 *Environmental perspectives of Phragmites australis (Cav.) Trin. Ex. Steudel. Jatin Srivastava, Swinder J. S. Kalra & Ram Naraian. 2013*
92 *Phragmites australis (common reed) (cabi.org)*
93 *WWF*
94 *www.un.org/waterforlifedecade*
95 *NASA*
96 *University of Dundee*
97 *WWF*

8.1.2. Data and analysis of the materials in the shelters

Below are the tables showing the materials used in each of the shelter models, by weight (kilograms). In the case of the Moundou Shelter model, the data was provided by the AI-CRL logistics team in Chad. As the Sahel Shelter was a model built in 2018, and there are no materials left in stock to weigh, the data could not be provided by the field team. However, since is the same design (and uses the same materials) as the Diffa shelter built in Niger by AI-CRL, that data has been used[98], except for the doum palm mats, which have been based on the weight of the mats used in the Moundou shelter.

Water consumption is calculated for all the man-made materials used to build the shelter. The water consumed by natural growth of the palm trees and common reed is not considered. To calculate the water in litres, the following baseline assumptions have been used:

- Production of 1 kg of plastic requires 17 litres of water[99]
- Production of 1 kg of steel requires 705 litres of water[100]

SAHEL SHELTER- Table 1

Raw material	
Doum palm tree	109.2 kilos
Water consuption	20,898 liters

Man-made material	
Steel	28.5 kilos
PVC	36.4 kilos
Plastic	11 kilos
Nylon	0.5 kilos

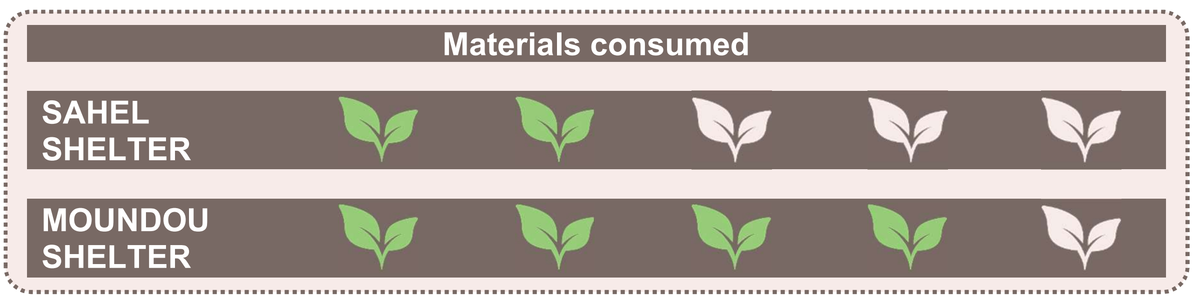
MOUNDOU SHELTER –Table 2

Raw material	
Doum palm tree	67 kilos
Date palm tree	143.75 kilos
Common reed	402.5 kilos
Basswood	92.3 kilos
Water consumption	505.5 liters

Man-made material	
Steel	0.5 kilos
Plastic	9 kilos
Nylon	0.25 kilos

8.1.1. Interpretation of the results

The Sahel Shelter model scored 2 out 5 and the Moundou Shelter model scored 4 out 5



1 poor, 2 average, 3 medium, 4 good, 5 very good

The Sahel Shelter model used a higher amount of man-made material, especially steel and plastic, and also a considerable amount of water which goes into the production of those. The Moundou Shelter used mostly locally available raw materials and minimal amounts of man-made materials, meaning much less water consumed in the production process. Note that under this criteria the quantity of materials is considered, and not whether the extraction of local raw materials is environmentally harmful, which is considered under Criteria 3.

98 *Further information could be found in the Comparative Study of the environmental impact of Niger emergency shelter models*
99 *Shelter and Sustainability, UNHCR, 2021*
100 *Shelter and Sustainability, UNHCR, 2021*

Both scores could be improved by reducing the amount of man-made materials, especially plastic, steel and PVC, used in the shelters, without compromising the functionality.

8.2. Criteria 2: Carbon emissions

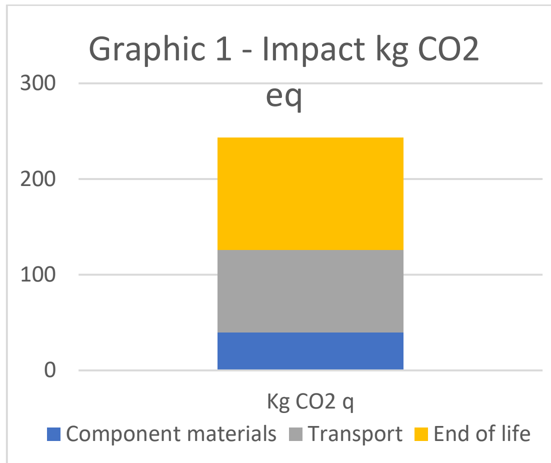
Below are the total carbon emissions generated by each shelter model, in CO_2 equivalent. This is using the SMAC calculator and taking into account all the parameters and assumptions explained above in section 7.2.

8.2.1. Sahel Shelter Model

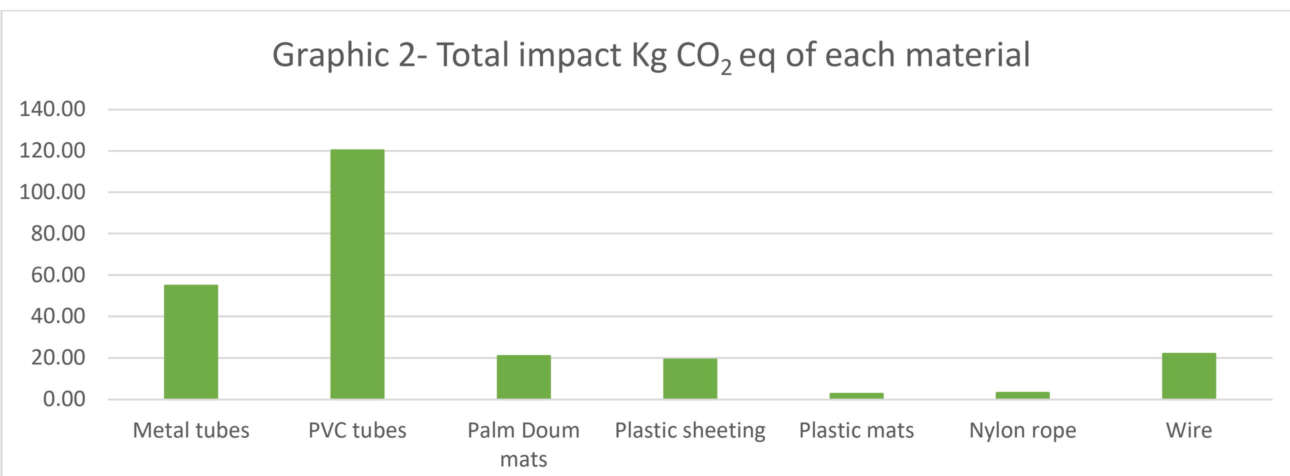
The follow Table 3 & and Graphic 1 show the breakdown of the carbon emissions, in terms of Kg CO_2 eq and relative % CO_2 eq, of the shelter unit per life cycle stage: 'production of the component materials', 'transport' and 'end of life'. Emissions from 'packaging' are not included as information was not available.

Table 3 – Sahel Shelter Model

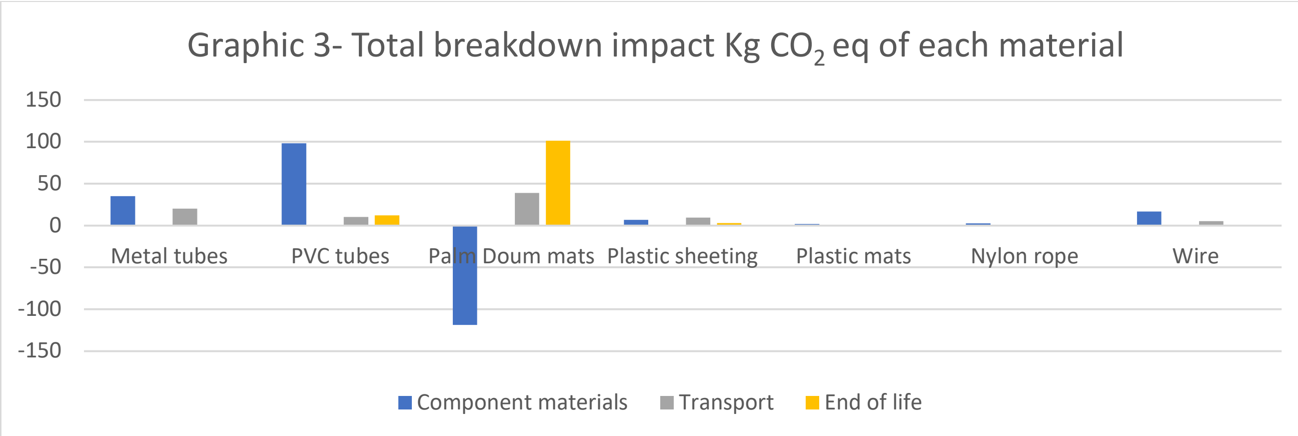
Impact	Carbon Emissions Kg CO_2 eq
Production of component materials	41
Packaging	*Data not available*
Transport	85
End of life	117
Total	**243**



The follow Graphic 2 shows the total Kg CO2 eq impact of each material.



The follow Graphic 3 shows the total impact Kg CO_2 eq emissions of each material, broken down into the emissions generated by 'production of the component materials', 'transport' and 'end of life'.



8.2.2. Interpretation of the result for Sahel Shelter model

As per Graphic 1 most of the carbon emissions for this shelter are from the 'end of life' of the component materials used, with 'transport' and 'production of the component material' making a smaller contribution. However, as will be explained, this overall picture is slightly misleading, because the use of the natural palm doum mats has the effect of offsetting many of the emissions from the metal and PVC tubes.

When looking into each of the materials, Graphic 2, PVC is the one that has the biggest emissions, followed by metal tubes and wire. As per Graphic 2, most of the emissions from the PVC and metal tubes come from the 'production of the component material'. 'Transport' also adds substantial emissions.

When looking into the palm doum mats, Graphic 3, the 'production of the component material' actually generates negative carbon emissions (-119 kg CO_2 eq), because natural materials capture carbon (and other greenhouse gases) during their growth. However, this captured carbon is released at the end of life, Graphic 3, where palm doum mats have the biggest impact on emissions. This is because these materials are usually burnt, therefore the level of CO_2 eq released into the air is relatively high. The SMAC tool assumes that these type of plant materials and wood are burnt at the end of their useful life. If the material is allowed to decompose, is composted, or is just buried, little or no CO_2 eq would be released into the environment.

So, initially, the CO_2 eq number for palm doum mats may be negative as producing the material takes less CO_2 eq than, for instance, plastic sheeting. But these negative emissions are 'balanced out' when considering what happens at the end of life of the material, when carbon is emitted, and also due to the emissions from transportation, which are significant for the palm doum mats.

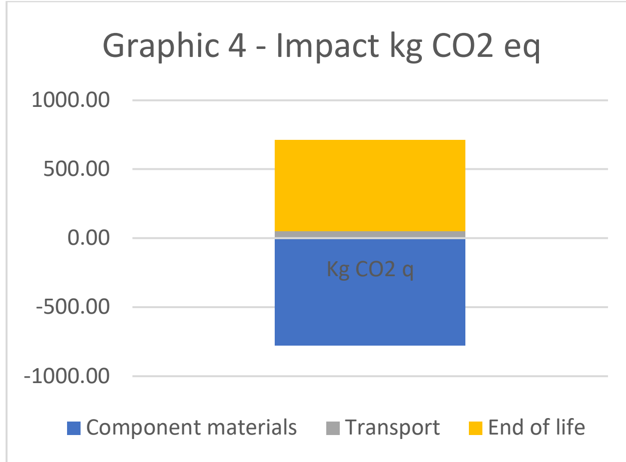
Overall, it is clear that the metal and PVC tubes are driving most of the carbon emissions; however, for the entire shelter the emissions from production appear lower due to the 'carbon capture' effect of the palm doum mats; similarly the emissions from 'end of life' appear much higher due to the emissions released from the burning of the palm mats.

8.2.3. Moundou Shelter Model

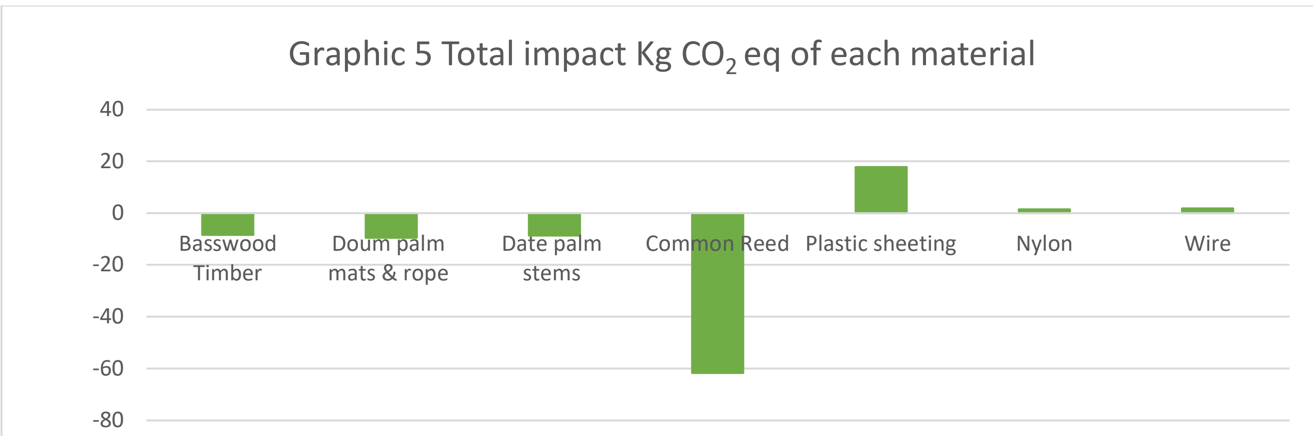
The follow Tables 4 and Graphic 4 show the breakdown of the carbon emissions generated, in terms of Kg CO_2 eq and relative % CO^2 eq, of the shelter unit per life cycle stage: 'production of the component material', 'transport' and 'end of life'. Emissions from 'packaging' are not included as information was not available.

Table 4 – Moundou Shelter Model

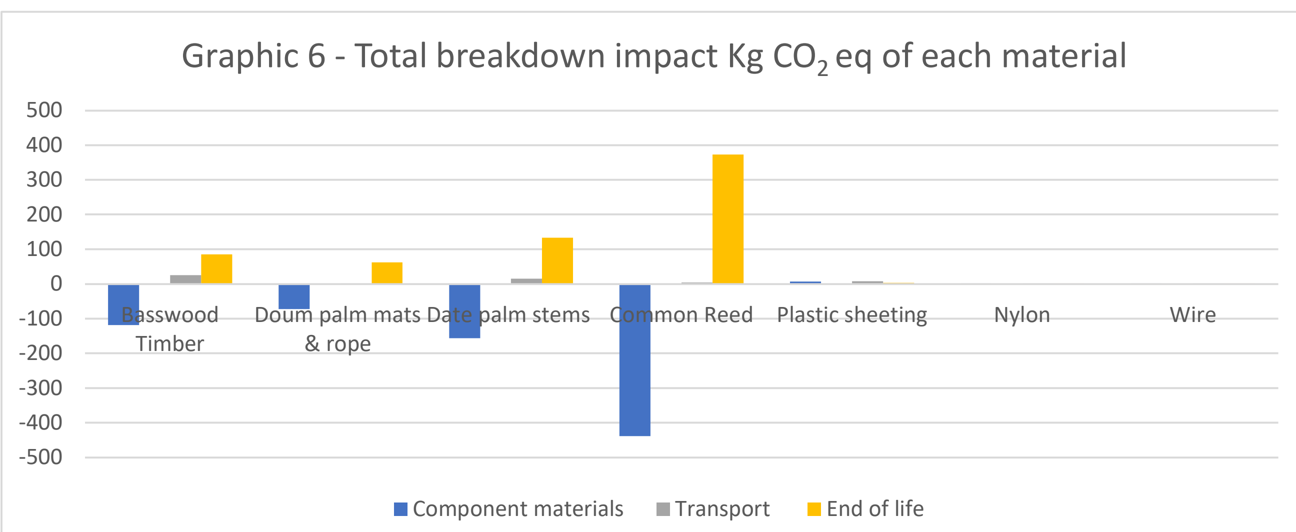
Impact	Carbon Emissions Kg CO_2 eq
Production of component materials	-778
Packaging	*Data not available*
Transport	55
End of life	656
Total	**-67**



The follow Graphic 5 shows the total Kg CO2 eq impact of each material.



The follow Graphic 6 shows the total Kg CO_2 eq emissions of each material, broken down into the emissions generated by 'production of the component materials', 'transport' and 'end of life'.



8.2.4. Interpretation of the result for Moundou Shelter model

Overall the Moundou Shelter generates no carbon emissions, due to its reliance on natural materials like wood, palm and reed mats. The plastic sheeting is the only material which generates any significant emissions, but these are offset by the carbon captured during the growth of the natural materials.

Considering the total impact of each of the materials used in the shelter, Graphic 5, the biggest impact is the plastic sheeting followed by wire and nylon. The emissions generated by the plastic sheeting are due mostly to the 'transport', Graphic 6.

As per Table 4 and Graphic 4 the biggest impact on carbon emissions is due to the 'end of life', followed by 'transport'. However, this is slightly misleading because of the carbon captured (negative emissions generated) by the natural materials during production, and the large emissions released when these materials are burnt at the end of their useful life.

Overall the Moundou Shelter captures more carbon emissions that it releases during its life cycle (-67 Kg CO_2 eq). This is because all the natural materials capture carbon (and other greenhouses gases) during their growth (-778 Kg CO_2 eq as per Table 4 and Graphic 4). However, this number is almost balanced out when considering what happens at the 'end of life' of the materials, when carbon captured is released (656 Kg CO_2 eq as per Table 4 and Graphic 4). This is because these materials, as explained in section 8.2.2., are usually burnt (and the SMAC tool assumes the same), therefore the level of CO_2 eq released into the air is relatively high. If the material is allowed to decompose, or is just buried, little or no CO_2 eq would be released into the environment. This would further Increase the 'positive' impact on emissions of the carbon captured by the natural materials used.

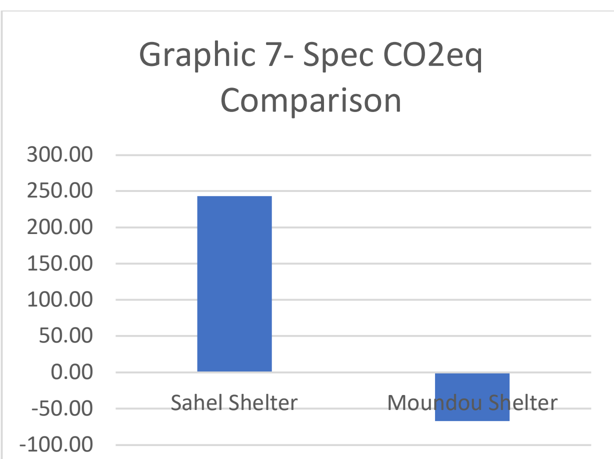
Comparing the result for both models

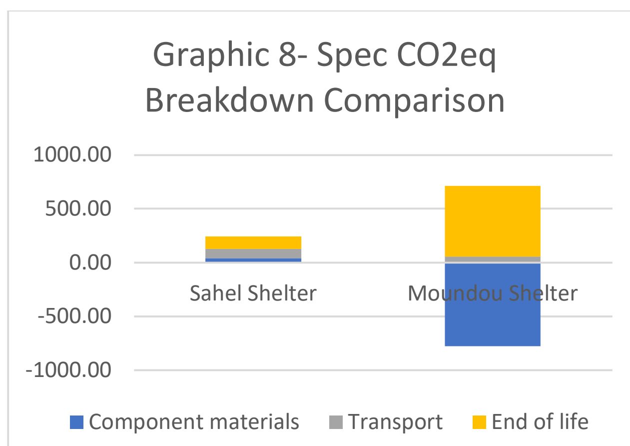
Table 3 - Sahel Shelter Model

Impact	Carbon Emissions Kg CO_2 eq
Production of the component materials	41
Packaging	Data not available
Transport	85
End of life	117
Total	**243**

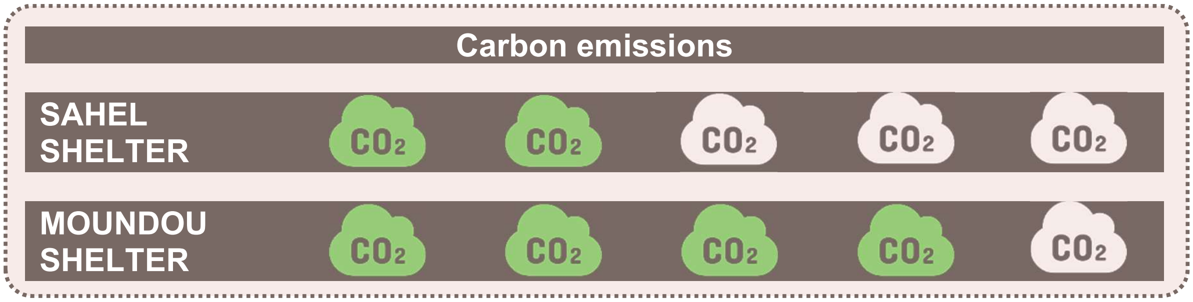
Table 4 – Moundou Shelter Model

Impact	Carbon Emissions Kg CO_2 eq
Production of the component materials	-778
Packaging	Data not available
Transport	55
End of life	656
Total	**-67**





Sahel Shelter model scored 2 out 5 and Moundou Shelter scored 4 out 5



1 poor, 2 average, 3 medium, 4 good, 5 very good

The comparison of overall carbon emissions is very clear, with the Moundou Shelter model considerably better than the Sahel model. Obviously this is due to its reliance on natural materials like wood and palm tree products, rather than metal and plastic.

The score card for the Sahel Shelter model could be improved by:

- To consider to use different materials, especially replacing the PVC and metal tubes which have the highest embodied CO_2 emissions, or reducing the amount used without compromising the quality of the shelter.
- To ensure that doum palm mats are not burnt at the end of their useful life, and are composted or left to degrade instead.
- To reduce the emissions from transport. The highest impact came from the doum palm mats, because of its heavy weight (109.2 kg per shelter). Since they are locally sourced, the only way to reduce overall emissions is by reducing the amount and weight of the mats, without compromising the quality of the shelter. However this can be challenging. Another way is by procuring metal tubes more locally, if possible.

For Moundou Shelter model, the overall result is “positive”, since it captures carbon from the atmosphere. However it can also be improved by:

- To ensure that the natural materials are not burnt at the end of their useful life, and are composted instead. So the total amount of captured carbon could be even higher.
- To reduce the impact on transport from the basswood timber. However, it can be challenging to purchase timber more locally in Chad. The alternative could be carefully identify a supplier that can source sustainable wood locally. If so, the wood should come from a sustainable plantation and it should be clear that over-extraction or other environmental damage does not happen.

8.3. Criteria 3: Impact on local natural resources

A common assumption is that the more natural a material it is, the better is for the environment. However, when selecting a natural resource, there are certain impacts on the local ecosystem that need to be considered, such as deforestation and vegetation removal, soil erosion, degradation of water quality, pollution etc. Where possible, options to mitigate these effects should be considered as part of project design.

Desertification, deforestation, soil degradation and loss of biodiversity are the major environmental problems in Chad. Like other Sahelian countries, it has been experiencing recurrent rainfall deficits for nearly three decades, which, combined with human activities that are not always respectful of the environment, have led to a degradation of natural resources[101]. Communities in Chad depend on the exploitation of these natural resources, and forests play a strategic role, which in addition to wood energy, provide food supplements, medicines, housing material, fodder for livestock and

101 *Evaluation des ressources forestierese mondiales 2020. Rapport Tchad. FAO*

cash income. The forest revenues[102] in Chad are 3.81% of GDP (2018 est.), which is the 19th highest of 204 countries analysed. Therefore the use of local forest resources in shelter construction needs to be carefully analysed.

Chad has suffered from the encroachment of the desert, traditional herding practices and the need for firewood (wood energy remains the most used energy source in Chad) and wood for construction have exacerbated the problem[103]. In view of the generally expected population increase, higher demand will have a destructive effect and forest degradation will continue to grow, while the degradation is aggravated by the danger of desertification[104]. Tree mortality has also been linked to Sahelian droughts, which can further exacerbate climate change impacts by diminishing the ability of plants to uptake carbon dioxide[105]. Therefore, in 2008, Chad authorities implemented a new set of environmental regulations over the use and exploitation of wood fuels. Cutting wood and producing charcoal were declared illegal[106]. Also, a National Reforestation Programme (NRP) was created to enable the forestry sector to contribute effectively to poverty eradication and promote Sustainable Development[107].

The overuse of wood for shelters and cooking energy was one of the three primarily impacts identified in the IDP Shelter & Settlements Environmental Impact Report in the Lac Province of Chad, from the Chad Shelter Cluster. The Cluster’s highest priority going forward is mitigating the high dependency on wood, as this has the biggest environmental impact in the Lac Province[108].

The environmental degradation observed in the Sahel is gradually influencing the evolution of Lake Chad's water resources as well[109]. Lake Chad plays a major role in the organisation of the economic, social and cultural life of the basin's populations. It therefore offers important opportunities for agriculture, fishing and livestock breeding.[110] Inadequate natural resource management and lack of coordination between the different countries in the region, as well as the general impact of climate change, have contributed to a deterioration in the natural capacity of the lake ecosystem[111]. Cohabitation is difficult, between the different communities living on the outskirts and on the islands of Lake Chad. Tensions and conflicts are a direct translation of these growing pressures on resources[112]. Using natural resources from the lake eco-system, like the lake reed, should be done with care.

In the context of climate change and pressure on local natural resources, it is important to analyse whether the shelter models contribute to this degradation of the environment. To do a proper study of potential harm done to the environment, it should really go beyond the local natural resources used, in this case the doum and date-palm trees and the common reed, and look into the overall sheltering strategy and implementation (site selection, access, infrastructure and services, environmental protection, etc.). However, this is beyond the scope of this study and so analysis is restricted to the local materials used.

Attempts were made to contact several local environmental organisations[113]. However, in the end only one responded, ANADER (Agence Nationale d'Appui au Développement Rural).

102 *CIA. Chad - The World Factbook (cia.gov)*
103 *Combating Desertification in Asia, Africa and the Middle East. G. Ali Heshmati, Victor R. Squires. 2013*
104 *FAO https://www.fao.org/3/AB579F/AB579F01.htm*
105 *Climate Change, Food Security and migration in Chad: A Complex Nexus. American University, IOM Chad and the Chad Food Security Cluster*
106 *Enjeux et conséquences de la réglementation sur le bois-énergie au Tchad. Ronan Mugélé.*
107 *Evaluation des ressources forestierese mondiales 2020. Rapport Tchad. FAO*
108 *IDP Shelter & Settlements. Environmental Impact Report. Shelter Cluster Chad. March 2021*
109 *Variabilité du lac Tchad, changement climatique et mobilités des populations vers les zones exondées. IED AFRIQUE*
110 *Variabilité du lac Tchad, changement climatique et mobilités des populations vers les zones exondées. IED AFRIQUE*
111 *FAO. 2021. Évaluation de la réponse de la FAO à la crise dans le bassin du lac Tchad 2015-2018. Série évaluation de programme, 01/2021. Rome*
112 *Variabilité du lac Tchad, changement climatique et mobilités des populations vers les zones exondées. IED AFRIQUE*
113 *LEAD, DAFNA, NAFIR and ANADER*

A quick overview about forests, why they are important to fight against climate change, and forest situation in Chad

Forests play a key role in mitigating climate change[114] and increase the resilience of rural communities. They regulate ecosystems, protect biodiversity, play an integral part in the carbon cycle, support livelihoods, protect homes from major weather events, improve health and can help drive sustainable growth[115].

Environmental issues[116]

- 30 % of global tree species are threatened with extinction. And over the past 300 years, the global forest area has decreased by about 40%.
- The main threats to tree species are forest clearance and other forms of habitat loss, direct exploitation for timber and other products. Climate change, like fire, extreme weather and sea level rise, is also having a clearly measurable impact.
- Around 25% of global emissions come from the land sector. About half of these come from deforestation and forest degradation.

Chad Forest Information and Data

- Chad has struggled with desertification, soil degradation, drought and loss of biodiversity for many years.
- Chad is subdivided into three distinct zones[117]:
  -The desert zone in the north, 47% of the total country area and has a 0.75 % of vegetation cover;
  -The Sahelian zone in the centre, 43% of the total country area and has a 0.82% vegetation cover;
  -The Sudanian zone in the south, 10% of the total country area and has a 6.67% vegetation cover.
- In 2020, 0.34 %[118] (4,313,000 ha[119]) of Chad total area is forested (99.5% Naturally regenerated forest and 0.5% of planted forest[120]), and 1.34% of other woodland[121].[122]
- The average annual reforestation area is 300 ha. (Direction des Forêts, 1988) [123].
- The deforestation rate on natural forest resources is approximately 2.5% year (SIDRAT, 2013) [124]
- Chad has 27 protected areas. Three national parks, seven wildlife reserves, six operational hunting areas, one biosphere reserve, ten classified forests, i.e., 12.05% of the national territory[125].
- The forest revenues in Chad is 3.81% of GDP (2018 est.)[126]
- The Government prohibits all abusive cutting of trees by the population and companies[127]. A high population growth rate puts pressure of the few remaining forest lands[128].

8.3.1. Overview of the local natural resources

114.Forests and climate change. IUCN
115.Forests and climate change. IUCN
116 State of the World's Trees. Sept 2021. Botanic Gardens Conservation International
117 Evaluation des ressources forestierese mondiales 2020. Rapport Tchad. FAO
118 AFRICA UN data for Development. https://ecastats.uneca.org/unsdgsafrica/SDGs
119 AFRICA UN data for Development. https://ecastats.uneca.org/unsdgsafrica/SDGs
120 FAO. 2020. Global Forest Resources Assessment 2020: Main report. Rome.https://doi.org/10.4060/ca9825en
121 These are plant formations composed of shrubby savannahs and steppes
122 Evaluation des ressources forestierese mondiales 2020. Rapport Tchad. FAO
123 Evaluation des ressources forestierese mondiales 2020. Rapport Tchad. FAO
124 Evaluation des ressources forestierese mondiales 2020. Rapport Tchad. FAO
125 Evaluation des ressources forestierese mondiales 2020. Rapport Tchad. FAO
126 CIA. Chad - The World Factbook (cia.gov)
127 Information provided by the AI-CRL local team
128 https://data.worldbank.org/indicator/ER.LND.PTLD.ZS?locations=TD-NE

Doum palm tree in the shelter model

The palm flora of continental Africa, are amongst the most useful plants across the continent. The small-sized palm tree, the doum, (Hyphaene thebaica), can be found in the north of Chad. They are among the types of trees that are found in abundance in the Lake Chad province and grown in the wild[129]. It has significant local and regional economic, social and ecological value[130].

Most of its parts are used by local people. The trunk is used as timber. The pulp of its fruit is eaten, dried palm cores produce flour, several parts are used as fuel, palm trees have a favourable influence on associated crops or pastures and above all the leaves are used for numerous craft products. These leaves are normally purchased by craftswomen to make mats, commonly used in these semi-arid regions, which serve to sit on and to make the walls and roofs of housing. Other different uses are basketry and ropes[131].

Harvesting[132]

Leaf harvesting is very intensive, but collecting practices can differ from one region to another. The mats are made after cutting the leaves of the doum or dwarf palm tree, which are left to dry in the open air for three or four days. It is usually done during the rainy season. Professional artisans, usually women, weave the fibres into strips of about ten centimetres wide and two meters long. In general, twelve strips are needed to make a mat the size of two people[133].

Labour productivity is low: on average, it can take one person more than a day to make a rectangular mat, to which must be added cutting, drying, transporting and processing of the necessary palms. There is no industrial production of these mats.

Environmental impacts

- Palm trees promote soil fertility. In cultivated fields, farmers have found that the soil is more fertile inside doum patches than outside.
- In the dry season, the leaf traps the fine elements transported by the wind. This contributes effectively to the fight against wind erosion and the desertification of certain fields.[134]
- Today, the Hyphaene thebaica is rated as one of the tree types at “the least concern” from extinction in Chad[135.] However, the general degradation of the Sahelian environment and its desertification, on account of climate uncertainties and the commercial exploitation of the doum palm tree, will lead to the disappearance of adult seed trees, then to sprout exhaustion and disappearance of young seedlings[136], if measures are not taken.

Total amount of palm doum mats in the models

- Sahel Shelter model: 109.2 kilos for the wall and roofing
- Moundou Shelter model: 67 kilos for the walls, roofing and rope.

129 *Information provided by the field team*
130 *Low extinction risk for an important plant resource: Conservation assessments of continental African palms (Arecaceae/Palmae). April 2018*
131 *Valoriser les produits du palmier doum pour gérer durablement le système agroforestier d'une vallée sahélienne du Niger et éviter sa désertificationRégis Peltier, Claudine Serre Duhem et Aboubacar Ichaou*
132 *Little information has been found on the specific cultivation of the doum palm in Chad, so some of this information comes from the previous report « Comparative study of the environmental impact of Niger emergency shelter models » , where the same natural material is also used,*
133 *Low extinction risk for an important plant resource: Conservation assessments of continental African palms (Arecaceae/Palmae). April 2018*
134 *Valoriser les produits du palmier doum pour gérer durablement le système agroforestier d'une vallée sahélienne du Niger et éviter sa desertification. Régis Peltier, Claudine Serre Duhem et Aboubacar Ichaou*
135. *Botanic Gardens Conservation International. https://www.bgci.org/resources/bgci-databases/globaltree-portal/*
136 *Valoriser les produits du palmier doum pour gérer durablement le système agroforestier d'une vallée sahélienne du Niger et éviter sa desertification. Régis Peltier, Claudine Serre Duhem et Aboubacar Ichaou*

Date palm tree used in the shelter models

Date-palm (Phoenix dactylifera L.) is present in sub-Sahelian African countries. Date palm growing is a component of the sub-Sahelian agriculture landscape and is present in different sub-Saharan parts of the region and is proposed to be extended to other wetter regions in the Sahel. The date palm is adapted to the Sahel and its planting can contribute to combating desertification and, above all, contribute to the creation of microclimates favourable to the development of under-canopy crops such as other fruit trees, fodder, and market garden vegetables[137] .

Date palm cultivation in Chad is concentrated in the northern part of the country near the Libyan border (Borkou, Ennedi, and Tibesti) is the northernmost prefecture of Chad. It is a desert region which covers an area of 600,350km^2 or almost half of the country[138]. Date palm population's estimation in Tchad in 2015 was 1,360,000, the highest number of all the Sahelian countries.[139]

All parts of the date-palm yield products of economic value. Fruit, livestock feed, handicrafts, fuel, fibre, etc.[140] In North Africa, date-palm leaves, are commonly used for making huts[141]

Harvesting[142]

There are two modes of cultivation: the extensive palm grove (not irrigated around 90%) and the maintained palm grove (irrigated gardens, around 10%). In the first one, the dates are harvest in July and August, outside this period, their palm trees are hardly maintained at all. They are often grown in clumps, due to the shoots that develop at the base of the mother plant. The second one, it is a more productive pheniculture. The palms that shade irrigated gardens are generally well pruned and pollinated. Their appearance contrasts with that of date palms in extensive gardens: well-developed stipe, green palms, they are grown with one, two, sometimes three or more stipes.

Both modes of cultivation are planted each year on new plots of land, both by nomads and by sedentary people, in order to ensure the continuous renewal of palm groves that are too old or have become sandy. There has even been an increase in the area planted over the last thirty-five years.

Environmental impacts

- Date palms have strong roots that hold well, even in sandy soil. This makes them useful in preventing soil erosion, especially in areas with poor soil quality. Date palms also prevent soil erosion by holding additional water and slowing down the flow of rainwater, which prevents fertile soil from being washed away in heavy rains[143].
- Date palms are drought resistant as they have been grown in dry areas throughout history. This makes them ideal for growth in dry climates where desertification is a problem and many other trees cannot be grown[144].
- Date palms can help reduce the temperature of the surrounding air[145].
- Date palms are also effective at removing harmful pollutants from the atmosphere[146].
- Date palm cultivation in the sub-Saharan countries suffers from a lack of effective propagation, pollination, protection procedures, and very low fruit quality[147]
- Date palm is not listed in the Chad tree species list in the Botanic Gardens Conservation International, So the conservation status in Chad is unclear. However, at global level it is listed as not under threat of extinction[148]

137 *Date Palm Status and Perspective in Sub-Sahelian African Countries. Mohamed Ben Salah. 2015*
138 *Date Palm Status and Perspective in Sub-Sahelian African Countries. Mohamed Ben Salah. 2015*
139 *Date Palm Status and Perspective in Sub-Sahelian African Countries. Mohamed Ben Salah. 2015*
140 *Date palm | Description, Uses, & Cultivation | Britannica.*
141 *Wikipedia*
142 *Le palmier du Borkou, végétal social total. Catherine Baroin. Pierre-François Pret, 1993*
143 *https://datepalmdubai.com*
144 *https://datepalmdubai.com*
145 *The Role of Date Palm Tree in Improvement of the Environment. Kadhim M. Ibrahim*
146 *The Role of Date Palm Tree in Improvement of the Environment. Kadhim M. Ibrahim*
147 *Date Palm Status and Perspective in Sub-Sahelian African Countries. Mohamed Ben Salah. 2015*
148 *https://www.bgci.org/resources/bgci-databases/globaltree-portal/species-search/?species=Phoenix+dactylifera*

Total amount of date palm tree in the models

- Moundou Shelter model: 143.75 kilos for the structure.

Common reed used in the shelter models[149]

The common reed (Genus Phragmite) It is a native species in Chad[150]. It is a wild grass which grows only in water, mostly in the waters of Lake Chad, and is renewed every rainy season.

Harvesting

It is harvested from its underwater roots, and this is managed by community members. It grows wild every year and renew themselves every rainy season.

Environmental impacts[151]

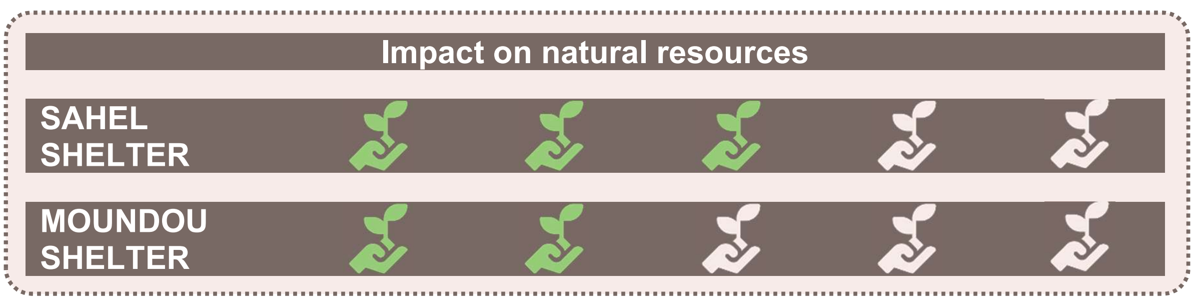
Common reed is not listed in the Chad tree species list in the Botanic Gardens Conservation International. So, it the conservation status in Chad is unclear. However, at global level it is listed as "least concern" on the IUCN Red list[152]

Total amount of common reed used in the models

- Moundou Shelter model: 402.5 kilos for the wall.

8.3.2. Interpretation of the results

Sahel Shelter model scored 3 out 5 and Moundou Shelter scored 2 out 5



1 poor, 2 average, 3 medium, 4 good, 5 very good

Moundou shelter model used more local natural resources, doum and date palm trees, as well as the common lake reed, compared to the Sahel shelter that only used doum palm. As the following analysis notes, the use of such local resources is not without concern. For this reason, the score is lower (worse) for the Moundou model.

On one hand these natural resources are used traditionally by the communities for many years, and the harvesting and preparation provides a source of income. But as the Shelter Cluster in Chad points out, "*in principle, the use of*

149 *Little formal information has been found about the common reed in Chad. Most information has been sourced from the local team in the field*
150 *https://www.cabi.org/isc/datasheet/40514#REF-DDB-150742*
151 *Information provided to the field team by the Directeur technique de l'ANADER in the Lac province*
152 *https://tools.bgci.org/plant_details.php?plantID=3403*

construction materials that are being sourced locally from the natural environment it is desirable. But in practice, the demand significantly outweighs the resources available. The number of shelters needed in comparison to the density of vegetation in the region poses a high risk of environmental degradation and accelerated desertification. In and around the majority of IDP settlements, severe degradation of trees and plants is already occurring"[153].

When asking different interviewees about the potential impact the natural resources used in the shelters could have on the local environment, the answers were mixed. What is clear, is that these resources all have multiple benefits for communities, and over-harvesting is a potential problem:
"These *palm trees provide food for camels and dromedaries who eat the leaves, if there are no leaves, they will die". "Trees provide shade for nomadic herders and travellers. Without trees, there is no shade and it is difficult to make long journeys without resting on foot".*
"*The use of date palm stalks and doum palm leaves, it is considered to be a good initiative because it is part of the development of the country's natural resources. However, a period of one year is needed for the uprooted stems to be able to renew themselves again on the same branch for both palms"*.
"The common reed that grows on Lake Chad, grows wild every year in the waters and therefore, even if they are cut, these renew themselves every rainy season, *they are used for construction of shelters and enclosures, and as the lake shrinks due to desertification, these common reeds are also disappearing"*.

So, the question whether the supply of these species could keep up with the demand from the shelters in Chad, when considering thousands of shelters in a crisis that keeps growing, remains unanswered. Overexploitation and climate change could have a negative impact on growth of the plants. While the quantities used for the shelters already built are unlikely to exhaust supply, it is difficult to estimate what the implication of many more shelters might be. However, the analysis is already sufficient to raise questions in future about a shelter model which uses so much local natural materials.

The score can be improved in the future by promoting mitigation strategies for some of these negative impacts, like including a reforestation/replanting or forest protection project, or advocating for such a project or partnering with a suitable local organisation who can make this happen in the relevant area. Note that this would also offset the overall carbon emissions generated, as well as ensuring protection of the local eco-system.

8.3.3. Household Energy and Fuel efficient cookstoves

As mentioned above, one of the three primarily impacts identified in the Shelter & Settlements Environmental Impact Report in the Lac Province of Chad is the overuse of wood for shelter and cooking energy[154]. Strictly speaking, the question of household energy and the use of wood biomass for cooking fuel is not an aspect of the shelter project being considered in this study. However, it is closely linked to the household needs of the displaced and it is too important an environmental issue to ignore.

Around 3 billion people still cook over an open fire, usually using some form of biomass (wood, charcoal etc.). In 2019 the Moving Energy Initiative (MEI) estimates that forcibly displaced families living in camps are burning 64,700 acres of forest (equivalent to 49,000 football pitches) each year[155]. In Lake Chad Region, firewood accounts for 97% of all cooking energy in IDP settlements, whereas biogas stoves, dried African palm fruits and animal excrement account for the remaining 3%. Households reported using roughly 8 tree branches per day for daily cooking needs, although the precise quantity was not confirmed. Most households cook on open fires as improved cookstoves (ICS) are not part of the NFI kits distributed by humanitarian actors. The predominant use of firewood directly accelerates the rate of deforestation and desertification already occurring in the region. Furthermore, the increasing scarcity of trees and wood can prompt an increase in inter-community clashes over resources[156].

153 *IDP Shelter & Settlements. Environmental Impact Report. Shelter Cluster Chad. March 2021*
154 *IDP Shelter & Settlements. Environmental Impact Report. Shelter Cluster Chad. March 2021*
155 *Cooking in displacement Setting. Engaging the Private Sector in Non-wood-based Fuel Supply. Laura Patel and Katie Gross. January 2019*
156 *IDP Shelter & Settlements. Environmental Impact Report. Shelter Cluster Chad. March 2021*

Chad is ranks[157] amongst the lowest countries in terms of its cooking energy capacities, having the highest number of household air pollution-related deaths in the countries studied, and little capacity to address this through either on- or off-grid solutions.

The question of household energy is a cross-cutting issue, often ignored by humanitarian agencies because it does not easily fit into one sector. There are the issues of health (indoor smoke pollution, harmful particulates in the air); environment (deforestation); protection (women and girls spending a lot of time collecting wood in insecure contexts); and also, the extensive time spent collecting wood and cooking on an open fire.

Where more sustainable fuels are not an option, fuel efficient cookstoves are a well-recognised solution to improve the sustainability of household energy. Affected populations generally have limited access to modern cooking solutions. Most either depend on insufficient humanitarian agency handouts of 'in-kind' firewood or have to travel long distances to collect firewood (in the latter case, exposing themselves to the risk of attack and/or sparking conflict with host communities). In many cases, host governments are recognising the environmental damage and are now pushing for change, banning in-kind firewood distribution or requesting humanitarian agency support to transition refugees to alternative more sustainable fuels[158].

As well as considering the impact of use of wood and other plants for the construction of shelters, future projects should also consider the use of wood for cooking fuel by the displaced living in the shelters, the impact of local forests, and how it can be reduced.

8.4. Criteria 4: Waste Management

When designing a shelter and choosing the construction materials, what happens to each material at the end of its useful life should be considered. Prolonging the life of each material by looking at the options for reusing or recycling contributes to reducing waste. The task is to find value in the waste, but unfortunately, once these materials are no longer used, most of them will end up discarded in open fields or unsafely burnt, contributing to pollution. In a country like Chad with a very weak waste collection, storage and treatment system, this is a major concern. This is especially relevant for those materials which take many years to decompose, potentially harming the environment for years to come. Thinking in advance of all the different waste management options in place should be a must for all programs.

In Chad, several ministries are involved in solid waste management (SWM), including The Ministry of Land Use, Housing Development and Urban Planning (*Le ministère de l'Aménagement du territoire, du Développement de l'habitat et de l'Urbanisme*), and The Ministry of Territorial Administration and Local Governance (*Le ministère de l'Administration du territoire et de la Gouvernance locale - MATGL*). However, apart from N'Djamena, the urban communes have very few resources[159].

According to the Shelter Cluster in Chad, "*To date there is no distinct practice of household waste management in IDP settlements, with few or no designated refuse pits or compost piles. The same can be said about local towns and villages. This is made especially evident by the amount of waste scattered throughout and near human settlements in the province. Although many durable items are reused and recycled in IDP settlements, solid household waste is typically burnt, buried, or left scattered. This can be particularly dangerous in the case of batteries among other potentially hazardous materials*" [160] Another challenge in IDP settlements, as pointed out by one of the interviewees "*IDPs may have less direct concern for the impact of waste on the land as they don't perceive it as "their" land, but just a place where they are stopping before going back "home".* This perspective can be a source of tension with the resident population, adding conflict prevention to the waste management issue. As IDP settlements become more long-term, there should be more options to move toward sustainability and local ownership.

157 *Global market analysis for electric cooking. MECS. https://mecs.org.uk/publications/global-market-assessment-for-electric-cooking/.*
158 *Cooking in displacement Setting. Engaging the Private Sector in Non-wood-based Fuel Supply. Laura Patel and Katie Gross. January 2019*
159 *Chad_FR.pdf (africancleancities.org)*
160 *IDP Shelter & Settlements. Rapport d'impact environnemental. Shelter Cluster Chad. March 2021*

Attempts have been made to identify what initiatives, private companies, start-ups, etc. exist in the country for solid waste management and recycling options, but without success. This may be because there are very few such examples. The global Joint Initiative on Sustainable Humanitarian Assistance Packaging Waste Management[161] was also contacted. One of the activities they are working on in partnership with the Global Logistics Cluster is to map out recycling and waste management infrastructures in countries with humanitarian contexts. However, at the moment Chad is not one of these countries[162].

In the two tables below examine for each of the shelter materials, how long they take to decompose, if they can be reused and recycled, and what the options are – both in theory (Table 6), and the potential in Chad (Table 6). It is important to note that the rate of decomposition can depend upon disposal or landfill conditions. Also, the recycling options are based on potential from other neighbouring countries (Niger) or ideas shared by some of the interviewees. No actual examples have been found in Chad during the research.

Table 5

Material	Life expectancy[163]	Time to decompose	Reuse	Recycling
Plastic sheeting	1 year[164]	500 to 1000 years	Yes	Yes
Plastic mats	6- 12 months[165]	500 to 1000 years	Yes	Yes
PVC	1 years[166]	450 years[167]	Yes	Yes. However, PVC products cannot easily be separated for recycling, which makes breaking vinyl products down into their original components nearly impossible.
Steel poles	1 year[168]	200 to 500 years[169]	Yes	Yes
Wire	*2 years*[170]	200 to 500 years	Yes	Yes
Nylon	*3 years*	40 years[171]	Yes	Yes
Doum palm mats	1 year[172]	Yes 100%	Yes	No
Date palm stems	More than 5 years	Yes 100%	Yes	No

161 *Information can be found at https://eecentre.org/2019/07/15/https-www-eecentre-org-2019-07-15-sustainable-humanitarian-packaging-waste-management/*
162 *The information is then uploaded onto the Global Logistic Cluster LCA; https://dlca.logcluster.org/display/public/DLCA/LCA+Homepage.*
163 *Information provided by the field team through direct observation on the field.*
164 *According to the field team; the time when the first damage appears vary, and it depends when the shelter was constructed. It happens faster during the dry season, where the shelter is exposed to strong winds and high temperature, that sometimes exceeds 45°C*
165 *According to the field team; it depends on the context and exposure to the sun. First damages can appear 3 months after the construction, if it has been exposed to the sun, and 12 if they have been protected from the it.*
166 *According to the field team; under normal circumstances, if the beneficiary does not hang objects on the roof, the PVC can last up to 12 months before deforming. This also depends on the cladding, PVC tubes that are well installed last longer.*
167 *https://expandusceramicsquestions.com/qa/how-long-does-pvc-take-to-decompose.html*
168 *According to the field team; first damage (oxidations) appears from the 7th / 8th to12th months, depending on the quality of the rust inhibitor applied by the manufacture.*
169 *How long does it take for metal to degrade - Riba Farré (ribafarre.com)*
170 *This usually rusts*
171 https://www.dnr.sc.gov/up2u/decompose.html
172 *According to the field team; the mats can last 1 year or more, if they are sheltered from strong winds, rain and domestic animals. However, the first damage can appear during the raining season, if they are exposed to the water, so they start deteriorating.*

Common reed brunches[173]	6-12 months	Yes 100%	Yes	No
Basswood timber	4 years[174]	Yes 100%	Yes	No
Doum-palm rope	1 year[175]	Yes 100%	Yes	No

Table 6: Potential options in Chad

Material	Potential Reuse option[176]	Potential Recycling options[177]
Plastic sheeting	• To reuse for auxiliary construction (e.g.: roofing for showers or shelters, smaller sun shades, walling) • Interior floor mats, covering exterior cooking areas[178]. • As lining for rainwater runoff collection, to be used for watering of community kitchen gardens and/or as drinking water for herds. • Privacy screens around latrine pits[179].	• Production of latrine slabs, paving stones, racks and gutters
Plastic mats	• To reuse for auxiliary construction (ex; roofing for showers or shelter) • Sleeping mats.	• Recyclable through the production of latrine slabs, paving stones, racks and gutters
PVC[180]	• Handicrafts (earrings, home decorations/accessories, etc.) • Made into various functions; can be cut and glued together	• Crushing and export
Steel poles	• Information not provided	• Made into various functions if welding is available. Collect and take to N'Djamena for recycling. • Compacting and export
Wire	• Handicrafts (earrings, home decorations/accessories, etc.) • Used for various functions – can be used for attachments of reused mats, etc	• Collect and take to N'Djamena for recycling. • Compacting and export
Nylon[181]	• Re-use as rope	• Input for making bags, baskets, satchels, etc.
Doum palm mats	• They are not reused	• Not relevant
Date palm stems	• To reuse for auxiliary construction (construction of new shelters or latrines) • Combustible wood • Resell at the local market	• Information not provided

173 *According to the field team; common reeds brunches are vulnerable to termites and pets rubbing. Also, rain reduces their resistance to high winds.*
174 *According to the field team; basswood timber can be used for a long time if they are protected against termites. However, in the lake area in Chad termites are rare.*
175 *According to the field team.*
176 *Information provided by the field team through direct field observations, and from the Global Shelter Cluster community of practice.*
177 *Based on potential from other neighbouring countries (Niger) or ideas shared by some of the interviewees*
178 *IDP Shelter & Settlements. Environmental Impact Report. Shelter Cluster Chad. March 2021*
179 *IDP Shelter & Settlements. Environmental Impact Report. Shelter Cluster Chad. March 20211*
180 *https://expandusceramicsquestions.com/qa/how-long-does-pvc-take-to-decompose.html*
181 *https://www.dnr.sc.gov/up2u/decompose.html*

Common reed brunches	• Combustible wood	• Information not provided
Basswood timber	• Combustible wood • Resell at the market	• Information not provided
Doum palm rope	• They are not reused	• Not relevant

According to the field team, most of the materials are discarded once they are no longer used or reach an advanced state of deterioration (wire, doum palm mats, plastic sheeting, plastic mats and doum palm rope), or used as firewood (date palm stems, doum palm mats, common reed brunches and basswood timber) or directly burnt (plastic sheeting). Which contributes to air pollution.

On the questions of packaging and single-use plastics, the field team confirmed that only the plastic sheeting comes packaged in plastic. Attempts could be made to eliminate this, in discussion with suppliers. Note that Chad has banned the use for plastic bags in N'Djamena[182], however this is not enforced as they continue to be sold and used in the capital's markets and shops[183].

8.4.1. Interpretation of the result

In the score card, Sahel Shelter model scored 1 out 5 and Moundou Shelter scored 2 out 5.

1 poor, 2 average, 3 medium, 4 good, 5 very good

As it can be seen from the two tables, most of the materials have the potential for reuse or recycling, and on top of this, both shelter models have been designed to be easily dismantled and transported, enabling the material to be easily reused, recycled or even sold. But when thinking about disposal options, it became more challenging, and this is where the two models diverge and the reason why Sahel Shelter scores worse in comparison to Moundou Shelter.

From an environmental perspective, answering the question of how long it takes various types of waste to decompose is of great importance. The consumption of products that generate waste that takes a long time in landfill to completely decompose, should be reduced. From this perspective, one of the biggest concerns is plastic, and the Sahel Shelter uses a lot more compared to Moundou Shelter. Not only plastic sheeting, also the very polluting PVC, and the steel tubes, which also take long time to decompose. While Moundou uses timber and natural resources, for which the time of decomposition is much less of a concern. However, most of these natural materials end up being burnt or used as firewood. By doing this, it releases the carbon that they captured during their growth into the atmosphere, thus reversing much of the 'positive' benefit. Special attention should be focused on avoiding this, however it must be acknowledged that this is be challenging, since affected families depend on firewood for cooking energy. In the other hand if this materials are burned for cooking or heating then there is an offset against other combustibles not used.

182 https://www.privacyshield.gov/article?id=Chad-Prohibited-Restricted-Imports
183 https://tchadinfos.com/tchad/tchad-interdits-dutilisation-les-emballages-en-plastique-font-un-retour-en-force/

Also, good quality materials and construction practices are important. Both affect the durability of the shelter, and therefore the materials, by increasing their life expectancy. As the Chad Shelter Cluster notes, "*This gap in construction and maintenance knowledge significantly impacts the durability of the shelters. Poor construction not only poses safety risks but increases the material turnover period, further compounding the environmental impact of shelter construction."*[184] So promoting this is a must in every programme. The life expectancy of the Moundou shelter's materials is shorter than the Sahel shelter. Taking this into account, together what happens with the Moundou materials at the end of their useful life, makes the score to be relatively low.

However, many of the materials do have possibilities for reuse and even recycling. However, the reality is that while reuse is already happening, given the Chad waste management context, recycling is unlikely to take place unless proactive steps are taken.

The score card can be improved in the future by promoting different waste collection and recycling projects. Connecting communities to recycling companies, or helping them putting a system in place, will not only improve the waste management situation, it can also create income generating opportunities for the communities. All efforts to reduce or eliminate plastic packaging should be made – although in this case it is only relevant for the plastic sheeting.
Raising awareness of the pollution generated by the disposal of the products, though advocacy with communities, or projects in partnerships with other organisations, would also be a way of mitigating the waste impact. Also, promoting the composting of the organic materials would make a big difference, instead of burning them. But this would require parallel efforts to decrease the dependency of families on firewood for cooking, by promoting cleaner fuels of more fuel-efficient cookstoves.

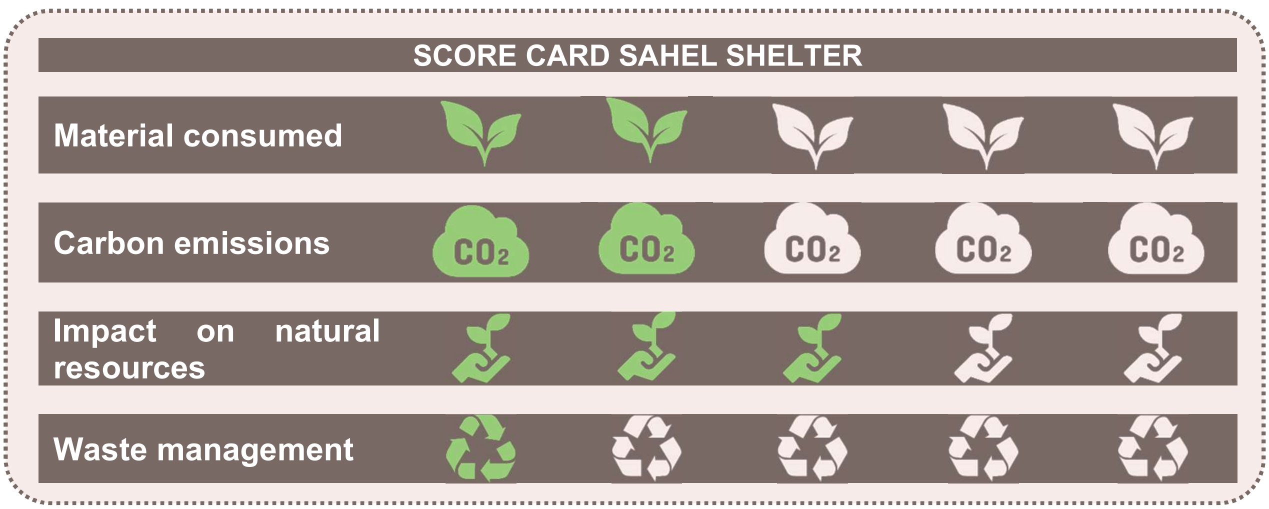
184 *IDP Shelter & Settlements. Environmental Impact Report. Shelter Cluster Chad. March 2021*

8.5. Summary: Sahel Shelter vs Moundou Shelter Models

Summary of the results for each model, conclusions are drawn in section 9.

SAHEL SHELTER MODEL

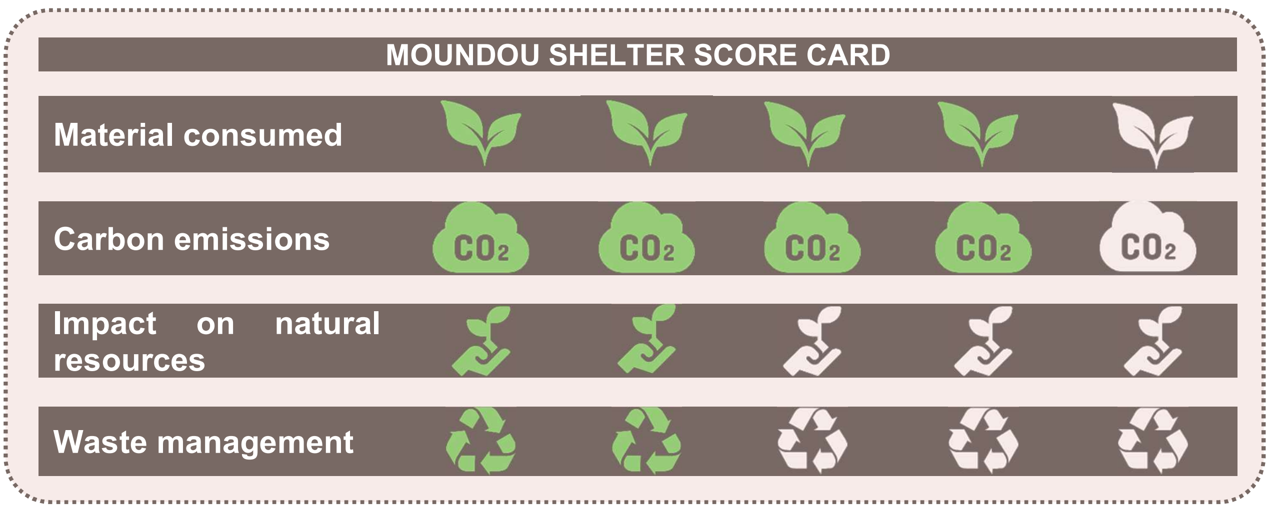
Summary of the environmental impact SAHEL SHELTER		
Raw material used	Doum palm tree Water consuption	109.2 kilos 20,898 liters
Manmade material used in kg	Steel PVC Plastic Nylon	28.5 kilos 36.4 kilos 11 kilos 0.5 kilos
Carbon emissions in kg CO_2 eq	Production of material Packaging Transport End of life Total for shelter	41 *Data not available* 85 117 **243**
Impact on natural resources	Deforestation and erosion due to the harvesting of natural or farmed vegetation (palm)	
Waste managment	Almost all the materials have potential for reuse or recycling. However, it practice much is discarded. The biggest concern is the time that most of the materials take to decompose, especially the plastic products, and that the organic materials end up being burnt, polluting the air.	



1 poor, 2 average, 3 medium, 4 good, 5 very good

MOUNDOU SHELTER MODEL

Summary of the environmental impact MOUNDOU SHELTER		
Raw material used	Doum palm tree Date palm tree Common reed Basswood timber Water consuption	67 kilos 143.75 kilos 402.5 kilos 92.3 kilos 505.5 liters
Manmade material used in kilos	Steel Plastic Nylon	0.5 kilos 9 kilos 0.25 kilos
Carbon emissions in kg CO_2 eq	Production of material Packaging Transport End of life Total for shelter	-778 *Data not available* 55 656 **-67**
Impact on natural resources	Deforestation and erosion due to the harvesting of natural or farmed vegetation (palms and common reed).	
Waste managment	Almost all the materials have the potential for reuse or recycling. The shelter uses materials that are easy to decompose, however at the moment they end up being burnt. The wire, plastic sheeting and nylon take a long time to decompose, but are used in small quantities.	



1 poor, 2 average, 3 medium, 4 good, 5 very good

9. Conclusion

The importance of examining in detail the entire life cycle of each shelter and each material, from production through to end of life, has been emphasised throughout this study. The criteria consider not only carbon emissions, but other factors, like use of local natural resources and waste management. While the need to reduce carbon emissions is critical and increasingly well acknowledged today, it is also clear that waste is one of the hidden problems of the humanitarian world. It is usually ignored during project design, and rarely discussed at more strategic levels.

Comparing the two shelter models requires us to balance relative sources of environmental harm across the different criteria. The scope of this remote study and the limited access to environmental information from Chad does not allow for a quantitative weighting for each criteria, leading to a numerical score. An overall qualitative comparison is all that is feasible.

Between the different options the “least harmful solution” should be adopted. The idea that there is a perfect shelter solution that ticks all the boxes is not realistic. Not only regarding the environment, but also the other factors that need to be considered: technical performance, durability, habitability, affordability, cultural aspects, etc.

So, while one solution complies better with some of these factors, another is better according to other factors. The same can be said about the criteria analysed. For example, Moundou shelter has much lower carbon emissions (a higher score in the score card), however its impact on the local environment due to the amount of natural resources used is worse (a lower score for this criteria). This is one of the benefits of using the score card approach, to highlight which shelter complies better with which criteria, as well as to help identify mitigating solutions.

The final verdict rests on the available options to mitigate some of the worst concerns, which if adopted in future could reduce the overall environmental impact of the shelters. When there is damage to the environment due to our actions, for example deforestation or over-harvesting of the palm doum, mitigation measures should be adopted, like reforestation or replanting projects. It is recommended that an environmental impact assessment or at least environmental screening such a NEAT+[185], and following that identification of mitigation strategies, should accompany the design of all shelter and site planning activities.

Overall, the Sahel shelter model scores better regarding the impact on local natural resources, while the Moundou shelter model scores better on materials consumed, carbon emissions and waste management. Sahel shelter uses more long-lasting materials that are unlikely to be recycled, and will take a very long time to decompose, polluting the environment for years to come, but on the other hand making the shelter more resistant with a longer life span. The biggest challenge with the Moundou Shelter model is the amount of local natural materials used, and what impact their harvesting can have on the already fragile environment on Chad. But its biggest benefit is that once the materials are no longer needed, most of them will decompose rapidly.

Most shelters built in Lac Province in the IDP settlement require reconstruction after 6 months or less of use due to the harsh environmental factors and poor resilience of materials[186]. So, it is important to recognize that the longer a shelter lasts, the more efficient and cost effective it is[187]. This semi-permanence may not be initially acceptable as it implies that the reasons for displacement will continue beyond tomorrow. But it makes sense when the designs are such that they can be deconstructed and become movable assets for their owners. In this sense, both models have been designed for this purpose. However, the Sahel Shelter model has a longer life span than the Moundou shelter.

Keeping this in mind, as well as noting that the Sahel shelter uses long-lasting materials that will take a very long time to decompose, mitigating actions can be taken to reduce its worst environmental as follows:

(1) Set up a project component for reusing, repurposing or recycling (R3) the materials once the shelter gets to the state it has to be replaced. The R3 process can be a livelihoods generator as well. This is especially for

185 *https://neatplus.org/*
186 *IDP Shelter & Settlements. Environmental Impact Report. Shelter Cluster Chad. March 2021*
187 *In the Shelter & Settlements Environmental Impact Report, Shelter Cluster Chad. February 2021, graph Cost vs Durability*

the plastics sheeting, PVC, and plastic mats, because it can be assumed that the metal poles have a good likelihood of continual reuse.

(2) To ensure that the doum palm supplies are not over-exploited. Promoting reforestation and replanting projects, Small-scale projects could be included as part of the shelter programme, such as supporting communities to replant palm doum. Larger scale efforts could be in partnership with specialist organisations.

(3) To consider to use different materials, especially replacing the PVC and metal tubes which have the highest embodied CO_2 emissions, or reducing the amount used without compromising the quality of the shelter. Of course this must be balanced against reducing the life-span of the shelter.

(4) Consider to use more long-lasting material for roofing, which would also be more likely to be reused. Example, metal sheeting for roofing instead of plastic sheeting, which lasts only one year.

(5) Invest in purchasing carbon off-sets for the CO_2 eq produced (following one of the many internationally recognised certification standards.

The Moundou Shelter model has been designed taking into account the hash climatic conditions of the region. In general terms affected families are also satisfied with the model, except they would rather have metal sheeting for roofing, instead of plastic sheeting, which often deteriorates because of the strong winds and high temperatures[188]. This goes in line with the Shelter Cluster recommendation in Chad. As of July 2021, the Shelter Cluster officially recommends shelters that use metal sheeting for roofing, as the preferred option for emergency shelters. This is based on durability, cost and overall environmental impact. The shelter cluster also advised against the use of shelter designs that use plastic sheeting for siding/walls and roofing, since the use of plastic sheeting has proven to be the least durable and least adapted do the climate[189].

In the case of the Moundou Shelter model, the project should consider some of the following mitigating actions which could significantly reduce the environmental impact of the shelter:

(1) Advocating with communities to avoid burning the natural materials once they are no longer needed, due to the amount of CO_2 eq that is released during this process. It is better the wood is reused, and the palms and common reed allowed to decompose.

(2) Set up a project component for reusing, repurposing or recycling (R3) the materials, specially the plastic sheeting once it gets to the state it has to be replaced. The R3 process can be a livelihoods generator as well.

(3) Promoting reforestation and replanting projects, to ensure that natural materials are not over-exploited. Small-scale projects could be included as part of the shelter programme, such as supporting communities to replant palm doum. Larger scale efforts could be in partnership with specialist organisations.

(4) Consider to use more long-lasting material for roofing, which would also be more likely to be reused (example; metal sheeting for roofing instead of plastic sheeting)

(5) Carefully examining sustainability issues with the suppliers for the sourced basswood timber, even if is not purchased locally, to ensure over-extraction or other environmental damage is not happening. The alternative could be identifying a supplier that can source wood locally. The wood should come from a sustainable plantation and it should also ensure over-extraction or other damage won't happen. This would also reduce carbon emissions from transportation of the timber.

This study does not make a definitive recommendation of one shelter over the other. However by adopting some of these mitigating solutions in future, both shelters can incorporate the environmentally 'best' aspects in their designs.

188 *As per information provided by the field team,*
189 *IDP Shelter & Settlements. Environmental Impact Report. Shelter Cluster Chad. March 2021*

10. Recommendations

Recommendations from the environmental analysis

A. Materials

1. Further study on the risks of overexploitation of the doum palm, date palm and common reed, and explore other alternatives if necessary. Include reforestation or replanting projects within the shelter programme. Either directly with communities, or if on a bigger scale through partnerships with other specialist organisations. See below recommendation on protecting / restoring local eco-systems.
2. Consider to avoid using PVC, since it is one of the most polluting materials and which has the highest embodied CO_2 emissions.
3. Further study if there are other alternatives to the plastic sheeting by using metal sheeting for roofing, as recommended by the Shelter Cluster. However, further study on the impact on the environment and mitigation strategies should also be considered for these alternative materials.
4. Market assessment and supply chain analysis to identify alternatives for wood framing, as well as materials with increased durability and structural integrity.
5. Carefully examining sustainability issues with the suppliers for the sourced basswood timber, even if is not purchased locally, to ensure over-extraction or other environmental damage is not happening. The alternative could be identifying a supplier that can source wood locally. The wood should come from a sustainable plantation and it should also ensure over-extraction or other damage won't happen. This would also reduce carbon emissions from transportation of the timber.

B. Reduce carbon emissions

1. Advocate with communities to avoid burning the natural materials once they are no longer needed, due to the amount of CO_2 eq that is released during this process. By promoting composting. This could be difficult to implement in a country like Chad, where families often rely on burning organic matter for cooking fuel. This can be partially addressed by integrating some activities on household energy (see point E below).
2. To procure more "locally", especially the steel tubes and wire.
3. To consider to decrease the amount of materials if possible, without compromising the quality and durability of the shelter.
4. Carbon offsetting: Another way to pursue carbon neutrality is to offset emissions generated by reducing them somewhere else, or by purchasing carbon credits[190] from a project that has been accredited by a recognised standard[191].

C. Waste management practices

1. Raising awareness of environmental sanitation and the pollution generated by the disposal of the materials, though the programme (link to WASH), or through advocacy in partnership with other organisations.
2. Cataloguing the type and quantity of waste. This is useful in defining what can be done under #3
3. Defining how to turn waste into value. Materials can be collected and reused as raw materials in other products, especially those materials that take a long time to decompose, like plastic sheeting or steel tubes. This can easily be linked with livelihood or education programmes. The most common is to turn organic waste (human and animal) into compost. Other things, like plastic sheeting can be transformed into bags, coats, etc.[192].
4. Through community engagement, encouraging people to brainstorm what can be done with the items.
5. Set up a reuse/recycling/repurposing site to sort and process the waste. A bit away from the main camp, preferably with a water supply or water storage.
6. Hire people to run the waste processing. This can be a good "cash" transfer/livelihoods support option.
7. If possible, link communities to private waste companies to collect materials which are not reused, for recycling. There is also the possibility to generate income for communities from this.

190 *One potentially interesting case study in Chad that might be of use as an example of how the provision of stoves can impact refugee settings is the CooKit Solar Cooker, which utilised carbon credits from saving CO2 emissions to facilitate expansion of the programme https://www.fairclimatefund.nl/en/projects/chad-solar-cookers-for-refugee-families*
191 *European Parliament*
192 *recycling_reuse_and_disposal_of_plastic_sheeting.pdf (sheltercluster.org)*

8. Reduce the packaging for all material, or support the reuse of this for other purposes.

D. Protecting / restoring local eco-systems

The Chad Shelter Cluster encourages planting trees as part of a compensation effort for the wood used in shelter construction. But it is important to be aware that actions involving reforestation and land can be seen as statements of ownership from a cultural perspective. This could be an issue in Chad. Planting trees could be a source of conflict if not well managed. There is also ongoing care and maintenance required for such initiatives, which is never easy to sustain.

To engage in such an initiative in an IDP or refugee context:

1. All actions should be approved by local government and traditional leaders. (each village in Chad has one or more individuals charged with allocating land and adjudicating land disputes. If they exist, they need to approve any plans.)
2. Ownership of the land, trees and produce from the trees, including branches and when a tree is coppiced, needs to be agreed with local leaders and land owners. For instance, an IDP-planted tree may be owned by the land owner, but the fruit can be used by the IDP as long as they are present at the location. These types of agreements may seem complicated, but are normal within a society.
3. Any environmental improvements should not be done by the IDPs alone. If this is the case, then the local host community will not have ownership and any actions will probably not be maintained after the IDPs leave.
4. Another solution for IDP camps, is not to place plants in the ground, but to do something less fixed, like a *permaculture-in-drum*[193] approach.
5. Approach other organizations in the country, which already have experience providing families with fruit tree plants, like IOM.

E. Household energy and cooking stoves

The project could consider to provide families with access to cooking stoves that do not rely on organic materials, and rely more on solar power or alternative fuels; or at least are more fuel-efficient if they have to burn wood fuel. It will reduce the dependency on firewood and pressure off of forest resources:

1. First priority is to work with the current practices (e.g., reduce demand, change behaviour where possible) and then encourage a more sustainable type of fuel (e.g., gas). But if this is not possible then improved cook stoves can make a difference, some can reduce fuel (wood) consumption by up to 60% compared to an open fire.
2. There are many cook stoves available on the market[194]; also, there are various simple designs that can be manufactured from locally available materials. There are also devices (like insulated cooking bags) that are not stoves, but also speed up the cooking time and use less wood.
3. A choice must be made between procurement of stoves; and encouraging local production of fuel-efficient stoves. Either way extensive market analysis is required. It is not just a case of buying stoves and distributing to communities, as this seldom has a sustainable outcome. Many cook stove projects have not delivered the improvements they should have, due to poor design. Again, careful analysis of local preferences, what is available on local markets, what could be produced is required. Not just blindly importing new cook stoves.
4. A link to livelihoods is often encouraged – where people can be trained to manufacture cookstoves locally, as a livelihood. However, there are many examples in Africa where this has not been very successful.
5. UNHCR's Cooking Options in Refugee Situations Handbook[195] particularly Annex A, shows a cooking energy checklist, which highlights some of the key considerations for practitioners looking to implement cooking-related programmes.
6. One potentially interesting case study in Chad that might be an example of how the provision of stoves can impact refugee settings is the CooKit Solar Cooker, which utilised carbon credits from avoided CO2 emissions to facilitate expansion of the programme https://www.fairclimatefund.nl/en/projects/chad-solar-cookers-for-refugee-families

193 *(Example: 2000-liter drum, cutting it in half, filling it with rocks and soil and planting a tree). Waste water is used to water the tree and tree can be moved (or even sold off) when the IDPs move. The tree itself can provide shade, provide fruit or be coppiced to provide wood for making things. An advantage of a garden-in-barrel approach is that all the materials needed, knowledge of what to grow and seeds or cuttings are available in Chad. It is the kind of thing where you get 10 families doing it and others will figure it out.*

194 *Standardizing the Performance of Clean Cooking Solutions, Clean Cooking Alliance, Clean Cooking Catalogue https://cleancooking.org/research-evidence-learning/standards-testing/*

195 *https://www.unhcr.org/uk/protection/environment/406c368f2/handbook-experiences-energy-conservation-alternative-fuels-cooking-options.html.*

F. Others

1. Advocate and work with the Shelter Cluster working group and other partners in Chad to pass key environmental messages, including some of the findings from the Shelter & Settlements Environmental Impact Report, from the Shelter Cluster Chad.
2. Advocating for reforestation and ecosystem restoration programmes more broadly, to help with Chad's environmental problems. This requires a nexus approach to deploy longer-term funding for climate change adaptation and environment.

General recommendations to consider for future programmes

G. Design

1. Design a shelter that allows the materials to be easily dismantled and transported if relocation occurs, to enable reuse.
2. Incorporating vegetation on the site can promote water retention and reduce flooding. This can be done by promoting replanting projects; also by careful protection of any existing ground cover and vegetation.

H. Materials

1. To encourage the use of construction materials of an appropriate quality and which consider climate, culture, durability, local supply and environmental impact[196]. This does require some research on the ground.
2. To encourage and promote procurement of construction materials based on quality, environmental, social and economic considerations[197]. Local procurement is often, but not always, more sustainable, so careful analysis is needed.
3. Use long lasting products and materials, to minimize the replacement and allow a second life through reuse.
4. No single-use plastic wrapping or packaging on any materials, work with suppliers to eliminate this.

I. Reduce carbon emissions

1. Procurement choices:
    - Select manufacturing companies that produce 'green' products or from countries that have demonstrated results in terms of lower carbon emissions through good governance and investment in clean energies.
    - Ensure that acquired products were manufactured under acceptable conditions in terms of environmental compliance.
    - Use locally produced and purchased shelter materials, if acceptable quality can be guaranteed.
2. Transportation routes.
    - Optimize the logistics supply chain to reduce the carbon footprint from transport.
    - Reduce weight and volume, noting that packaging can be relevant here also.
    - Take into account that transportation by road, sea and air can also lead to a significantly different emission. In the African case, ocean shipping is better than long distances by road, while of course air transportation is the worst.
3. Manufacturing phase: There are fewer opportunities to reduce carbon emissions at the manufacturing phase, but influence can be exerted by:
    - Try to support wood suppliers with FSC certification, which can reduce carbon emissions indirectly as plantations growing trees sustainably means that each felled tree is replaced with new trees. The carbon emitted by the felled trees will be sequestered by the growing trees, hence use of sustainably sourced timber can potentially be carbon neutral or even carbon negative (D'Arrigo et al. 1987). Or by favouring manufacturing processes that facilitate pollution control.
3. 'End of Life' phase: emissions from natural materials can be greatly reduced if composting or decomposition is promoted, instead of burning.

196 *Further information can be found at QSAND manual MW01 Material Properties / Specifications*
197 *Further information can be found at QSAND manual MW02 Material sourcing*

4. Carbon offsetting: purchasing carbon credits from a project that also delivers benefits to local communities, and has accreditation from a recognised international standard.

J. Waste management practices

1. Waste management practices should be taken into consideration, ideally early in the planning phase. This means selecting materials with higher probability of reuse, and investigating how communities can be linked to private sector recycling firms for those materials which can be recycled locally.
2. Integrate solid waste management initiatives in disaster-affected communities, at least with community education, waste reduction, waste collection and sorting. Promote the concept of the circular economy, and that waste can have a value if appropriate linkages are made to external partners and companies.[198]

K. Local natural environment

1. To advocate for, and if possible participate in the development and implementation of a locally appropriate Action Plan which will identify existing ecosystem services and facilitate effective management of human activity in the natural environment[199]. Given that this is outside the normal expertise of humanitarian actors, it will require a Nexus approach, working in partnership with development and environmental stakeholders.
2. To encourage the protection, restoration, rehabilitation and enhancement of the ecological value of the site during settlement or re-settlement and the operation of the site[200].

L. Others

All shelter projects should do, as a minimum, a basic environmental assessment (often referred to as an environmental screening) as part of the planning and design process. Tools like the NEAT+[201] are designed for humanitarians for this purpose. Whether or not a more detailed and technical EIA is required will depend on the scope and complexity of the project, the sensitivity of the environmental context, and also local regulations. Indeed an environmental screening may recommend that a full EIA is done.

198 *Further information can be found at QSAND manual MW05 Operational Waste Management*
199 *Further information can be found at QSAND manual NE01 Human Relationships to Ecological Services*
200 *Further information can be found at QSAND manual NE03 Ecological Restoration and Rehabilitation*
201 *https://neatplus.org/*

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- https://www.sheltercluster.org/community-of-practice/environment
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12. Annexed documents

ANNEX 1 – Term of Reference

TdR étude comparative de l'impact environnemental des modèles d'abris au Tchad

Contexte et Justification

L'Aide Internationale de la Croix-Rouge luxembourgeoise (AICRL) intervient depuis plusieurs années dans le domaine des abris d'urgence et de l'habitat durable dans la région du Sahel. Elle collabore étroitement avec le IFRC Shelter Research Unit (IFRC-SRU) dans le cadre de développements de modèles d'abris adaptès aux conditions climatiques et contextes culturels sahéliens. De nombreuses missions de recherche ont permis de développer des modèles d'abris tenant compte des spécificités (contextes) et de la disponibilité du matériel au niveau local. Dans le cas particulier du Tchad, l'AICRL et la Croix-Rouge tchadienne ont réalisé 2 modèles d'abris. Le premier modèle d'abri construit au Tchad est de type sahel Shelter stockable développé par l'AICRL au Niger et au Burkina. Cet abri d'urgence a été construit au sud du Tchad, en 2018 dans un camp de réfugié (Camp de Belom, département de Maro). Le deuxième modèle d'abri est en expérimentation, dans le cadre de la mise en œuvre de nos projets d'urgence dans la province du Lac et est basé sur l'architecture traditionnelle de la zone d'intervention. Ces abris sont de forme rectangulaire avec une toiture en voute. Les chevrons sont utilisés pour les poteaux en remplacement du bois local pour éviter la coupe abusive du bois (interdiction par le ministère de l'environnement). Les murs sont en caille et nattes végétales et la toiture en fait de tige de dattier, de nattes végétales, de caille et couverte de bâche.

L'expérience acquise sur le terrain et des retours des bénéficiaires recueillis par les équipes projets et les volontaires formés, AICRL souhaite de capitaliser ces expériences et les ressentis des bénéficiaires sur les modèles conçus par l'AICRL et adoptés par tous les acteurs humanitaires aux différentes payses du Sahel. Cependant, un facteur clé n'a pas été analysé en détail, l'impact environnemental comparatif des différents modèles d'abris. Ceci est nécessaire pour comprendre quelle sont réellement les options les mieux adaptés au contexte sahélien et alignée sur la tendance mondiale actuelle à améliorer la durabilité environnementale de l'aide humanitaire.

La première activité de construction d'abri au Tchad s'est déroulée en 2018 dans le département de Maro(camp de belom) ou l'AICRL a assisté 6000 personnes par la construction de 505 abris d'urgence, réhabilité 695 maisons durables et formé 85 volontaires de la Croix-Rouge du Tchad (CRT) sur le montage et le suivi des activités de constructions de logement en situation d'urgence. Un an après, l'AICRL et la CRT signent pour six ans une convention générale de partenariat qui officialise la mission au Tchad. Cette convention générale de partenariat, marque également le début de deux projets. Il s'agit d'un projet d'urgence qui consiste en la construction de 180 logements, 180 latrines, 180 foyers améliorés et la distribution de 450 kits intrants agricoles clôturé en mai 2020. Actuellement, un projet de développement sur trois ans est en cours, axé sur l'autonomisation des populations hôtes et les retournés tchadiens revenus de la RCA. Ce projet consiste en l'utilisation de l'approche PASSA, la construction de 490 maisons durables et latrines dans la sous-préfecture de

Yamodo. Un autre modèle d'abri d'urgence de type Sahelien a été monté dans la province du lac en proie à des conflits armée.

En 2021 l'AICRL a mené une étude équivalente pour le Niger dont les résultats sont disponibles. La présente étude cherche à s'appuyer sur la même méthodologie afin d'obtenir des résultats comparables et de pouvoir analyser l'impact environnemental et fournir des recommandations pour l'ensemble de la région.

Outcome

- Avec le soutien de l'SRU, l'AICRL cherche à réaliser et améliorer la qualité de la réponse en matière d'abris dans le pays et minimiser l'impact environnemental de nos opérations.

Output

- Une étude comparative des différents modèles d'abris au Tchad. Cette étude individuelle (Tchad) fait partie d'un travail comparatif dans quatre pays de la région (Tchad, Burkina Faso, Niger et Mali)
- Recommandations pour réduire l'impact environnemental des interventions d'abris de l'AICRL
- Une étude portant notamment sur l'utilisation de la bâche en plastique et son impact sur l'environnement ainsi que sur les alternatives possibles.

Produit et format a livrée

- Rapport d'Etude.
- Format prédéfini.
- Taille a4.
- Langue française et anglais.
-

Approche méthodologique

Ce qui suit est une proposition initiale de méthodologie. Elle pourra être ajustée au fur et à mesure de l'avancement de la consultation, en discussion avec le responsable technique du AICRL, en fonction des informations trouvées, des délais disponibles et de toute contrainte liée au travail à distance. Cette méthodologie correspond à celle utilisée dans l'étude de 2021 menée au Niger. Pour maintenir la cohérence de l'étude comparative entre les quatre pays du Sahel qui font l'objet de ce projet, la même méthodologie doit être suivie, en l'adaptant aux circonstances particulières de chaque contexte lorsque cela est nécessaire et justifiable.

Recherche documentaire et définition du problème

- Analyse documentaire : documentation du programme (y compris la logistique/chaîne d'approvisionnement) ; profil environnemental du Tchad, etc.

Collecte et analyse des données

- Entretiens avec des informateurs clés (semi-structurés) : avec le personnel de la AICRL (abris, logistique, autres) ; d'autres agences d'abris / cluster ou secteur Abris (ou le groupe de travail abris) ; acteurs locaux / gouvernement (si nécessaire).
- Brève revue des nouvelles meilleures pratiques en matière d 'analyse du cycle de vie / outils d'empreinte carbone.

- Discuter et préparer avec l'équipe de terrain pour un suivi léger des abris sur le terrain (en particulier pour déterminer la durée de vie utile des abris ; également la réutilisation des matériaux). Supposons que ce ne soit pas quantitatif
- Calculs des émissions de carbone des différents types d'abris.
- Analyse des autres facteurs environnementaux des abris.
    - La durabilité des sources des ressources naturelles utilisées
    - Options d'élimination et/ou de réutilisation en fin de vie des matériaux (perspective de gestion des déchets).
- Analyse de différents types de couverture (bâche, tissues, matériaux naturels)
    - Prise en compte du processus de fabrication, des ressources naturelles utilisées, des émissions de carbone, de la biodégradabilité, de la durée de vie utile, etc.
- Rédiger le rapport et le partager avec le responsable technique du AICRL.

Conclusions et rapport

- Commentaires et validation du rapport.
- Présentation des résultats au personnel du AICRL et groupes sectoriels abris, réunions de suivi
- Rédaction finale

Un suivi détaillé sur le terrain, des enquêtes, etc. ne sont pas prévus et n'entrent pas dans le cadre de cette étude.

Soutien des équipes sur le terrain

Opérations

- Être disponible pour des entretiens semi-structurés.
- Remplir les formulaires si cela s'avère nécessaire après l'analyse documentaire : et la préparation des outils de travail.

Disponibilité pour discuter et préparer une évaluation rapide avec l'équipe de terrain

- Référencer ou mettre en contact avec les acteurs clés sur le terrain que l'équipe considère nécessaires pour la réalisation de l'étude (groupe sectoriel Abris) ; acteurs locaux / gouvernement (si nécessaire) etc.

Ressources humaines

- Disponibilité d'une équipe de terrain pour effectuer une évaluation rapide. On ne prévoit pas plus d'une journée. Les détails seront définis une fois que le consultant et l'équipe de terrain auront échangé leurs idées.

Logistique

- Préparer toute la documentation nécessaire à la réalisation de l'étude environnementale.
- Être disponible pour des entretiens semi-structurés.
- Remplir les formulaires si cela s'avère nécessaire après l'analyse documentaire : et la préparation des outils de travail. Référencer ou mettre en contact avec les acteurs clés sur le terrain que l'équipe considère nécessaires pour la réalisation de l'étude (fournisseurs, etc)

Documentation.

- Fournir toutes les informations détaillées et accessibles sur les matériaux utilisés dans les différents types d'abris (BoQ, fournisseurs, chaîne d'approvisionnement, emballage, etc.),
- Fournir tous les rapports que l'équipe juge nécessaires à la réalisation de cette étude (Impact study, etc.).
- Si disponible, recommandez ou fournissez plus de sources de données secondaires (profil environnemental du Tchad, etc.).

Agenda calendrier et activités

La date limite pour présenter les résultats de l'étude est le 20 mars

	Semaines					
	S1	S2	S3	S4	S5	Total
Analyse documentaire et élaboration des outils de travail	1,0 jours					1,0 jours
Entretiens avec des informateurs clés / Préparer a l'équipe de terrain pour un suivi léger des abris sur le terrain	1,0 jours	0,5 jours	0,5 jours			2,0 jours
Collecte des données et analyse comparative des différents facteurs environnementaux	2,0 jours	2,5 jours	0,5 jours			5,0 jours
Préparation du projet de rapport et validation			3,0 jours	3,0 jours		6,0 jours
Présentation des résultats / réunions de suivi					1,0 jours	1,0 jours
Total						15,0 jours

Budget

	Tarif	Jours	Total
Etude comparative d'impact environnemental		15,0 jours	€ -
Revue de langue française		1,0 jours	€ -
			€ -

ANNEX 2 – Informants

International Aid of Luxemburg Red Cross

- Leandro FERNANDEZ-JARDON, Délégué Régional Habitat Humanitaire
- Éric Pegdwindé BAMBARA, Chef de misión Chad
- Olivier Djimadoum DJIMRAMADJI, Chef de projet

Technical support in the use of SMAC for the report was provided by:

- Charles KELLY, Co-Chair, Environment Community of Practice, Global Shelter Cluster.
- George FODEN, SMAC Consultant and QSAND Programme Manager

Groupe de Travail Abris & Biens Non Alimentaire Chad

- Pierre Claver NYANDWI, coordinateur du cluster Abris/AME et mouvement de population

Global Shelter Cluster

- Madelaine MARARA, Global Shelter Cluster Environmental Focal Point.

IOM

- Pauline MAGUIER, Emergency Coordinator

UNHCR

- Eve ZORAWSKA, Shelter Officer
- Victor ALLANDIGUIBAYE, Assistant Environment Officer

ANADER

- Abakar Mahata KAILA- Directeur technique (DT) de la délégation de l'ANADER dans la province du Lac

Other person contacted:

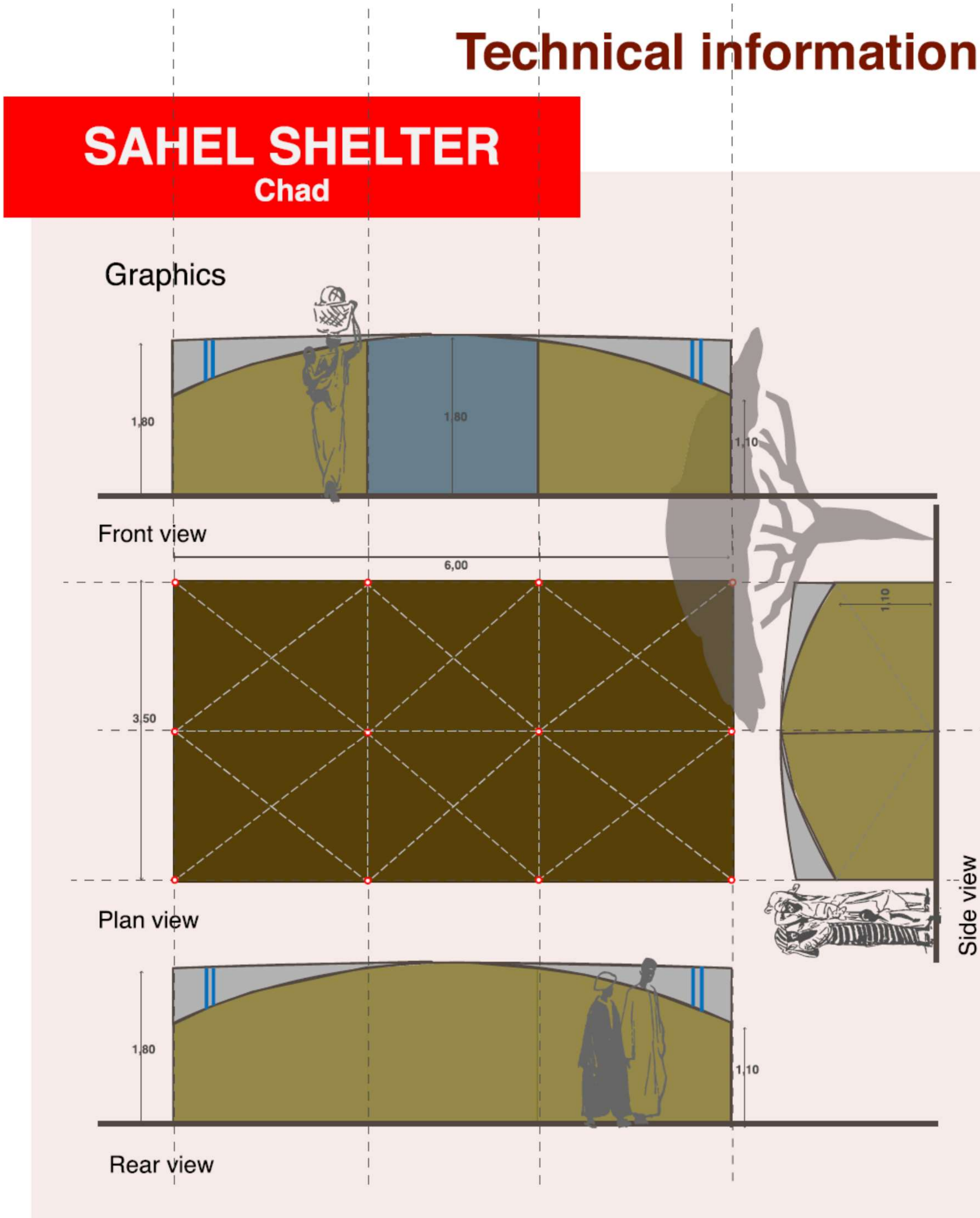
- Samantha brangeon. Consultant- JI Sustainable Humanitarian Packaging Waste Management

Other organisation contacted:

- LEAD, DAFNA, NAFIR

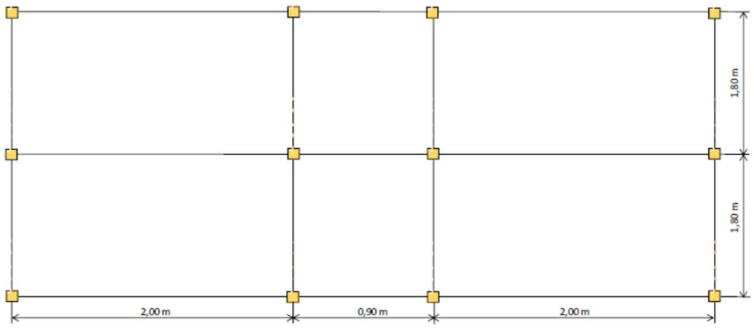
UNEP-Africa

ANNEX 3 – Shelter Models Technical Information

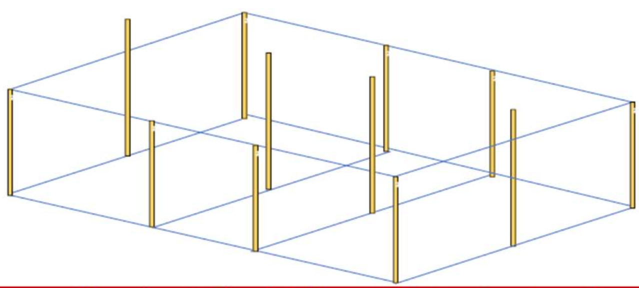


MOUNDOU SHELTER

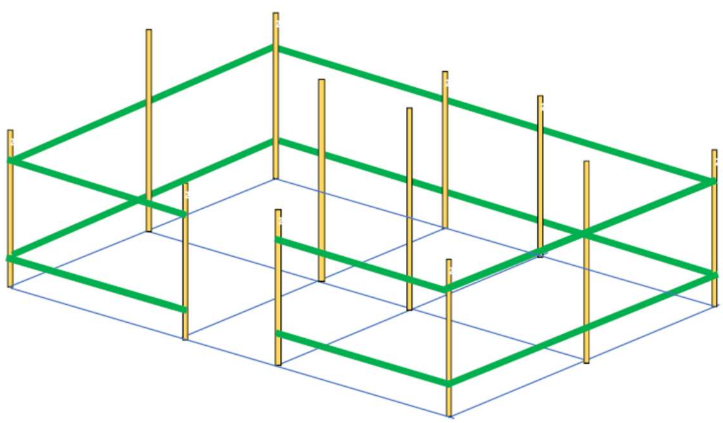
I. Implantation



II. Fixation des poteaux



III. Pose des tiges de dattier pour relier les poteaux (en vert)



IV. Vue de toiture en forme de voûte (tige de dattier)

ANNEX 4- Shelter components material, packaging, quantity and country of origin

Sahel Shelter model[202]

Name	Raw material	Quantity/ Kg	Country of origin	Packeting
Steel poles	Steel	22.5	Nigeria (Lagos)	Information not provided
PVC poles	PVC	36.4	Chad (N'Djamena)	Information not provided
Plant mats	Palm doum	109.2	Chad (Ngouri)	Information not provided
Plastic sheeting	Polyethylene	9	China (China)	Polyethylene bag
Plastic mats	Polyethylene	2	Chad (N'Djamena)	Information not provided
Synthetic rope	Nylon	0.5	Nigeria (Lagos)	Information not provided
Wire	Iron	6	Nigeria (Lagos)	Information not provided

Moundou Shelter Model

Name	Raw material	Quantity/ Kg	Country of origin	Packeting
Timber Wood	Tila Americana (Basswood)	92.3	Cameroon (Garoua)	No packeting
Palm stems	Date-palm	143.75	Chad (Mao, Bol, Moussoro)	No packeting
Plant mats	Doum palm	58	Chad (Bol, Bagasola)	No packeting
Straw brunches	Common Reed	402.5	Chad (Bagasola, Ngouboua)	No packeting
Plastic mats	Polyethylene	9	China (China)	Polyethylene bag
Synthetic rope	Nylon	0.25	Nigeria (Etat de Borno)	No packeting
Wire	Iron	0.5	Dubai	No packeting
Plant Rope	Doum palm	9	Chad (Bol, Bagsola)	No packeting

202 *All this information was provided by the AICRL team in country, except the quantity in kilos of the packaging for the Sahel Shelter model, which was not known, so this data has not been included in the calculation for both shelters.*

ANNEX 5 - Transport distances

Country of origin to point of arrival in country

Distance by boat

Departing point	Arrival point	Distance
China	Ivory Coast - Port Abidjan	19000 km[203]
Port Abidjan	Cameron- Port Douala	1626 km[204]
Port Dubai	Cameron- Port Douala	14847 km[205]

Distance by road

Departing point	Arrival point	Distance
Nigeria (Lagos)	N'Djamena	1892 km
Nigeria (Maiduguri / Etat de Borno)	Baga Sola	767 km
Cameroon (Port Douala)	N'Djamena	1824 km
Cameroon (Garoua)	N'Djamena	446 km

Point of Arrival to Warehouse / Store

Departing point	Arrival point	Distance
Ngouri	N'Djamena	231 km
N'Djamena	Maro (site de Belom)	880 km[206]
N'Djamena	Baga Sola	374 km
Mao	Baga Sola	394 km
Moussoro	Baga Sola	412 km
Bol	Baga Sola	71 km

Warehouse to Construction Site (km)

Area	Location warehouse	Distance
Bagasola	Ngouboua Koura	32 km[207]
Maro	Site de Belom	*Information not provided*

203 *Since the exact location of the Chinese factory wasn't available, the suggested approximate distance baseline provided by the SMAC guidelines from Asia to West Africa has been used.*
204 *Sea distance were calculated in nautical miles (http://ports.com/sea-route/Ports.com) and converted to kilometres for entry into the tool*
205 *Sea distance were calculated in nautical miles (http://ports.com/sea-route/Ports.com) and converted to kilometres for entry into the tool*
206 *Distance provided by the field team*
207 *Distance provided by the field team*