NGO Placement Report

Sunseed Desert Technology

Background

Sunseed Desert Technology is a non-profit charity that exists to research, teach, and encourage sustainable living. Although registered in the UK, the Sunseed community is based in a small, remote village in the hills of Andalucia, southern Spain.

Image 1. A welcoming sign at the entrance to the main house at Sunseed.

The staff at Sunseed use the basic principles of permaculture and their accumulated knowledge and experience to “develop, demonstrate, and communicate” methods of low-impact and low-carbon living (Sunseed, 2011). Through their six different departments: 'Sustainable Living', 'Appropriate Technology', 'Drylands Management', 'Eco-Construction and Maintenance', 'Education, Publicity and Fund raising', and 'Organic Growing', they offer volunteers a varied and dynamic insight into a lifestyle that focuses less on consumption and more on independence and resilience. During my eight week placement I was given the opportunity to work within each of these departments in the morning work sessions when volunteers at Sunseed help with communal tasks.

As the isolated village where Sunseed is located is not connected to the national electricity network, all of their energy must be generated on site. Most of their electricity

requirements are met by photovoltaic solar panels, which are situated on the rooftops of each of the three Sunseed properties. These work tirelessly on sunny days to charge battery units at each property, which in turn provide power for all of the LED light fixtures and wall sockets. There is also a micro hydro turbine in the nearby river that provides a continuous supply of energy to the batteries in the main house, picking up the slack at night-time or during a cloudy day.

Image 2. The photovoltaic solar panels installed on the roof of Sunseed's main property. They supply the vast majority of the electricity used at the house.

Two of the houses at Sunseed have running water, which comes from an old irrigation channel that diverts water from the river running through the valley. The water is pushed uphill to the top of the village by a 'ram pump' (that requires no electricity) and then flows downhill through the cluster of houses, providing water to each residence as required. Unfortunately, due to the high concentration of calcium sulphate in the water (the surrounding mountains are rich in gypsum), it is not drinkable, so potable water must be brought in to Sunseed in large, refillable plastic containers. It is, however, used for showering, and washing dishes and clothes.

Once this water has been used, it must be processed before it can be returned to the river. Sunseed achieve this by having their waste water pass through a series of man-made filters and natural vegetation beds that remove some of the harmful materials and chemicals. It is, however, far from 100% efficient. As a result, both visitors and staff are urged to use cleaning products that are as natural and biodegradable as possible, as certain man-made chemicals found in soaps and shampoos for example, are known to have particularly harmful and long lasting effects on the environment.

All of the hot water at Sunseed comes from two sources. Solar water heating panels on the rooftops of two of the properties do a great job of using the sun's energy to heat the water in their pipes. These pipes then run into a nearby water tank where they transfer their heat and return to the solar panels with colder water to be heated again. On a rare cloudy day, or if something goes wrong with the panels, heat can also be drawn from the back boiler of the thermal mass oven on the ground floor. This is a stove that burns wood at exceedingly high temperatures, heating the high density bricks in the oven's structure rather than just the air surrounding it as a conventional open fire would. This means that although the wood burns quickly, the heat it creates is trapped by the bricks and released slowly over a long period of time. Not only does this provide plenty of hot water for showers, but it also warms the downstairs dining room where the evening meal is enjoyed by everyone after a hard day's work. There are also solar ovens on the roof, which capture the sun's energy through a glass lid and trap it efficiently within their insulated walls. Using this relatively simple technology, water can be heated to approximately 70°C, cutting down on the amount of gas that needs to be used for boiling kettles and cooking staples such as potatoes or rice.

Image 3. A solar oven at Sunseed, used for pre-heating water to high temperatures.

I first heard about Sunseed through one of my lecturers during my undergraduate degree. He used the organisation as an example of sustainable community living, where energy was harnessed from nature and food was grown organically on-site. I have been interested in their work ever since, and when I had the opportunity to work with them for my NGO placement, I immediately got in touch with their project manager, Jef Carrick. He told me they had an abundance of projects that needed only energy and imagination to get off the ground.

Project

After a friendly conversation over the phone with Jef, we decided that the project that would best suit both of our objectives would be the construction of a new 'caña' bridge. The old bridge had been built seven years prior and had succumbed to use from not only the Sunseed community, but also other people living in the village and tourist traffic, as the area surrounding the village is also a national park.

The bridge is used to connect Sunseed's main quarters with it's dry-land sites over a small river, which runs through the park's valley, and is therefore an important asset to the organisation. Although the walking platform had been replaced by Jef within the last couple of years, the foundations of the bridge had collapsed in some parts and the whole

structure was in desperate need of replacing.

Image 4. The old caña bridge. The damage can be seen at the bottom of the photo.

Caña

Caña is the local name for Spanish cane, or *Arundo donax*, a tall perennial, bamboo-like plant that grows throughout the Mediterranean. Also known as giant cane or giant reed, it is considered in some countries an invasive species and poses a particular threat to river banks, where it tends to grow in thick clusters, out-competing native plant species. This tenacity is due partly to its rapid growth rate (almost 10cms per day in the summer) and partly to the fact that it reproduces through its rhizomes which can form tough root networks up to 1 metre underground. This latter property has made it a particular problem in flood plains, where the forceful nature of the water helps it to spread further downstream by breaking up and transplanting parts of the plant's roots.

Image 5. A small clump of *Arundo donax* growing near one of the properties at Sunseed.

Its fast growth rate and ability to grow in different climates and soil types have made it a potentially viable second generation biofuel crop. Initial studies have shown that *Arundo donax* can produce on average 3kgs of dry matter biomass per squared metre of area planted on an annual basis and that it yields an energy density when burnt of approximately 17 MJ/kg whether it is grown with or without the use of fertiliser (Angelini *et al.*, 2005). This is comparable to wood (also 17MJ/kg) and corn (19MJ/kg), but less than charcoal (30MJ/kg) (Biomass Energy Foundation, 2009). It also compares favourably with other biofuel crops in terms of bioethanol yield per hectare (see Table 1 below).

Crop	Corn	Switchgrass	Sugar cane	***Arundo donax***
Bioethanol yield (litres/hectare)	4,400	4,600	8,800	11,000

Table 1. Yields of bioethanol for different biofuel crops, shown in litres per hectare. (Williams *et al.* 2008)

There have also been studies done to assess the effectiveness of *Arundo donax* in the bioremediation of polluted waste waters and the removal of salt from saline soils. A study carried out in Greece showed that when cultivated in a closed gravel hydroponic system, with pig's waste used as the nutrient solution, the cane responded positively and an increase in biomass was recorded. It also cleaned the wastewater that was supporting its growth, without showing any visual signs of toxicity (Mavrogianopoulos *et al.*, 2002).

This strengthens the case for the use of *A.donax* as a biofuel, as not only does it grow prolifically in certain areas that can't be used for food crops, and produce large amounts of heat energy when burned, but it can also recycle water that has become polluted from human activities like farming. It is important to bear in mind, however, that the giant reed is an invasive species and is especially troublesome in floodplains and riparian systems. If plantations were to be established, they should be far from these areas to reduce the risk of uncontrollable spread.

The stem of the caña plant is widely used in the production of reeds for a variety of instruments, including bassoons, saxophones, and also for bagpipes. In the Andalucia area, where Sunseed is based, the caña is used extensively in the construction of partitioning walls and ceilings where it is often employed in conjunction with a plaster made from gypsum rock (known locally as 'yeso'), which gives it strength and increased insulation. It can also be used outdoors to make a number of temporary structures such as fences or frames for poly-tunnels, or even something more permanent, like a geodesic dome or compost toilets.

Image 6. The compost toilets at Sunseed, made from the locally abundant caña.

Unlike traditional bridge building materials such as wood, stone or metal, caña is completely sustainable. Not only is it abundant in the area where the bridge is to be built, but it is also 100% natural and biodegradable. The only major problem with using caña as the primary building material in any outdoor construction is that over time, and exposure to the elements, it inevitably weakens leaving it susceptible to cracking when put under strain. This is especially undesirable in a structure like a bridge that is put under pressure every time it is used. Unfortunately, this means that the bridge I have built will have to be replaced, either in parts or its entirety, every year or so, in order to maintain its structural integrity.

Sisal

The caña will be tied together with sisal, a tough natural fibre that comes from the *Agave sisalana* plant. Due to its strength, stretch, durability, and resistance to deterioration under water, sisal has traditionally been used to make rope, twine and other types of cordage. Although it has been replaced to a certain degree by polypropylene and other synthetic materials, there is still a strong global market for sisal. In 2007, 240,000 tonnes were produced globally, of which Brazil produced almost half (FAO, 2008).

Image 7. A column of caña that has been tied together using sisal from the *Agave sisalana* plant.

Sisal is produced locally in Andalucia, but is of inferior quality to that produced in East African countries like Tanzania, which is where the sisal I have used on the bridge originates.

Methods

The first and most time consuming phase of any building project involving caña is the cutting and cleaning stage. Although caña enjoys prolific growth in the national park where Sunseed is located, it is not all suitable for construction. Ideally, the cane should be between 8 and 12 feet long and between 1.5 and 2 inches in diameter. Smaller canes can be used as struts to join columns together to make a super-column, but they are not suitable for the columns themselves due to their diminutive nature. Canes exceeding these dimensions are also not suitable, as they are often not as flexible as their smaller counterparts and therefore too brittle to use in a load bearing structure.

Once a suitably sized cane has been identified, it should be cut away using one of two methods. It can either be ripped from the ground using the 'flex and jerk' technique, or cut at an appropriate point using a gardening saw. The so called 'flex and jerk' technique is achieved by first holding the cane at roughly its midpoint and pulling it down towards the ground. It should then be pushed away from the body, causing the section of the cane between your hands and its rooting point to flex. Using two hands, you then quickly pull the

cane back towards your body in a long, jerk-like motion, allowing your body to twist with the movement. If done correctly, this will result in the base of the cane being ripped free from its root mat.

Alternatively, if the cane is growing amongst other unsuitable canes, or the working area is too small, a small saw can be used to cut the cane below one of its ridges, preferably on the horizontal plane. If cut at an angle, the resulting stump left behind may be spiked dangerously, creating a hazardous working environment. Even stumps with a flat cut can be harmful, so greater care must be taken when using this method.

After cutting, but before cleaning, the canes must be tested to make sure they are flexible enough to be used in the construction of the bridge. A simple flex-test is carried out by pressing the thicker end of the cane against a rock or other steadfast object and bending its thinner end towards the ground by hand. If the cane bends into an arch without snapping, it has passed. If it snaps, the broken cane should be discarded. During the flex-test, some cracking sounds may be heard, but this is not necessarily an indicator of inflexibility. It may simply be the sound that the bark makes as it is separated from the cane by the bending process.

The cleaning stage involves removing any lateral branches, shoots, or buds from the entire length of the cane, making it easier to tie them together into columns. A hand sickle is the best tool to use for the job, but it is important to exercise strict control over the blade, as it is a delicate process. If the angle of a cleaning stroke is too steep and the sickle cuts into the cane, its strength and flexibility will be compromised and it will be unsuitable for use in construction. The thin dry bark that covers the cane must also be removed to prevent water from being trapped close to the green skin underneath, which would speed up the process of decay. This is done most easily by hand while wearing rubber-palmed gloves for added grip. Finally, if the canes have been removed using the 'flex and jerk' method, you should use a saw to make a flat cut at the base of the cane. This is best done just below one of the ridges, as this is the strongest point and provides a solid base that is less prone to splitting.

Once the caña has been cleaned, it can be tied together into a column structure. Using a process of trial and error (and past building projects involving caña at Sunseed), it is possible to ascertain that the strongest configuration for the canes to fit together is in groups of either three or seven. As the bridge required a thicker support, I used seven canes to make each column, with each cane being of similar length and width to the others in the grouping. The diagram below (Fig. 1) shows in cross-section how the canes are arranged in the column structure. As the canes are not of uniform diameter, it may be necessary to experiment with different canes in different positions before a satisfactory arrangement is achieved. The column can then be secured using pre-cut lengths of natural sisal, wrapped tightly around the caña three or four times and fastened with a solid knot. This should be done four or five times along the column, at intervals of about 12 inches, starting at the base.

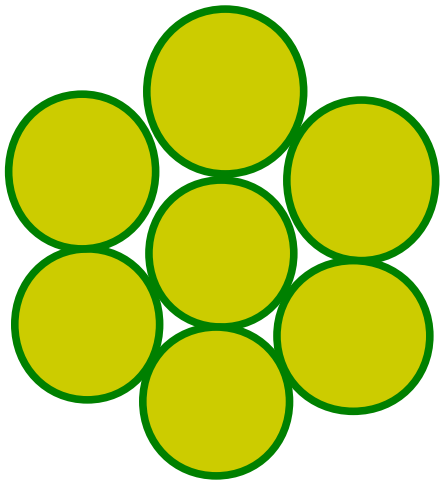

Figure 1. An illustrated cross-section of a caña column.

The fundamental building unit for the caña bridge was the 'super-column' – two columns of caña spliced together at their tips, using four thinner canes as joining struts (see Fig. 2 overleaf). Although the resulting super-column structure has eighteen cane pieces in the middle and only seven at each end, the thinness of the tips and thickness of the bases of each of the two columns ensure that the overall width is roughly uniform. Just like the columns, the super-column should be secured across its mid-section using sisal string.

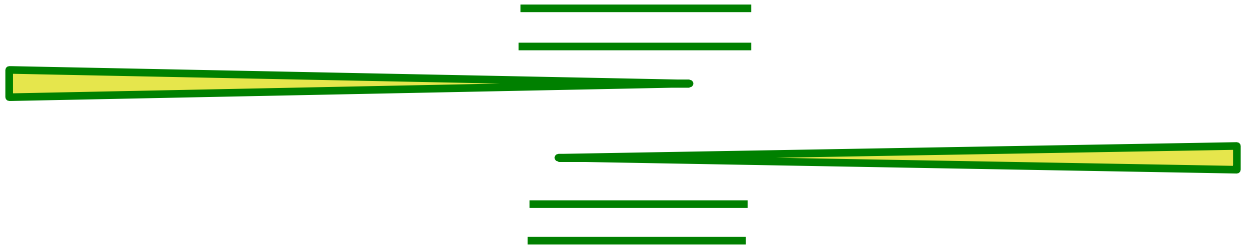

Figure 2. Exploded view of the super-column structure. You can clearly see each of the columns and the four joining struts in the centre.

When the super-column has been constructed, it should be flex-tested in the same way as each individual cane that comprises its structure has been. Place one end of the super-column against a rock and carefully push the other end towards it, allowing the middle to rise into an arch. This requires at least two people to be carried out safely. Once the arch has been made, it is important to look and listen for any signs of weakness in the structure. This includes cracking or splitting noises during the flex, and watching for pieces of cane that might be protruding from the arch. It might be necessary to re-tie some of the sisal knots on your super-column or to replace any pieces of cane that have split or cracked during the flex-test.

Image 8. Flex-testing a super-column upon assembly.

Design and Build

The bridge had to cross the river at a point where it is approximately 10 feet wide, with a large boulder positioned roughly 7 feet from one side and 3 feet from the other. This was used as a support for the bridge. The bridge also had to curve slightly from left to right, due to the lie of the rocks on the river banks. A basic sketch is shown below (Fig. 3). The design of the new bridge was based somewhat on that of the old one, with a few modifications that have hopefully improved its strength and longevity.

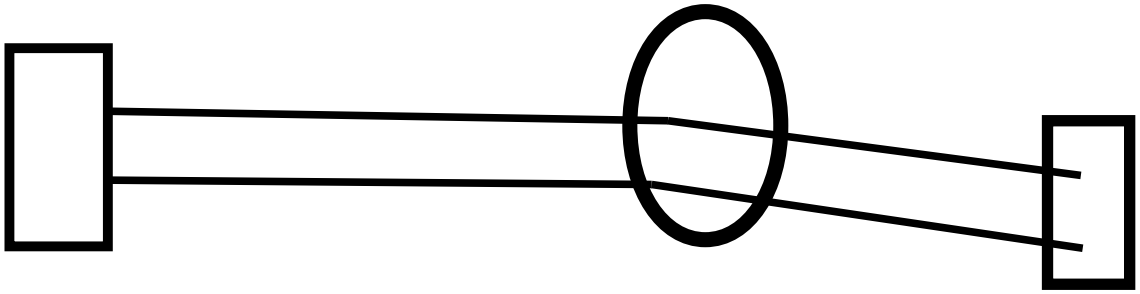

Figure 3. A basic schematic of the bridge layout from above, showing the position of the large boulder.

Before any part of the old bridge was removed, we closed off the path leading up to it and diverted it to a point in the river further downstream where the river is narrower. Here we placed a stout plank of wood between a couple of rocks to create a make-shift crossing. It should be noted that this would not be a suitable location for a permanent bridge as the lay of the rocks in this area is less suitable. The old bridge was then de-constructed slowly, in order to ascertain which parts of its structure failed and for what reasons. Suggestions were then made on how these aspects could be improved and how they could be implemented into the new design.

The main problem with the old bridge was that it wasn't quite on the same level as the path that approached it, on the side closest to Sunseed's main quarters. This meant that people had to step down onto the bridge, putting more weight and therefore more pressure on

both the caña in the walking platform, and the super-columns underneath that supported it. Eventually, this resulted in one of the main foundation columns snapping, causing the bridge to drop further, which only made the problem worse as people continued to use it. In order to prevent this from happening again, the new bridge was built right up to the same level of the approach path and supported securely to ensure that it doesn't suffer the same fate.

Image 9. The space where the old bridge used to be, with the boulder and the back of the caña half-dome clearly in view.

The main restriction on the bridge was that it could not be free standing, due to the flexible nature of the caña and the lack of solid foundations. For this reason, the bridge had to be integrated into an existing structure, in order to provide it with a solid anchor. This came in the form of a caña 'half-dome' that was constructed at the same time, and by the same person, as the old bridge. It is situated just beside the bridge site and was built originally to provide shade over a nearby pool in the river, where people can go to escape the heat of the sun in the summer.

Image 10. The caña half-dome. The bridge site is on the other side of this structure.

The foundation of the bridge is composed primarily of arched super-columns that we anchored against large stones on the river bed and bent into shape. We then stabilised the arches by tying them securely against other super-columns that were in turn connected to the back of the caña half-dome structure. A network of super-columns were then weaved in and out of each other and tied securely together to form the solid base structure of the bridge.

Image 11. The foundation structure of the new bridge. The rear of the caña half-dome is just visible in the top left corner of the image.

Next, we added short horizontal cross-struts, cut from longer super-columns, to the top of the foundation columns. These not only provided a flat base for the walking platform, but they also added strength to the structure. As each cross-strut was tied securely into place, the bridge really started to take shape and it was much easier to visualise what needed to be done next.

Image 12. The cross-struts greatly strengthened the structure of the new bridge.

After this, we added a caña mat over the top of the cross-struts. This was made separately, using 40 lengths of caña assembled vertically, side by side and tied together with sisal. This was then attached to the main structure of the bridge by painstakingly weaving yet more sisal through the mat itself and around each of the cross-struts. Although a hugely time consuming process, this gave the walking platform a solidity that could otherwise not have been achieved.

The end result was a solid, sturdy and sustainable bridge that will allow tourists, villagers and the staff and volunteers at Sunseed to cross the river without fear of getting wet. It is also a fine example of caña architecture and what can be achieved when we think and act in a more sustainable way.

Image 13. Tying the walking mat securely to the main structure, bringing the project to an end.

Conclusions

This work placement has given me a valuable insight into not only the workings of a non-governmental organisation, but also a low-impact, permaculture driven community. Living and working in the same environment allowed me the opportunity to realise the full potential of the project I was involved in and the community that I was now a part of. This gave me a strong feeling of responsibility for the work I as doing as I knew exactly what it meant to the people who lived in the area.

The placement has also given me some new skills and allowed me to develop some old ones. My teamwork and communication skills, for example, have been enhanced as a result of working with both small and large groups of people on various tasks during my stay. I was also able to exercise my problem solving abilities on many occasions and I was reminded of the need to be patient more than once. The ability to work with caña as a construction material is undoubtedly one of the most valuable skills that I can take away from the project and I hope to work with it again in the future.

The most obvious limitation of the bridge is that it has to be replaced to some extent every year or so. While this might seem like an extremely undesirable trait, it is actually beneficial in this case. Sunseed exists primarily to educate people about sustainable living. The temporary nature of the bridge and its need for renewal gives the staff an excellent opportunity to demonstrate to volunteers and other interested parties how the local caña can be used in construction. This sharing of knowledge is one of Sunseed's key objectives and therefore the bridge can be used as a learning tool in the future.

Time is often a limiting factor in any project and this certainly was no exception. In the opening phases of the project I found that I was spending far too long cleaning each individual cane piece. It soon became clear that I was being too thorough and the necessary level of cleaning could be achieved in under half the time. It was also necessary to ask for assistance from the other volunteers within the organisation from time to time. The extra hands made light work of the cutting and cleaning process, and real progress was made on the days when two or three other people would pitch in to help.

It also helped that during the last couple of weeks of the build, real focus was given to my project, by both the project manager and the rest of the volunteers at Sunseed. We were allowed to dedicate not only our afternoons, but also our mornings to the construction of the bridge, which until now had only been an after lunch activity for myself and one assistant. This really sped up the progress of the build and was a key factor to the project being completed within the allotted time period. That said, I still really valued the opportunity to work in the different departments during the morning communal tasks, as it allowed me to experience other facets of permaculture and sustainable living, and to develop new relevant skills. Had I only worked on the bridge during my stay at Sunseed, I definitely would have missed out on a lot of enjoyable and educational activities.

Given more time on the project, there are a few additions I would like to have made to the bridge. Most importantly, I would have constructed hand rails to give support and guidance, especially on the down river side of the walking platform. Although the bridge is fairly wide, it is not exactly level, and caña surfaces can be extremely slippery on a wet

day. I would also liked to have added an additional caña mat on top of the walking platform, with the caña running horizontally instead of vertically. This would be sewn in directly onto the vertical caña mat already in place, allowing the weight of each footstep on the bridge to be distributed evenly across more pieces of caña, resulting in less pressure and therefore less breakages.

Acknowledgements

Many thanks to all those at Sunseed, both staff and volunteers, who made my stay so enjoyable. Every day brought something new to be learnt, enjoyed or even just laughed at. The whole Sunseed community really came together during the last week of my project to help me get it finished in time, and for this they have my eternal gratitude.

Special thanks go to Jef, my project manager, for introducing me to the world of caña construction. His passion for it proved to be infectious and his involvement was key to the success of the project. A special mention must also be given to Alan, for never thinking twice before getting wet with me, and of course my project assistant Kaelegh, without whom none of this would have been possible.

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