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Shelter Research Unit
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TESTING FOR 3 TENT PROTOTYPES IN BURUNDI

Burundi 2013

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1. *Introduction*

In 2011 the three largest entities operating in humanitarian sheltering, IFRC, ICRC and UNHCR launched an Research and Development project, to continue the efforts of defining a lightweight, self-supporting family-shelter solution for emergency operations. The aim was, to develop a solution even lighter than the standard family tent, at a lower cost and with fewer constraints regarding production, transport and storage. In addition to these technical and logistics criteria, further criteria for usability and for user-satisfaction were introduced.
A number of large tent suppliers participated in the development process to propose new solutions for the challenge. The process being coordinated and managed by Senior Shelter Specialists from IFRC-Shelter and Settlements Department (IFRC-SSD) and UNHCR. From the proposed models, three were selected to be field tested and the suppliers of these models were requested to each produce 15 prototypes of their model for comparative testing. Three testing sites, each in a different climatic and cultural environment were chosen by the coordination team, following a test-protocol proposed by the IFRC-SSD, focusing particularly on usability and beneficiary satisfaction.
By begin of 2013 the prototypes of three the different tent models were ready for field testing.
Each of the three partners IFRC, ICRC and UNHCR, committed to organize the field tests in one of the chosen contexts, Burundi, Burkina Faso and Tanzania. IFRC was in charge of the testing in Tanzania and UNHCR in Burkina Faso. ICRC asked IFRC-SRU to conduct the testing in Burundi on their behalf.

2. *Executive summary*

IFRC-SRU assumed the responsibility and undertook the field testing for the Burundi location on behalf of ICRC, in collaboration with Burundian Red Cross and with funding by Luxemburg Red Cross.
In addition to the set test-protocols for the comparative testing of the three prototypes, IFRC-SRU introduced some further tests to complement the basic protocol with general observations regarding rigidity and weather influence as well as more detailed testing on thermal comfort and translucency (privacy).
IFRC-SRU also included the standard tent in the tests as a reference model to evaluate the performance of the new types. Special focus has been to document and evaluate the influence of a shade net on thermal comfort of the different types.
The beneficiary selection as well as the selection of a suitable test-site in direct vicinity to Bujumbura, has been carried out by the Burundian Red Cross with the support of the Luxembourg Red Cross.
The beneficiaries lived in the tents during the whole testing period and actively participated in the evaluation. The setup of the tents and installation of measurement instruments was supervised by the IFC-SRU research officer. Technical monitoring of the tents and measurement instruments during the testing period from beginning of July until end of August 2013, was assured by the Burundi RC technical focal point who reported on weekly basis to the research officer using pre-established monitoring formats, fotos and regular phone-calls. At the end of the testing period the research officer conducted a final evaluation visit and recuperated the data collected during the testing-period.
The five models of each of the following tents were subject to the testing, all in the same site under the same conditions and on the same criteria: the Standard “Family tent”, the “Umbrella tent”, the “Dome tent” and the “Hexagonal tent”. The shade net has been tested on each of the different tent types.

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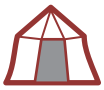
Table 1. basic description of the tested tents

Family Tent 	*17.5m² Rectangular based double fly tent with two covered polygonal entrance-spaces. The outer tent must be supported by 3 poles, 1 ridge pipe Inner, the side walls must be supported by 6 metallic poles. Inner tent canvas in one piece including walls, doors, windows and groundsheet. Outer Tent includes roof, doors, side windows and optional accessories.*	
Umbrella tent 	*17.5m² Square based double fly tent. Center pole with roof bars pushing the 4 corners. "Pre-assembled tent". Both outer fly and inner fly are attached to the frame from factory.*	
Dome Tent 	*17.5m² Square based single fly tent. Frame made of four flexible poles in sections, sliding in sleeves on the outer face of the canvas. Two long poles for the diagonal lines and two short poles for the median lines. Canvas in one piece including all components, doors, windows, shutters, roof, walls, groundsheet, door canopies.*	
Hexagonal tent 	*17.5m² Hexagonal based double fly tent. Frame made of 6 poles and 6 roof pipes with a 6 branches connector in the roof center. Inner tent canvas in one piece including walls, doors, windows, roof ventilation, groundsheet. Outer fly includes roof and shutters.*	

3. *Test methodology*

The main objective of the field testing was to assess the usability and user satisfaction with the different models. The same methodology was followed for all test-sites to collect qualitative data from the beneficiaries through pre-established questionnaires at the beginning of the period (after tent set up), and again the same questionnaire at the end of the period (without referring back to the first questionnaire). Another questionnaire was used for the supervisor to document specific topics like transport, setting up, performance towards climatic condition, and cultural acceptance.
In addition to the questionnaires, quantitative data was collected by keeping a daily climatic records and measuring the inside and outside temperature of the different tent types.
IFRC-SRU used a weather station installed on the site to record the wind speed, rainfall, humidity and temperature.
IFRC-SRU gave special attention to the conditions determining thermal comfort, which is clearly the principal factor for beneficiary satisfaction and also has effects on beneficiary health. For this reason a shade net was introduced into the test-setup on one of each of the prototypes.
Furthermore illumination levels inside the tent were measured using a luxometer. This data gives indications for comfort levels and allows some basic analysis of the effect of material translucency on the inner temperature, as well as the effect for privacy during night time.

Table 2.: different topics explored to indicate performance and perceived quality of the tents

Quantitative Data			
Topic	*Parameter/Indicator*	*Tool*	*Objective*
1.-Thermal Comfort	*Inner temperature*	- *Thermometer (LOGTAG) placed at the upper part and at the of bottom of each tent*	*Comparison of temperature inside the tents with outside temperature.*
	Outside temperature	- *Thermometer (LOGTAG) for continued registering of outside temperature*	
2.-Weather/ Impact of weather conditions on comfort.	*Wind speed and direction*	- *Weather station, continued monitoring*	*Analysis of the wind influence on the interior temperature*
	Rainfall incidence and intensity	- *Weather station, continued monitoring*	*Analysis of rain influence on the thermal comfort*
	Humidity percentage	- *Weather station, continued monitoring*	*Analysis of humidity influence on the interior temperature*
3.-Illumination level	*Interior tent illumination with and without Shade net*	- *Luxometer: measures inside each tent taken at floor level and one meter above floor level*	*Comparison of interior level of illumination/translucency of the different tent models with and without Shade net.*
	Outside illumination level	- *Luxometer: measures taken at one meter above ground in shade and in direct sun*	
Qualitative data (interview and observation)			
4.-Ease of setup	*-Time measured* *-Observed difficulty* *-Beneficiaries' comprehension*	- *Observation during the implementation process* - *Questionnaires**	*Comparison of ease of set-up for the different tent models*
5.-Stability and Rigidity	*Stability and deformation during and after the test time*	- *Continued documentation during the testing time*	*Comparison of stability and rigidity of the different tent models*
6.- window openings usability	*-Beneficiaries' comprehension of opening systems* *-perceived security and protection* *-Perceived privacy* *-Additional pieces*	- *Regularly documented observations by shelter focal point and research officer* - *Collection of weekly feedback from beneficiaries*	*Comparison of the usability of window/ventilation openings in the different tent models.*
7.- Level of comfort	*- Inner temperature of the tent* *- Ventilation* *- Illumination*	- *Continued documentation of observation by shelter focal point.* - *Questionnaires**	*Comparison of perceived level of comfort in the different tent models*

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8.- Livability	*- closing system (doors)* *- perception of cladding material & color* *- inner space & partitions*	*- Daily registered by the shelter focal point observation during the testing time* *- Questionnaires*.*	*Comparison of user satisfaction with different practical and materials aspects of the tent models*

** One Standard questionnaire provide by IFRC was completed by each beneficiary in the beginning and at the end of the testing period. Another questionnaire was completed by the local supervisor in charge of weekly monitoring of the tents.*

4. Basic Analysis of obtained technical data

4.1. General weather data for the test site

A small weather station was installed on the test site to record windspeeds, humidity, rainfall and temparature. The data was recorded every day by the shelter focal point. To have more exact data on the temperature one logtag was attached to the weather station to automatically record hourly the outside temperature.

Table 3: average weather data recorded durign testing period

Weather			
Weather station	*Registered data*		*Average*
	MAX 24 km/h *MIN 5 km/h*	*Main wind direction: South*	*15,38km/h S direction*
	Two precipitations during testing period	*Jul 15th = 9,4mm^3* *August 1st = 4,8mm^3*	*0,36mm^3*
	MAX 45°C *MIN 13,20°C*		*MAX 41°C* *MIN 15°C*

The testing period in Burundi was during the dry season, with very stable weather conditions.
The recorded wind-speeds were between 5 and 24 km/h which in the beauford scale is definded as "moderate breeze". In this case the wind effect on the temparature in side the tents is neglegible.
The same can be concluded for humidity, which was stable from around 60-70% troughout the testing period with athmospheric pressure between 923 to 929 hpa.
Only two minor rainfalls were recorded during the testing period causing a drop of outside temparature of around 5°C.

4.2. Detailed temperature data for the tested tent types

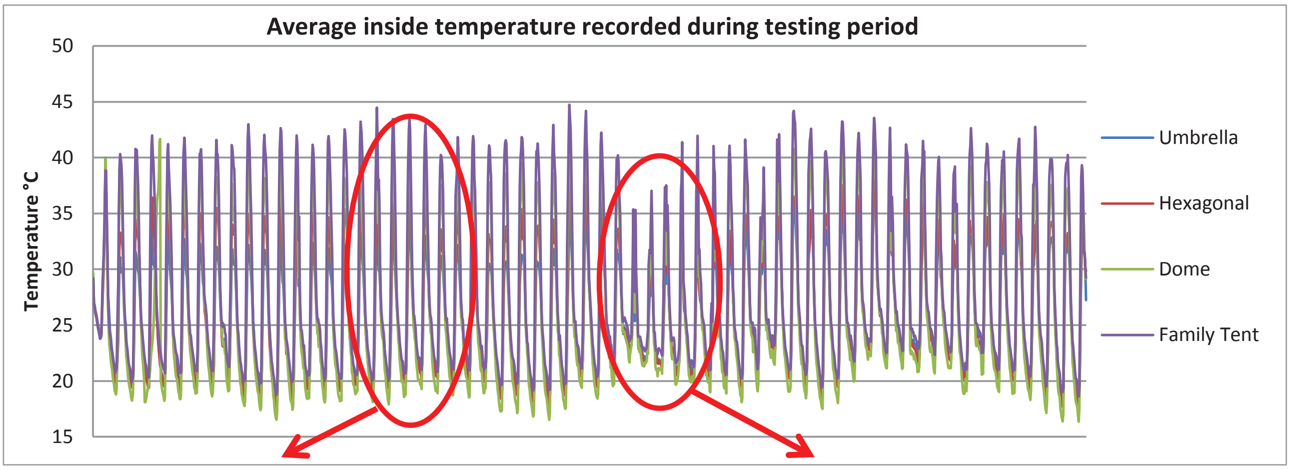
44 Logtag SRIC-4 were installed to record exact temperature data in all the tents. Two logtags in each tent in different positions (see table 6) and four under the four shade nets that were installed over one of each tent type.

Table 4.: The position of the Logtags inside the tent, the average min & max temperatures measured in both positions and the average of the minimum and maximum temperature measured inside the tent during the testing period, in comparison to the average outside temperatures.

Temperature				
Tent model	*Thermometer Position*	*Data average recorded in the two positions of the thermometers*	*Average of **interior temperatures***	*Average **external** temperature Min/Max*
family tent		*MAX 47,12°C* *MIN 18,2°C*	*MAX 44,73°C* *MIN 18,63 °C*	*MAX 41°C* *MIN 15°C*
		MAX 42,9°C *MIN 19,6°C*		
umbrella		*MAX 41,98°C* *MIN 17,62°C*	*MAX 39,98°C* *MIN 18,12°C*	
		MAX 39,96°C *MIN 18,56°C*		
dome		*MAX 46,88°C* *MIN 15,88 °C*	*MAX 42,72°C* *MIN 16,36°C*	
		MAX 39,48°C *MIN 16,83°C*		
hexagona l		*MAX 42,02°C* *MIN 17,20°C*	*MAX 38,80* *MIN 17,40*	
		MAX 37,72°C *MIN 17,60°C*		

The logtags automatically register the temperature every hour during the whole testing period in total registering 1486 measures for each logtag (in total 66870 lectures). The log-tag data was recuperated by the IFRC-SRU Research Officer at the end of the testing period and processed for analysis.
For each of the tent types the average temperatures are calculated from the four models of each type that were set up without shade net.

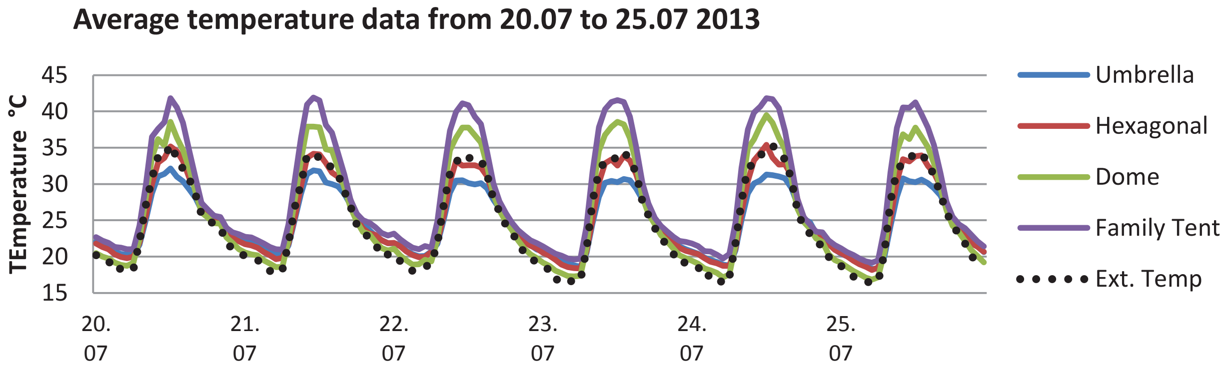
Table 5: average inside temparature recorded during testing period



See table 6 for enlarged graph of recorded temperatures inside the tents.

See table 7 for enlarged graph of recorded temperatures inside the tents on the rainy day

Table 6: Temperature data recorded from 20.07 to 25.07.2013

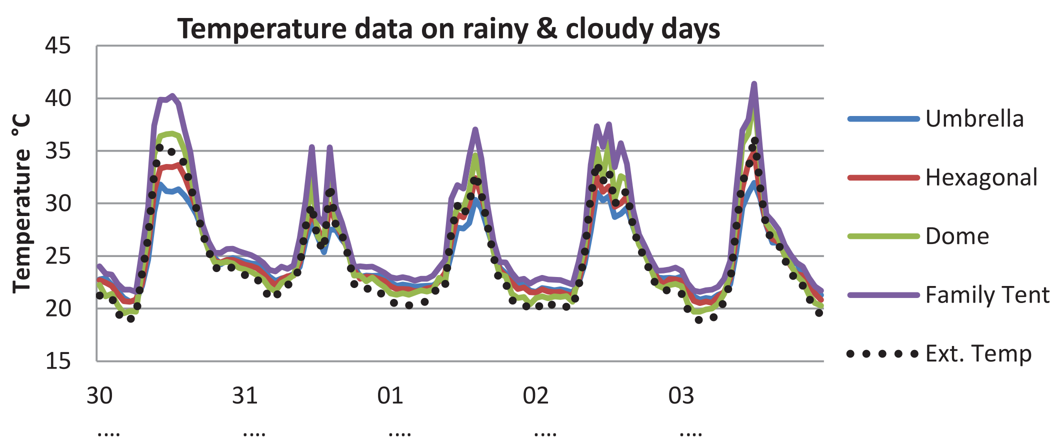


The recorded data in table 6 clearly shows that the inside temperature of both the family tent and the Dome tent regularly exceed the external temperature by between app. 5-15°C!
On average the temperature recorded during daytime in the family tent is 6 °C higher than the average outside temperature.
However maximum recorded temperture in Family tent was 52°C that is 15 °C more than the outside temperature of 37°C recorded that day. See table 8 for more detail on highest recorded temperatures and the effect of the shade net.
The Hexagonal tent shows almost the same temperature curve as the outside temperature.
In the five days presented in the table the temperature inside the Umbrella tent stays 2-4°C lower than the outside temperature. However in average the maximum temperatures inside the Umbrella tent for the totality of the testing period is around 41°C, like the hexagonal tent corresponding to the outside average maximum temperature.

As all tents were installed in basically the same exposure situation, the reason for these differences clearly lie in the tent features not in outside conditions like a shaded or particularly breezy site.

During the recorded rainy day on July 31the drop of outside temperature by almost 5 degrees during the rainfall is directly reflected on the inside temperature of all tents. During the two following days, 1st and 2nd August, the outside temperature went back to 33-34°C but with cloudy skies. With reduced direct sun-radiation the inside temperature of all tents stayed very close to the outside temperature. With only little clouds and the sun back on the 3rd the different thermal performance of the tents under direct sunlight is again clearly visible.

Table 7 *Average temperature data recorded from 30.07 to 03.08.2013*

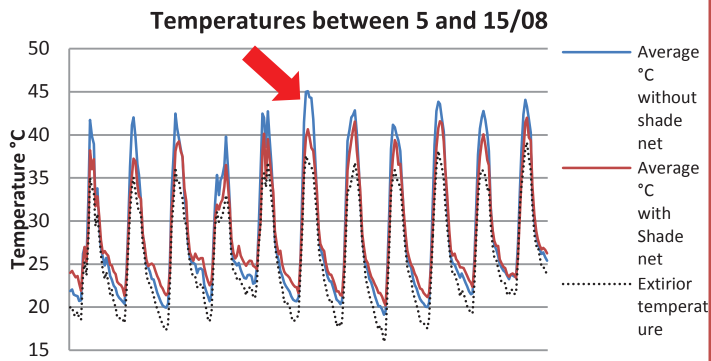
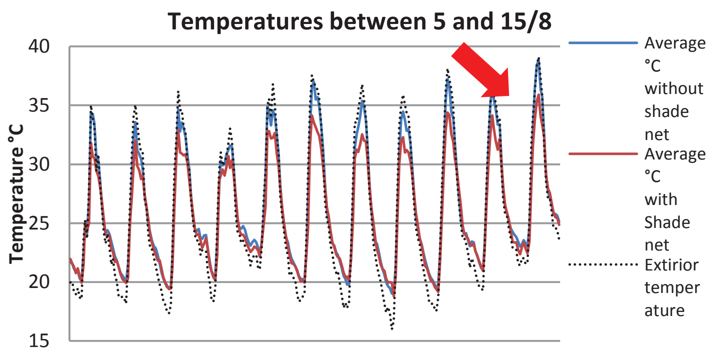


4.3. Observations on the Influence of Shade Net

Each of the of tested tents types was also tested with a shade net installed over the tent, to recover data of the influence on the climatic comfort as well as the structural stability of the shade net.

The graphs in table 8 clearly show the effect of the shade net on the inside temperature, causing reduction of average temperature between 3°C and 6 °C degrees.
However looking at the at peak temperatures during the hottest time of the day the importance of the shade net becomes even more apparent. Here reduction of interior temperature through the shade net lies between 6°C up to 16°C.

Table 8: Shade net influence on interior temperature; the red arrows indicate the maximum and minimum impact of the shade net for this extract part of the testing period.

<table>
<tr><th colspan="3">Average temperatures registered in the tents with shade net</th></tr>
<tr><td>Tent Model</td><td>Registered Data</td><td>Graphic data</td></tr>
<tr><td></td><td>With shade net the inside temperature in the family tent was an average of 6 °C less than without shade net. For peak hours the reduction was up to 16°C
During night time, an average of 2 °C higher temperature was recorded in the model with shade net. This interesting observation is probably due to the cladding material (polycotton). More detailed testing would be necessary to confirm this assumption.</td><td>
</td></tr>
<tr><td></td><td>For the Umbrella tent the average recorded temperature reduction with the shade net is around 3°C and up to 8°C during hours of maximum outside temperatures.
For this type there is no registered influence on the minimum temperatures during night time.</td><td>
</td></tr>
</table>

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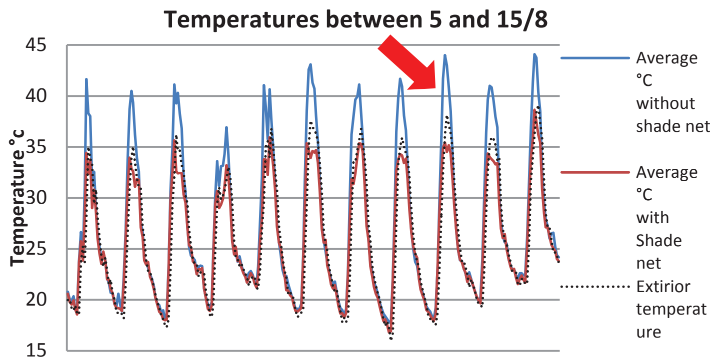
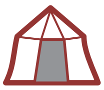
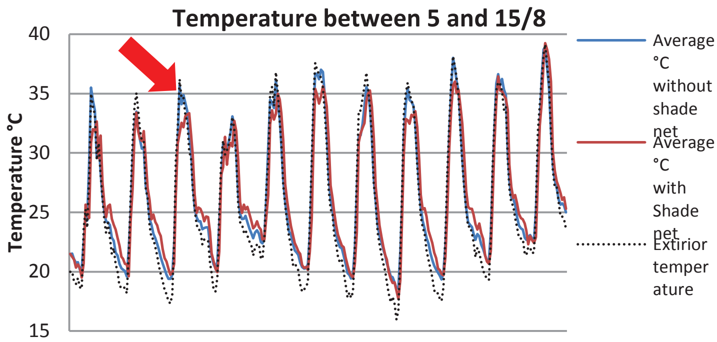
The shade net effect on the Dome tent is significant, with a reduction around 5 °C in the total average of the collected data and up to 16 degrees reduction during peak hours with maximum temperatures
The influence on the minimum temperature is not relevant on this tent model.





For the Hexagonal tent the average recorded temperature reduction with the shade net is around 3° C . A slight influence of 1°C on the minimum temperatures during night-time was recorded on total average of the collected data.



For the three new tents, the use of the shade net reduces the inside temperatures to the about the same temperature than the outside temperature. For the family tent even with shade net, the inside temperature during the hot hours still remains higher than the outside temperature, but with a significant reduction as compared to the situation without shade net.

Table 9: Impact of shade nets on inside temperature on the three hottest days

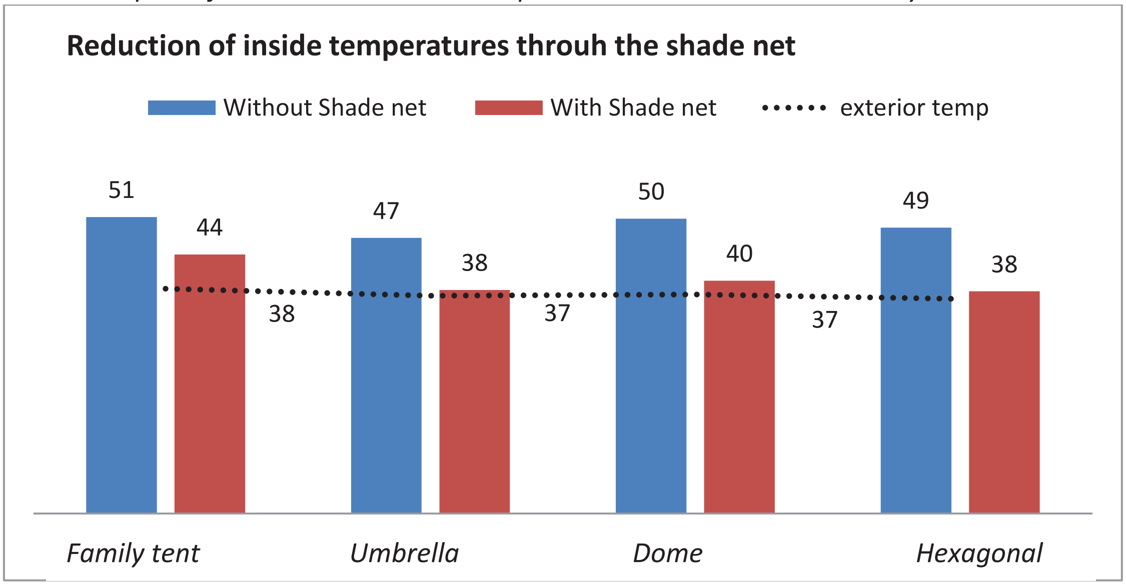


Table 10: The three maximum interior temperatures recorded for each of the four tested tent types with and without shade net, compared to outside temperature measured at noon.

Model	**Date**	**Time**	**Inner temp.**	**Inner temp. with Shade Net**	Exterior temp	**Difference without Shade Net**	**Difference with Shade Net**
Family **Tent**	10/08/2013	11:58	52.6	44.9	36.98	15.62	7.92
	27/07/2013	11:41	50.9	43.6	39.15	11.75	4.45
	28/07/2013	12:35	48	43.9	38.83	9.17	5.07
Umbrella	13/08/2013	11:52	51.4	37.2	36.15	15.25	1.05
	15/08/2013	12:13	43	39.8	39.13	3.87	0.67
	14/08/2013	11:52	46.4	37.3	35.95	10.45	1.35
Dome	15/08/2013	11:40	49.8	39.9	39.13	10.67	0.77
	13/08/2013	11:31	50.9	37	36.15	14.75	0.85
	15/07/2013	11:47	50	42.1	36.65	13.35	5.45
Hexagonal	27/07/2013	12:03	50.4	39	38.5	11.9	0.5
	16/08/2013	11:22	47.8	38	37.93	9.87	0.07
	18/08/2013	13:27	47.9	36.5	33.28	14.62	3.22

4.4. Illumination and translucency

The translucency of materials has important effects on the level of comfort perceived by the beneficiaries. The feedback collected from the beneficiaries indicates that high levels of illumination in the tent during day-time are not much appreciated.

During night time, when beneficiaries use candles or other lights to illuminate their tent the translucency of material clearly compromises privacy, which is also not much appreciated.

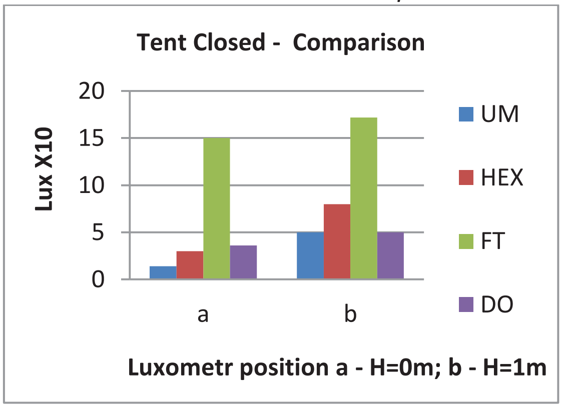
Table 11: Measurements of LUX taken in two positions inside each tent and with all opening closed The Luxometer position up/bottom, the tent position open/close, and the interior illumination levels.

Illumination level		
Tent Model	Average of the data measured in the two indicated positions	Average
	Tent closed 16,1 LUX (X10) Tent open 17,5 LUX (X10)	16,8 LUX (X10)
	Tent closed 3,2 LUX (X10) Tent open 13,3 LUX (X10)	8,25 LUX (X10)
	Tent closed 4,3 LUX (X10) Tent open 8,5 LUX (X10)	6,4 LUX (X10)
	Tent closed 5,5 LUX (X10) Tent open 16,3 LUX (X10)	10,9 LUX (X10)

Note: Lux levels under direct sunlight generally vary between 320(x100) to 1300(x100) and in the shade, e.g. under a tree 100 (x100) and 250 (x100).
For reference: Norms for working places recommend 20(x10)-50(x10) for working spaces (depending on the kind of work), for living areas in a home Lux-levels between 5(x10) and 15(x10) are proposed. The lux-levels measured in the family tent are slightly higher than the ones recommended for a living space while the closed Dome and Umbrella tents are slightly below. In general the measured lux-levels for all tents pretty much correspond to the recommended range for living spaces.

Another important factor is the heat-input through sun radiation.
It is interesting to note, that the family tent has almost the same levels of brightness inside, regardless of being opened or closed, while the other tents have significantly reduced illumination when the openings are closed.
This is due to the difference of material used for the outside cladding of the tents. The cladding of the family tent is made of a Polycotton canvas, while the other tents have outside claddings of different kinds of plastic sheeting materials. The specifications of the cladding materials were not made available by the suppliers, but it can be assumed, that the sheeting has an opaque layer inside, to block radiation.
The polycotton family tent which Is clearly the most translucent also has the highest temperatures during day-time. The assumption is, that the translucency of the cladding plays a main role in the accumulation of heat inside the tent. The other important factor for heat accumulation is ventilation. As observed throughout the testing period, the beneficiaries kept the windows/ventilation openings closed during the day-time. Therefore the ventilation das not impact significantly on the test.

Table12a: Measured Lux in the closed tents at floor-level and at 1m height inside the tent
Table 12b: Measured Lux in the opened tents at floor-level and at 1m height inside the tent



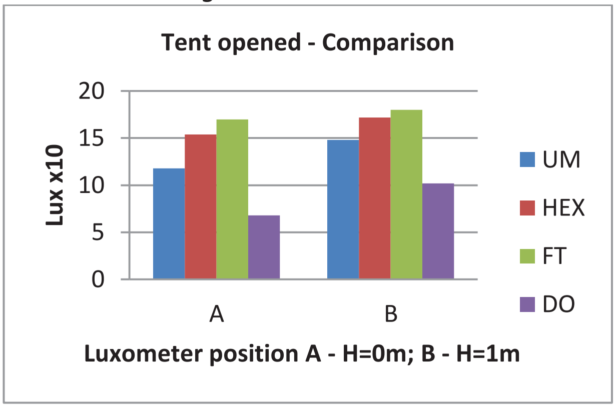
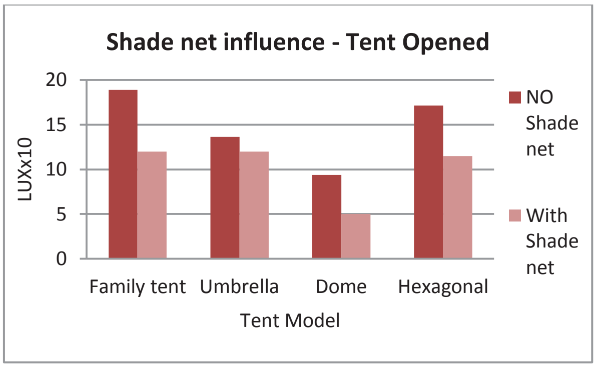
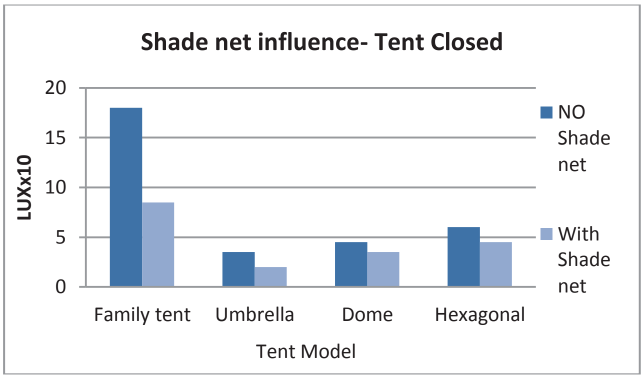


Table 13a: Influence of shade net on Lux levels in opened tents
Table 13b: Influence of shade net on Lux levels in closed tents





As the tables show, the shade net provides a reduction of the interior illumination level in all the tents, more significantly when tents were open (Table 12b)
Although the reduction of illumination was percieved positive by all benefciaries, that main value is rather in reducing the heat-input in the tent from direct radiation.

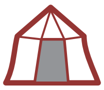
5. Basic Analysis of observations obtained and beneficiary feedback

5.1. Set-up

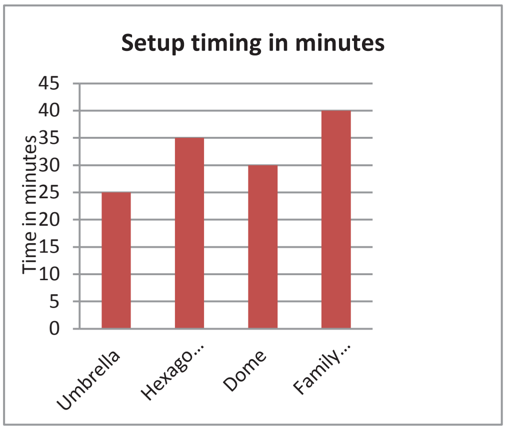
The first criterion investigated was the ease of set-up and the time.
The tents were distributed to the beneficiaries carried their tent- package to the plots about 10 mins walking distance away, without noticeable difficulties. The volunteers assisted in three cases of very vulnerable beneficiaries (a pregnant woman, an elderly woman and a handicapped woman).
One of each tent type was opened, all the pieces and the set-up manual showed and explained by the research Officer. Then one of each type was mounted by the Research Officer with the help of two RC volunteers, to demonstrate the set- up. After the demonstration the beneficiaries were left to "coordinate" the volunteers to help them with the setup. The research Officer gave further explanations on demand where necessary.

Table 14 summarized the observations during setup time.

Tent setup			
Tent model	*Setup time (3-4pers.)*	*Observations site supervisor/shelter expert.*	*Understanding beneficiaries during setup process*
	*35 to 45 minutes*	*-Because of weight and dimensions two people needed to carry the package.* *- number of different parts confusing* *- Difficulty to understand succession of setup of the exterior & interior tent.*	*- Difficulties to understand the manual.* *-confusion with different poles and pegs and have difficulties coordinating the setup*
	*20 to 30 minutes*	*- Setup process is simplified through the pre-assembled structure.* *- opening systems with extra parts are too complex* *-The provided pegs are too small to provide effective anchorage in the soft soil.*	*- Difficulties to understand the manual.* *-The pre-assembled structure and reduced number of pieces is quite self-explanatory* *-difficulties to place the Interior pole in the correct positions* *-The different options for openings the windows are not well understood and extra parts used for other purposes* *-option for full opening is not appreciated*
	*25 to 35 minutes*	*- Small package is easy to transport by one person* *-some difficulty to assemble to bars* *-a lot of space around the tent needed for assembly to slide the bars into the canvas sleeves* *-some difficulty to coordinate all actions to erect the tent.* *- only one cladding layer reduces set-up time*	*- Difficulties to understand the manual.* *- the assembly of the carbon bars was not easily understood* *- the beneficiaries had difficulties coordinating the set-up, the team members didn't well understand their different task.*

	*30 to 40 minutes*	*-Easy understanding of the setup process - good team coordination needed - The pegs the pegs for the window flaps are removed by the children and don't support correctly the windows flaps.*	*- Difficulties to understand the manual. - The simple shape and limited number of pieces facilitates comprehension of the set-up process. -The different options for openings the windows are not well understood - extra parts meant for the window flaps are used for other purposes -option for full opening is not appreciated*

The average setup time for the family tent was the longest. The Dome tent was the fastest to set up, in spite of the complexity and poor comprehension of the beneficiaries. This can be attributed to the fact, that the structure is pre-assembled with the inner and outer tent in one piece, while all the other tents have an outer tent and a separate inner liner which takes some additional time to install.
Although the Hexagonal tent scores only third in set-up time the structure was most appreciated by the beneficiaries, because the structure is self-supporting and most stable. Furthermore it allows for easy replacement of pieces in case of damage.



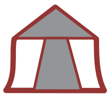
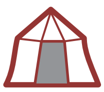
5.2. Stability of the structure

The family tent is the only structure of the tested ones, that depends fully on the guy-rope and pegs for stabilty. In consequence the rigidity is also compromised. This structure needs continuous mantainance and control to assure stability. The use of guy ropes als requires more space, which is a compromising factor in environments with space constraints.

The Umbrella tent with the central pole is "tensioned" through the cladding itself.

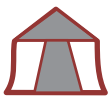
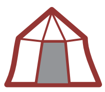
The Dome and the Hexagonal model are both self supporting structrues independent of the cladding or guy-ropes and pegs for stabilty. Pegs are only used to fix the structure to the ground. In terms of maintenance as well as for space consumtion this is a high added value.
The Hexagonal structure was most aprreciated by the beneifciaries because f its stability and because the structrual parts allwo for replacement easily.

Table 15: observations of rigidity/stability of the structure from setup time until end of the testing period.

Stability of the structure				
Tent model	*Rigidity*/stability** At Setup Day*	*Deformation After testing*	*Setup day*	*After testing time*
	*The rigidity and stability of the structural system depends on the tension of the ropes supported by the pegs.*	*-Slight displacement of pegs - loss of tension in the guy-ropes - some deformation of the shape - some loss of overall stability of the tent*		
	*-Good stability, the structure is "tensioned" through the cladding. - Medium rigidity of the structure due to the structural system. - The fixation to the ground with the provided pegs is inadequate*	*-Slight displacement of pegs and loss of tension in the ropes only affecting the fixation of the window flaps - the tent structure doesn't show deformations.*		
	*-Good stability as self-supporting structure - Low rigidity due to flexibility of materials - The fixation to the ground with the provided pegs is inadequate*	*-Slight displacement of pegs and loss of tension in the ropes but the tent structure doesn't show deformations.*		
	*Good stability and high rigidity of the self-supporting structure -The fixation to the ground with the provided pegs is inadequate*	*-Slight displacement of pegs and loss of tension in the ropes only affecting the fixation of the window flaps -the tent structure doesn't show deformations.*		
*Notes: *Rigidity as used in this evaluation: The tent-structure is rigid and resists deformation through applied forces. **Stability as used in this evaluation: The tent-structure is self-supporting and does not depend on ropes, stakes or additional support.*				

5.3 Usability

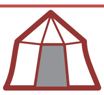
Table 16: observations of comprehension and use of the windows openings of the tents.

Usability: window-openings			
Tent model	*Windows openings*	*Comprehension of utilization*	*Additional pieces*
	*Small ventilation opening/windows - no privacy concerns -no secured closing system.*	*The beneficiaries understand the closing system, but in general it was observed that they prefer to keep the windows closed to prevent dust from entering*	*No additional pieces*
	*Big window openings, on the facing sides to provide cross-ventilation. -reduced privacy through the opening s size and position -no secured closing system*	*The beneficiaries do not understand the variety of opening and closing possibilities the tent offers with the extra pieces to support the flaps and therefor don't really make use of the different options. In general windows are kept closed for privacy reasons and to prevent dust from entering.*	*Metal bars, ropes and pegs to keep the window flaps open.*
	*Small ventilation opening/windows - no privacy concerns -no secured closing system.*	*The beneficiaries understand the closing system, but in general it was observed that they prefer to keep the windows closed to prevent dust from entering*	*No additional pieces*
	*Big window openings, on the facing sides to provide cross-ventilation. -reduced privacy through the opening s size and position -no secured closing system.*	*The beneficiaries do not understand the variety of opening and closing possibilities the tent offers with the extra pieces to support the flaps and therefor don't really make use of the different options. In general windows are kept closed for privacy reasons and to prevent dust from entering.*	*Metal bars, ropes and pegs for keep the window flaps open.*

The large window openings with extra flaps as shutter-systems provided in the Umbrella nad the hexagonal tent are not properly used or understood by the beneficiaries. Simplification of the system and reduction of the quantity of pieces seems recommendable.
In general the concern about dust prevented the proper use of the windows as important ventilation openings, which obviously has a negative impact on thermal comfort. It might be worth looking for design-solution that could reduce this problem.

Table 17: beneficiaries' perception of the tent materials and inner space.

Usability: appreciation of space and material quality			
Tent model	*Description*	*Beneficiaries perception of cladding*	*Beneficiaries perception of inner space**
	*-Rectangular ground-plan. -Inner and outer tent in poly-cotton. -Roof and wall cladding white --*	*-not good acceptance of the cladding material , -reduced privacy during*	*the interior space is perceived as bigenough all -demand an interior*

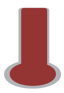
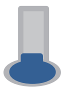
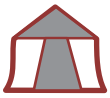
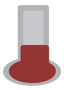
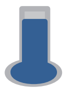
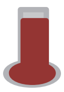
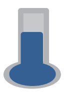
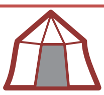
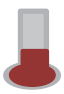
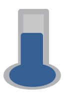
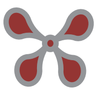
	Ground sheet dark gray. -Inner space without interior partitions.	*night, -dust accumulation and bad odor*	*division especially in families with children.*
	*-Square plan. -Exterior cladding plastic sheeting. -Inner cladding green polyester - one interior partition in green - Ground-sheet gray.*	*- good acceptance for the cladding material - positive appreciation of the colors.*	*the interior space is perceived big enough and comfortable.*
	*-Square plan -Single fly tent plastic sheeting. – Inner cladding gray polyester. One interior partition polyester. - Ground-sheet dark gray.*	*-cladding material and color not much appreciated -discolorations on the exterior parts of the tents at end of test period*	*The inner space is perceived as big enough but the dome shape is not much appreciated*
	*-Hexagonal plan. -Exterior cladding plastic sheeting. -Inner cladding beige polyester - One interior partition in beige - Ground-sheet gray.*	*- good acceptance of cladding material and color*	*the interior space is perceived big enough and comfortable.*

*NOTE: * Most of the beneficiaries are pygmies*

For all tent types the beneficiaries highlighted the concern that locking the tent is not possible.
Also the provided privacy was not perceived as sufficient.
In general the synthetic cladding materials seem to be appreciated more than the polycotton. It could be worth studying more in detail what are the important material qualities and also what colours that are more appreciated.
The Hexagonal tent has the best acceptance of inner the space and partition.

5.4 Beneficiaries perception of comfort

Table 18: The following table summarizes the beneficiaries perception on the tent comfort (temperature, illumination and ventilation) and observations from the local focal point

Usability: thermal comfort						
Tent model	*Inner temperature during day and night time*		*Illumination Open*	*Close*	*Ventilation*	
						*-Perceived as a very hot -bad odor inside. -No brightness variations between open and close.*
						*-Perceived as comfortable ambience. -Big brightness differences*
						*-Perceived has hot inside.*
						*-Perceived as comfortable ambience. -Big brightness differences*

The Family tent has the largest variationes on temperature, higher levels of brightness and is perceived as poorly ventilated.
The umbrella model has the smaller differences on temperature and the better illumination conditions inside. The interior level of comfort was perceived highest in comparison with the other models.

6. Conclusions and recommendations.

This study has been conducted in Burundi during two months of the dry season. While statements on technical performance, based on quantitative data can be generalized, the qualitative data of beneficiary satisfactions might only be valid for the particular context.

Stability
In terms of stability all the new models score better than the Standard Family tent, due to the different self-supporting structural systems. The Dome and the Umbrella tent are less rigid than the Hexagonal tent. The Hexagonal tent was particularly appreciated by the beneficiaries because the comprehensible structural system also allows for easy repair and replacement of pieces.
For all tent models the anchors provided were not sufficiently dimensioned for the soft soil of the test site. Providing longer pegs or other anchoring systems, that cannot easily be removed by playing children, and perform well in different soil types, would improve the acceptance, and stability of all tents.

Beneficiary satisfaction
The main concern brought up by the beneficiaries is the lack of a lock to close the tent while they are away, to prevent unwanted intruders like animals, playing children or thieves from entering.
The inclusion and design of a basic lock/security system for doors and windows presents only a minor adaptation and would be an added value highly appreciated by the beneficiaries.
A further issue for improvement is better provision of privacy through change of size and placement of window-openings, stated for the Umbrella and the Hexagonal tents and through less translucent cladding material for the Standard Family tent. More thought needs to be given to the windows/ventilation openings, to assure good ventilation and better thermal comfort whilst not compromising privacy and protections and as good as possible prevent dust from entering. Particularly the Hexagonal and the Umbrella tent have too many extra pieces, to adjust window-openings. The systems were not understood and used by the Beneficiaries.
Although the different tent models scored differently on the above mentioned criteria (ventilation, privacy), the general acceptance of the hexagonal models is the most positive.
Clearly inner partitions are very much appreciated in the prototype tents and mentioned as lacking in the Standard Family tent.

Thermal Comfort
Regarding the measured temperatures (see table 1for average temperature data on 5 days during the testing time) the Umbrella and the Hexagonal tent provide best thermal comfort. Although the five days that are shown in the table, The Umbrella tent is on average 2-3 °C cooler than the Hexagonal tent, the data during the whole of the two months testing period shows very similar results for both, on average staying some 1-2 °C under the average outside temperature during daytime.
It is remarkable that the standard family tent as well as the Dome tent exceed the outside temperature by an average 6°C (family tent) and 4°C (Dome)during daytime, with heat-accumulation of up to 15°C higher than the outside temperature during the hottest hours of the day. This is confirmed by the beneficiaries who perceived the both Standard Family and the Dome tent as too hot.

Shade Net

The Shade Net provides significant reduction of the interior temperature, for all models and also reduces the highest illumination levels during day. The thermal performance and the beneficiaries' acceptance of all the different tent models were better with the shade net.

Further added value of the shade net lies in the protection of cladding materials that are at risk to deterioration through UV-light, like most plastic sheeting materials. With shade net, the life span/durability of these materials can be increased. More long term testing is necessary to make more exact statements regarding the extension of durability but already a this stage it seems safe to state, that this element gives significant improvement for thermal comfort and has an added value to protect other cladding materials from UV degradation. To deepen the subject, IFRC-SRU is conducting a comparative study and lab testing of different shade net qualities as well as of the fixing methods and resistant structural systems and will present the results on the next conference in April 2014.

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