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CUVEwaters integrated water resources management

CuveWaters Construction Manual # 4

Greenhouse

Documentation and Work Instructions for Participants

of Training on Rainwater Harvesting Construction

SPONSORED BY THE

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All publications of this series:

Water Storage:

#1 Ferrocement Tank

#2 Rectangular Underground Tank

#3 Pond

Horticulture and related Infrastructure

#4 Greenhouse

#5 Drip Irrigation

#6 Sustainable Techniques and Practices for Water Harvesting and Conservation and their Effective Application in Resource Poor Agricultural Production (copy provided by the Water Research Commission South Africa)

Preface

„CuveWaters – Integrated Water Resources Management in central-northern Namibia" is a joint research project of German and Namibian partners funded by the German Federal Ministry of Education and Research (BMBF). Main research partners are the Institute for Social-Ecological Research (Frankfurt, Germany) and the Technische Universität Darmstadt (Darmstadt, Germany). Partners in Namibia are for example the Ministry of Agriculture, Water and Forestry (MAWF) and the Desert Research Foundation of Namibia (DRFN), the project furthermore closely cooperates with One World Consultants (OWC) from Kenya. CuveWaters has developed different technologies for water supply and sanitation in central-northern Namibia, ranging from Groundwater Desalination to Rain- and Floodwater Harvesting as well as Sanitation and Water-reuse. Between 2009 and 2013 different pilot plants were constructed at different places all over central-northern Namibia.

This Manual was developed as part of the Capacity Development measures within the technology line of rain- and floodwater harvesting. It is intended to guide you through the process of constructing rain- and floodwater harvesting infrastructure in Namibia.

This Manual is part of a series of Rain- and Floodwater Harvesting Manuals for Namibia:

Water Storage:

#1 Ferrocement Tank

#2 Rectangular Underground Tank

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Horticulture and related Infrastructure:

#4 Greenhouse

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#6 Sustainable Techniques and Practices for Water Harvesting and Conservation and their Effective Application in Resource Poor Agricultural Production
(copy provided by the Water Research Commission South Africa)

For more information on organisational, institutional and other general aspects of rain- and floodwater harvesting please have a look in the “CuveWaters Rain- and Floodwater Harvesting Toolkit”.

For more information on the CuveWaters project please visit http://www.cuvewaters.net

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Technische Universität Darmstadt

Darmstadt, 02.03.2015

About

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CuveWaters – Integrated Water Resources Management in Namibia

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This manual is also available on http://www.cuvewaters.net/Publications

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Table of Content

1 Preliminary considerations

Before beginning with the construction work of the greenhouse, preliminary considerations and work instructions should be read carefully. Indication of days means working days of 8 hours, although this may vary from one day to another. The labor needed for the construction process as described is 4-6 workers. At least one of them should be skilled in welding and another one in construction in general.

The construction manual describes how to build a greenhouse of 8m x 15m as conducted during the CuveWaters project for development and implementation of rainwater harvesting as a part of an Integrated Water Resources Management (IWRM) system.

1.1 Materials & Tools Preparation

Ideally, most materials (see bill of materials) should be purchased and brought on site before start of construction or at least until needed at construction site. Storage facilities for materials and tools should be provided at or close to construction site. The materials should be stored secure against weather conditions (e.g. rain, wind, and extreme heat) and theft. Tools needed for construction of the greenhouse should be available for the period of construction.

Material supply

All materials needed for construction can be obtained from hardware shops that can be found all over Namibia. In central-northern Namibia you will find the necessary materials for example in the following shops:

- Oshana Build it, Ongwediva (recommended, first choice)
- Benz Building Supplies, Ongwediva (recommended, second choice)
- Pennypichers, Ongwediva
- Pupkewitz Megabuild, Oshakati
- Chico, Oshakati

Please keep in mind that prices can differ in the different shops and seasonal variations are also common. So plan your construction site and the material supply well in advance and compare the prices in the different shops. Most hardware shops offer delivery of the materials for reasonable fees.

Cement

For the construction of the foundations of the greenhouse and other infrastructure we recommend the use of cement made by Ohorongo Cement Factory only! For all constructions the 32.5R cement is sufficient!

Plastic Foil

Unfortunately the quality of greenhouse plastic foil that is available in Namibia is not sufficient for the purpose and will easily break due to common strong winds typical for central-northern Namibia. Please order your plastic foil either from South Africa or from Kenya. You can get contacts for Kenyan plastic foil for example from One World Consultants (oneworldcc2005@yahoo.com).

1.2 Siting recommendations

Study the overall conditions at the site where greenhouse, pond and/or water tanks shall be constructed. Choose the site for the greenhouse, in a way which allows that the rainwater can easily flow from the roof into the pond or tank. Also consider that there is enough space for all infrastructures needed (e.g. water pump, storage facility, etc.).

In addition make sure that the greenhouse is not sited next to a tree. Shading and roots would complicate horticulture and reduce crop yields. Minimum distance from trees, and buildings as well, should be 10 m. If possible, choose a site where the number of rocks and stones is low. This will reduce the effort for bed making as preparation for horticulture.

1.3 Greenhouse size and other dimensions

This manual describes how to construct a greenhouse of an area of 120m². The dimensions of the greenhouse are 15 m in length and 8 m in width. The greenhouse is made of 3 rows of vertical steel tubes which are connected and stabilized by horizontal steel tubes. The height is 4 m in the middle of the greenhouse and 3 m on the sides. The higher and lower structure is connected by steel tubes which are fixed in a curved shape and form the roof of the greenhouse.

The greenhouse described here is made of round steel tubing of 38 mm diameter and 1.6 mm wall thickness. For the length of 15 m in total 6 tubes are used which means the distance from one tube to another is 3 m. If wooden poles are used instead of steel tubes, the distance shall be reduced to 2.5 m to ensure sufficient stability of the greenhouse.

If more area for horticulture is needed, the length of the greenhouse can be increased e.g. to 20 m which will lead to an area of 160 m². Increase the number of steel tubes used for the vertical structure accordingly and ensure maximum distance from one to another is 3 m.

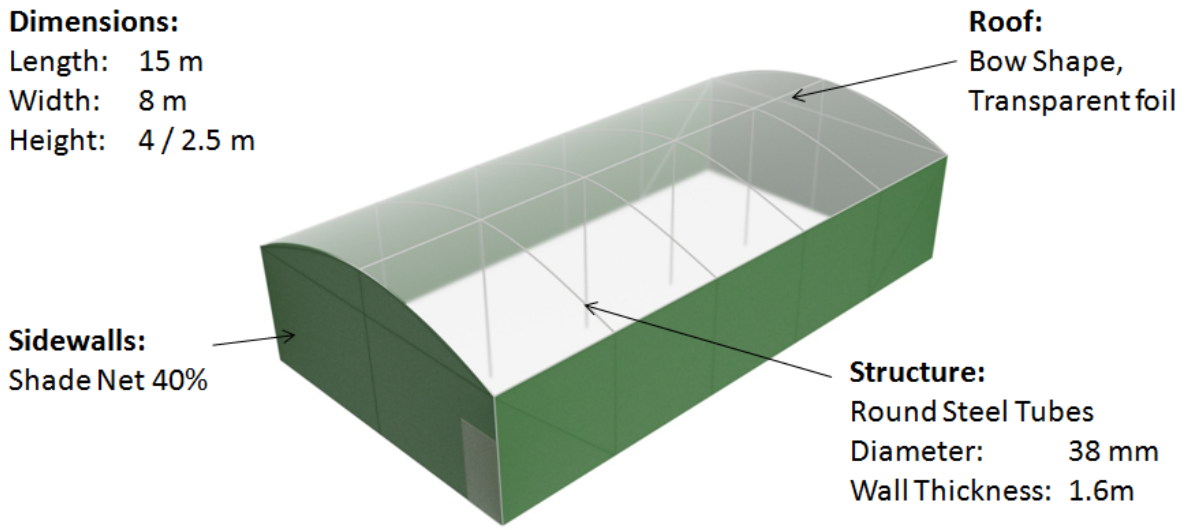

Figure 1: Illustration of greenhouse and its dimensions and description of main parts.

2 General Work Instructions

In the following chapter, activities which are to be done during the process of greenhouse construction will be described. These actions will be required in the detailed work instructions and therefore should be known.

Be aware that welding should be done by qualified persons only. Beside the necessary knowledge of welding, this person should bring along welding units and welding related tools, as well as power supply (e.g. fuel powered generator) if necessary at the construction site.

In general, it is possible to execute bed preparation and other activities which are part of horticulture while the greenhouse is constructed. For more details on horticulture and irrigation see publications #5 and #6 of this CuveWater publication series.

2.1 How to mix and use concrete

Proper mixing of concrete is very important! The concrete is needed as a foundation for the vertical tubes and therefore guarantees stability and long lifetime of the greenhouse.

Use concrete no longer than 45 minutes after mixing it with water. In general, concreting is better to be done in the morning or late afternoon to avoid too high temperatures, which will reduce the strength of the concrete. Use water sparingly as too much also water reduces the strength of the concrete. Nevertheless, make sure that the concrete does not dry before it is in place. Gravel should consist of stones of ½” to ¾” and if available, river sand should be used for mixing of concrete.

When mixing concrete, add only so much water to make the mix workable. It should not be shiny, but pasty. As a broad rule you can calculate with half the amount of water compared to the amount of cement used (for example: 10 kg cement are used for mixing concrete, then approximately 5 l water will be needed).

Mix concrete in a ratio 1 part cement, 2 parts sand and 3 parts gravel (e.g. 4 bags of cement, 8 wheelbarrows of sand and 12 wheelbarrows of gravel). First, mix sand and cement, until the color is the same all over the mixture. Second, add gravel and mix until color again is the same all over the mixture. Third, add water until the mixture is pasty.

Keep concrete humid after being applied to ensure ideal strength after curing. If necessary cover the concrete with wet towels or plastic foils. Sprinkling water onto the concrete from time to time helps as well to achieve an ideal curing process and therefore good strength of the concrete.

3 Detailed Work Instructions – Construction Diary

The sequence of actions for construction of a greenhouse made of round steel tubes described below is an ideal one for experienced workers. Depending on manpower, experience, and weather conditions the overall construction time may be longer than this. Sequence may be changed depending on availability of manpower, materials and tools as well as for weather conditions or other reasons. Some of the steps should be done parallel to work most efficiently. Ensure that all material and tools needed for construction are available at the time they are needed. Usually, 4 workers are sufficient to construct the greenhouse. Nevertheless, putting the foil on top of the greenhouse (see chapter 3.4) requires 6 workers to avoid damages.

3.1 Day 1: Siting, and Preparation

On the first day of greenhouse construction, the siting has to be done as well as preparation of material and concreting the foundations. Ensure that all material needed is available when construction is started or at least when specific material is needed during the construction process.

Work instructions:

- Choose a site for the greenhouse according to the considerations in chapter 1.2.
- Mark the dimensions of the greenhouse on the ground and indicate where the vertical steel tubes have to be placed. The greenhouse is 15 m in length and 8 m in width and consists of three rows of vertical steel tubes of 6 tubes each.
- Dig holes of 50 cm diameter and 50 cm depth into the ground where the vertical steel tubes have to be put.
- Cut 6 steel tubes of 38 cm diameter and 1.6 mm wall thickness to a length of 4.5 m.
- Cut 12 steel tubes of 38 cm diameter and 1.6 mm wall thickness to a length of 3.5 m.
- Cut 18 pieces of 45 cm length from a steel deformed with a diameter of 6 mm.
- Weld one of the pieces of the steel deformed bar to each of the round steel tubes. They shall be 25 cm away from the end of the steel tube. Later on, this will increase stability of the vertical poles.
- Place the steel tube into the holes in the ground.
- Mix concrete from 2 bags of cement and pour it into the holes of the vertical steel tubes. The concrete form the foundation and therefore gives stability to the greenhouse. Level the steel tubes.

Figure 2: Preparation of fixation of vertical steel tubes.

Figure 3: Pouring concrete around the steel tubes as foundation.

- The concrete needs around 12 hours to cure to a condition, where work can go on with the steel tubes acting as vertical support of the greenhouse.

- While concrete is curing, prepare the steel tubes which will be placed horizontally. For this reason cut 3 of the 6 m long tube in the middle. You get 6 parts of 3 m length each.
- Weld 2 steel tubes of 6 m length and one of 3 m length together to construct a tube of 15 m length in total.
- Cut two pieces of each 2 m length from one of the 6 m long steel tubes. Each piece of 2 m length has to be weld to a steel tube of 6 m to get 2 tubes of 8m length each.
- For the horizontal structure you will need the following steel tubes on the second day of construction:

1x	15 m length
2x	8 m length
2x	3 m length
4x	6 m length (as purchased)

- Finally, apply silver paint to the prepared tubes, but leave the ends untreated to allow proper welding the following day. For the 15 m long tube leave a spot unpainted every 3 m. For the 8 m long tubes leave a spot unpainted in the middle (at 4 m).

3.2 Day 2: Construction of the steel structure

On the second day of construction, the steel structure of the greenhouse will be continued after vertical support poles were fixed firmly in the ground the day before. For the following activities, ladders in an appropriate length are needed. Always ensure safety at work while being on ladders and while welding.

Work instructions:

- Start with one of the sides of 2.5 m height and place a steel tube of 6 m horizontally on the vertical tubes, beginning from one of the corners of the greenhouse.
- Weld horizontal and vertical steel tubes together with the welding unit. Welding connections have to be constructed with care to ensure the stability of the greenhouse even when strong winds lead to high loads on the steel structure.

- Continue with placing and welding another 6 m tube and finish the first side with one of the 3 m long pieces of steel tube.
- Do the same steps on the other long side of the greenhouse.

Figure 4: Horizontal steel tubes fixed to vertical structure by welding.

- Next, the 15 m long steel tube has to be placed and fixed to the centre row of vertical steel tubes. Therefore one worker has to position and weld the tubes beginning on one end. Two other workers have to position and support the horizontal tubes using positioning tools of appropriate length.
- Again, execute the welded joints with care to ensure stability and durability of the greenhouse.

- Continue work by connecting the ends of the three rows of vertical tubes with the 8 m long steel tubes on each of the short sides of the sidewall. Weld the 8 m long tubes in a height of 2.5 m to the outer and central vertical tubes.

Figure 5: Positioning a 15 m long steel tube on the centre row of support poles.

Figure 6: Sloping steel tubes joint to centre structure, supported by lower rows on the sides of the greenhouse.

- Finally, the sloping connections from the centre row to the smaller rows on the side of the greenhouse have to be constructed. For this reason, position the end of a 6 m long steel tube to the welded joint of a vertical support poles and the horizontal steel structure (this means the centre row of 4 m height). The end of the sloping steel tube should lie on the structure of 2.5 m height to allow welding with minimum load to the joint to be welded.
- In total 12 steel tubes have to be positioned and welded to the 4 m high structure, 6 in each direction.

3.3 Day 3: Completion of the steel structure.

On the third day of construction, the steel structure of the greenhouse will be completed. Therefore sloping steel tubes will be cut and fixed on the lower end. Furthermore, steel tubes will be joined diagonal the increase the stiffness and stability of the whole steel structure.

Work instructions:

- The sloping steel tubes where left lying on the lower structure on day 2 and have to be cut to an appropriate length now. While cutting the tubes, have in mind that the roof should have a curved shape and does not form a simple dual pitched roof. For this reason, the tubes have to be cut long enough to form a bow from the upper to the lower horizontal structure.
- Weld the bow shaped steel tubes to the horizontal lower structure. In total, 12 tubes have to be joined to the lower structure, 6 on each side of the greenhouse.

Finally, the steel structure of the greenhouse has to be reinforced by diagonal elements.

- First, cut 4 steel tubes of originally 6 m length to pieces of 4 m and 2 m.
- Then, the pieces of 2 m length have to be positioned between the first vertical support pole of the centre row (this means, the vertical tubes of 4 m height) and the bow shaped tube which are forming the roof (see Figure 8 and Figure 10). Join them to the roof structure already existing by welding. Same has to be done for the last vertical support pole of the row.
- The 4 m long steel tubes have to be positioned and joint diagonally into the first and last segment of each side of 15 m length. Position each of the tubes in the corner of the greenhouse at 2.5 m height and adjust them sloping to the next vertical support pole (see Figure 9 and Figure 10). The steel tubes have to be joined to the existing steel structure by welding.

Figure 7: Roof structure of the greenhouse completed.

Figure 8 (left): Diagonal reinforcement of the steel structure (1)

Figure 9 (right): Diagonal reinforcement of the steel structure (2)

- For the last reinforcement 4 steel tubes of 5 m length each are needed. Cut tubes to the length needed.
- Position the first of these tubes leading from the second vertical support pole in a row of 2.5 m height to the bow shaped tube which runs from the first 4 m high vertical support pole to the first vertical support pole of 2.5 m (see Figure 10). Weld the tube to the vertical and bow shaped structure.

- This has to be done for each of the corners of the greenhouse

Figure 10: Reinforcing elements of the steel structure of the greenhouse.

- Apply silver paint to those steel tubes which were not painted yet.

3.4 Day 4: Fixation of shade net and transparent plastic foil

After the steel structure was completed and reinforced to ensure long lifetime, the shade net has to be installed. Furthermore, the roof will be prepared, so the transparent plastic foil can be installed.

Work instructions:

- Measure and mark the height of 2.3 m at one of the vertical support poles forming a corner of the greenhouse.
- Stretch a rope to the other corners and mark the vertical support poles there in a height which ensures, the rope is leveled. Since all the other vertical steel tubes have to be marked as well, tie the rope to the corners in the leveled condition.

- Mark all 2.5 m high steel tubes of the sidewall at the height indicated by the rope.
- Drill holes into the steel tubes where they were marked. Holes should face from the outside to the inside of the sidewall and allow the fixation of timber rafters to each of the sidewalls. Diameter of the holes should match the bolts purchased.
- Position timber rafters to the steel structure. Drill holes matching the position in the steel tubes.
- Fix the timber rafters to the metal structure with bolts, washers and nuts. The sequence from outside the greenhouse to the inside is: bolt, washer, timber rafter, steel tube, and nut. Fit together rafters by putting a small piece of rafter behind and nailing all of it together. This will ensure stability

Figure 11: Timber rafters attached to the sidewall structure.

- Place one end of the shade net onto the upper edge of the timber rafters and stretch it around the whole greenhouse. Fix the shade house to the timber rafters with wire nails.

  Ensure that the shade net does not sag on the short sides of the greenhouse, where no rafters are. Keep in mind, that a gate will be installed at one of the short sides of the greenhouse. Attach the shade net in a way that allows entering and leaving the shade house and detaching it again, when the gate is installed.

Figure 12: Shade net fixed to green house structure.

- Now, the roof structure has to be prepared for application of plastic foil. For this reason, cut timber rafters to pieces of 1.5 m length. In total 12 pieces are needed.
- Position the pieces of timber rafters along the first and last bow shaped steel tubes. Mark suitable positions on the steel tubes for fixation and drill holes into the steel tubes and rafters.
- Fix rafters of 1.5 m bow shaped to the bow shaped steel tubes with bolts, washers and nuts.

Figure 13: Attaching timber rafters to the roof in a bow shape.

- In the next step, the transparent foil has to be pulled across the steel structure of the roof. Begin at one side of 2.5 m and pull the foil across the 4 m high centre to the other row. Timber rafters or steel tubes can be used to adjust and push on the foil. Nevertheless, ensure that the plastic foil is not damaged or torn.

Figure 14 (left): Pulling plastic foil across the roof of the greenhouse (1).

Figure 15 (right): Pulling plastic foil across the roof of the greenhouse (2).

- To fix the transparent plastic foil to the greenhouse three major steps are necessary. First, wrap one end of the foil around a timber rafter of 38 mm x 50 mm and position the rafter below the timber rafters already fixed to the greenhouse structure. Fix the foil with the thin rafters from below to the rafters of the greenhouse structure with nails. This ensures that the wood is kept dry and does last long.

Figure 16: Plastic foil and timber rafter fixed to the greenhouse below existing timber rafters.

- When the plastic foil is attached to the greenhouse on one side, tighten the foil from the other side to ensure it won't be waving in the wind later on. Again, wrap foil around timber rafters of 38 mm x 50 mm and fix it below the existing rafters with nails.
- Finally, attach the foil to the timber rafters that where fixed to the bow shaped roof structure. Again nail the foil to the rafters from below.

- Last task for the day is fixation of shade net to cover the still empty parts of the small sidewall. Position shade net on top of the timber rafters, which are part of the bow shaped roof. Turn up the net to have two or three layers, which will make to fixation more robust. Nail shade net to the rafters from above.

Figure 17: Shade net fixed on the bow shaped rafters of the roof.

- Tie the edges of the shade net to the vertical tubes of the short side

3.5 Day 5: Installation of gate and gutters

On day 5 of construction, the gate and the gutters will be installed to the greenhouse. The gutters allow for harvesting the rainfall from the roof of the greenhouse and leading it to a tank or pond nearby. In general, this measure will increase the availability of water for horticulture.

Work instructions:

- First, positions the mesh gate to the place, where the entrance is most convenient and the shade net was left open for the gate.
- Drill holes into the vertical tube on the corner of the greenhouse, to fix the gate with bolt and nut. A piece of timber may be used as counter piece to ensure optimum fixation.

- On the free end of the gate, position a wooden pole vertically. Fix it to the horizontal steel tube through a hole using screw and washer.
- Construct a lintel and a stop for the gate from timber rafter. Fix them to steel tubes and wooden pole with screws and washer.


Figure 18 (left): Fixation of the gate to the steel structure.
Figure 19 (right): Gate installation with wooden pole, lintel and stop.

- The next step is the installation of the gutters. Essential for the gutters is that they are sloping and allow a good drainage of the water. This description is for a drainage and tank/pond connection on the side of the greenhouse where the gate is installed. Therefore, the side with the gate will be named as beginning of the greenhouse. The other side consequently will be named end of the greenhouse.

  Nevertheless, it is possible to realize the draining in different ways.
- Install gutter brackets to the timber rafter fixed to the steel structure. For this reason, you have to cut small holes into the shade net, where brackets are put through. First install the bracket at the end of the greenhouse, second install it at the beginning. Ensure that the gutters have a slope of 3 mm per m length which means the total slope is about 45 mm for the 15 m long sidewall of the greenhouse. This can be done by stretching a cord from the last bracket first in leveled condition, then sloping about 45 mm.

  The slope of the gutters ensures a good draining of rainwater.
- For each of the long sides of the greenhouse 7 brackets are to be used. The distance from one bracket to another as 2.5 m accordingly.
- Joints of gutter elements have to be water tight. Therefore soldering or any other applicable treatment has to be done.

Figure 20: Fixation of gutters to the greenhouse.

- Finally, lead the gutters around the corner to the face of the greenhouse. Gutters can be fixed hanging with steel wire to the vertical steel tube of the structure and/or support by wooden support poles.
- Connect the gutters to a PVC junction and the PVC downpipe which will lead the rain water to the drainage system going to tank or pond. This draining system is not described here anymore.

Figure 21 (left): Connection of gutters and downpipes.

Figure 22 (right): Guidance of gutters from the sidewalls along the face oft he greenhouse.

Figure 23: Completed greenhouse, already in use.

Your greenhouse is ready!

4 Estimated Bill of Material

	Material	Quantity	Approximate Amount in N$
1	Round Steel Tubes 38 mm x 1.6mm	43	5670
2	Bolts	80	315
3	Nuts	80	55
4	Washers	80	45
5	Builders Line 0,85 x 100m,70LBS	1	25
6	Cement 32.5R 50kg	2	190
7	Sand	0,3 m³	30
8	Stone Concrete 19mm 0.5cbm	1	550
9	Gate Mesh 900 x 1800 x 32 x 75mm	1	290
10	Gutter 0.5 x 100 x 125mm x 6m	5	1750
11	Gutter Brackets Square Purlin 125 x 100	15	195
12	Gutter Downpipe 100 x 75 x 2.7m x 0.4mm	3	330
13	Gutter Square 3.6m x 100 x 75 x 0.4mm	1	100
14	Nails Wire 75mm x 3.55mm 1kg	15	210
15	Neo Industrial Aluminium Paint 1l	4	435
16	Transparent Plastic Sheet (for Roof)	1	5000
17	Poles CCA 50/75mm x 2.4m	4	160
18	PVC Junction SV Plain 110mm x 90°	1	80
19	PVC Down Pipe 110mm x 5m	1/2	95
20	Roofing Screws & Washer 90mm (100pp)	3	105
21	Shade Cloth 40% 3m	55	2475
22	Timber Purlin 50mm x 76mm x 6m (4pcs)	2	930
23	Timber Brandering 38mm x 50mm x 6m (9pcs)	1	540
24	Twine Sisal 1 Ply 500gr	2	55
25	Welding Rods 2.5mm 1kg	2	170
26	Blades Hacksaw 32TPI HSS	1	20
	Total Materials		**19820**
27	Proposed labor (man days)	22	2200
	Grand Total		**22020**

Gutters for harvesting of rain water from the roof are included in the bill of material. Depending on the specific position of tank or pond, amount of PVC pipes and bends needed could be higher.

5 Bill of Tools

	Tools	Quantity	Approximate Amount in N$
1	Spade	1	105
2	Hand Saw 550mm	1	105
3	Hammer Claw 500gr	2	340
4	Spirit Level, Aluminum 600mm	1	80
5	Bucket, builders 12l	1	45
6	Plier, combination	2	100
7	Bit HSS 10.5mm	1	20
8	Bit HSS 9.5mm	1	20
9	Bit HSS 7mm	1	20
10	Brush 75mm	2	120
11	Builders Square	1	55
12	Screwdriver 6x100mm	1	18
13	Tape Measure 5m x 25mm	2	80
14	Saw Hacksaw Frame	1	45
15	Positioning Tool 4m		
16	Welding Unit (equipment of welding specialist)		
17	Soldering Unit (equipment of welding specialist)		
	Grand Total		**1153**

Amount of tools needed depends on number of workers supporting the construction of the greenhouse. Tools and Quantity listed above is suitable for 4-6 workers.

6 Construction Procedure Table

Day of preparation and days for curing of concrete and mortar were not counted in the detailed work instruction, but are counted in the table below.

Day	Activity	Materials used	Remarks
Day 1	Purchase and supply of materials.		
Day 2	Site selection and preparation of material.	2 bags cement 6 wheelbarrows sand 9 wheelbarrows of concrete stone (½” to ¾”) round steel tubes silver paint	wawing of steel tubes is more easy with machine tool welding unit
Day 3	Construction of the steel structure	round steel tubes silver paint	welding unit
Day 4	Completion of the steel structure.	round steel tubes silver paint	welding unit
Day5	Fixation of shade net and transparent plastic foil	timber 50mm x 76mm bolts, washers, nuts shade net timber 38mm x 50mm nails transparent plastic foil	

Day	Activity	Materials used	Remarks
Day 6	Installation of gate and gutters	gate bolts, washers, nuts screws & washer timber gutters gutter brackets nails PVC junction and pipe	soldering unit or anything else to join gutters together

7 Maintenance of the Greenhouse

The steel structure of the greenhouse, as well as the usage of a strong plastic foil, guarantee a long durability of the greenhouse. Nevertheless, regular inspections of foil, shade net and steel structure are necessary.

7.1 Visual inspections

Once a week you should inspect the foil and the shade net for rips/tears. The sooner damages of foil or shade net are recognized, the higher is the chance to manage a repair at low costs. The steel structure of the greenhouse should be inspected at least once a year.

Check that all welding connections are still sound and as a result durability and safety is given. At the same time, latest short before wet season, check if the gutters are still in good condition.

7.2 Cleaning the gutters

Short before the wet season begins, the gutters have to be cleaned. This is necessary to ensure as clean water as possible running into pond or tank. First remove leaves and other objects from the gutters. Then clean the gutters can with a hand brush and or a piece of cloth.

7.3 Repair of cracks

Crack of the steel structure have to be repaired to ensure stability of the structure. If welded joints cracked, clean the area and grind away the old weld seam. Put a new weld seam on the joint to fix the parts together. If the steel tubes cracked or a welded joint cannot be repaired with a new weld seam, it may be necessary to form a bushing out of a steel tube with larger diameter. The bushing itself will allow execution of a new welding connection in appropriate quality.

Rips or tears in the shade net may be repaired with needle and twine. If the crack is too big, exchange of segment may be helpful. For this purpose the shade net has to be cut out from one of the segments of 3 m length and 2.5 m height. The remaining shade net has to be tied to the steel structure with twine. Where the shade net was removed, a new piece of shade net has to be positioned and tied to the steel structure.

Small rips and tears of the plastic foil can be repaired with duct tape. Best is to repair the rips from above, but depending on the position this may not be possible. In any case put tape on the crack to avoid further ripping or at least reduce the speed of deterioration.