



**WATER SUPPLY AND SANITATION IN INTERNATIONAL
DEVELOPMENT 4**

INTERNATIONAL DEVELOPMENT PROJECT

*The Trailblazer Foundation
Local Water Program in the Sras Village, Cambodia*

Group 8

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1 INTRODUCTION

Cambodia has suffered from years of devastating conflict leaving the country one of the poorest in the world with lack of clean water and sanitation. The poor standards of water facilities leads to the spread of water borne diseases. This is responsible for high infant mortality rates in Cambodia, in 2004 UNICEF recorded an infant mortality rate of 85 out of 1000 births¹. Clean water, sufficient sanitation facilities and education are key to reducing the spread of diseases and improving quality of life in devolving countries. Many aid organisations are carrying out projects in Cambodia to provide access to clean water supplies. Ensuring that the community is involved at all stages of any aid work project is vital for the project's success in providing clean water.

The Trailblazers Foundation is a non-government organisation that carries out work in the countryside of Cambodia in the Siem Reap province. The organisation aims to provide self-sustaining programs such as water projects and schools to improve the quality of life in the province. The organisation started work in the Sras village and is now looking to implement the same program in other villages in the province. It became evident as work started that clean water was a key requirement to any aid work carried out. Therefore the Trailblazer Foundation made the decision to install a number of bio-sand water filters to provide a cost effective potable water treatment in the village. The bio-sand filters are simple to construct and maintain therefore advantageous compared to other water treatment methods. In order to obtain water from the ground the Foundation installed a number of wells with pumps. This allowed extraction of the water from the ground that is relatively clean.

2 BACKGROUND

2.1 Cambodia

In the second half of the 20th century Cambodia was a war-prone country. The USA bombings (1969-1973) to expel the northern Vietnamese from the country, the guerrilla warfare (1962-1975) and the Khmer Rouge rule (1975-1979) left the country in an economic turmoil which it is still recovering from. There is little or no infrastructure especially in rural areas where 80.5% of the population lives². Cambodia has a total population of 13,388,910². 896,309² people live in the Siem Reap province where Trailblazer Foundation is active.

Cambodia has a poor income therefore resulting in high poverty and hunger levels in some areas. The millennium development goals in particular Goal 1- Eradicate extreme poverty and hunger³ is therefore applicable to Cambodia. Cambodia had 40.2% of the population in 2004 living on less than \$1.25 a day and 34.7% of its population living below the national poverty line⁴. These development indicators show that the Cambodia is not a rich country and requires aid work to improve the standard of living.

The country has abundant water resources including the largest lake in South East Asia, the Tonle Sap, the Mekong River and groundwater resources. However due to the absence of infrastructure and economic help, the exploitation of these resources is limited which leads to the consumption of untreated water. Only 29% of the rural population of Cambodia have access to an improved water source⁵. The lack of sanitation in the country also poses a significant health problem as only 8% of the rural population have access to improved sanitation⁵ forcing the other 92% to resort to public defecation in lakes and

rivers⁵. This water is then used for human consumption and irrigation creating severe contamination problems.

Naturally produced arsenic has been detected in the groundwater in Cambodia with concentrations ranging from 0.001–1.61 mg/L⁶. The human health consequence of continual exposure to arsenic above the 0.01 mg/L⁶ levels include visible effects involving skin disorders such as hyper-pigmentation, depigmentation and keratosis. With time, skin cancer may develop and the risk of other internal cancers (bladder, kidney, liver, and lung) is increased. Cardiovascular and neurological diseases have also been found to be linked to arsenic ingestion. Cambodia’s water is also high in iron. There is poor sanitation and low hygiene awareness in the country, this is evident as the Tonle Sap and Mekong River are infested with a variety of bacterial, viral and protozoan pathogens and helminth parasites that can cause infectious disease in humans and premature death especially in children. It is estimated that the absence of sanitation and the abundance waterborne diseases costs the country £294 million⁷ per year.

2.2 Sras Village Project & The Trailblazer Foundation

The organisation was founded in 2004 by Scott and Chris Coats with the aim of improving infrastructure, sanitation and water access in the poor areas of Cambodia. The approach of the Foundation to tackle such problem is the use of appropriate technology and self-sustaining programs. These are being implemented in one of the poorest villages of Siem Reap province called Sras Village.



Figure 1 – Map of Cambodia Showing Sras village⁸

Sras village is located 40km north west of Siem Reap. Cambodia is part of the African tropical monsoon zone, having two main seasons of the year, a rainy and dry season. The dry season starts towards the end of November and continues through until April, with the rainy season the rest of the year. The temperatures throughout the year remain high, ranging between 20-35°C. During the monsoon season flooding occurs causing the village to become inaccessible by road from September through to December each year.

When the project began in 2005 the village had a population of 1200, approximately 219 families⁹. The local practise to obtain water for consumption was to dig an open pit and use the groundwater directly. Many aid organisations have attempted to improve access to potable water in this region, however these efforts have failed as local culture and resources have not been taken into account. The Trailblazer Foundation has taken these factors into consideration and therefore has succeeded where others have failed. By using culturally relevant, sustainable technologies and local knowledge and resources the Foundation has built 79 pumps and 80 bio-sand filters⁹ that are maintained and managed by the local community. The economic climate of the village was also taken into consideration during the planning of the scheme. The community is involved in the scheme to give the locals a sense of ownership and understanding of the water treatment facilities being built. There are now over 1300 people⁹ in the Sras village most of them with access to clean water thanks to the efforts of the Foundation. This is a larger percentage increase than the population increase in the province of 5.2% over a similar time scale². Having had such a big success in Sras village the project is expanding to other poor communities in Cambodia as well as other organisations contacting the management team for information on the program and technology to implement in other countries.



Figure 2 - image of open well¹⁰

2.3 Common Water Contaminants in Cambodia

The main groundwater contaminant concern is arsenic, as this affects a large area of Cambodia and has the most severe health issues when consuming the water for long periods of time, which can be internal cancer or manifestations on hands and feet.

Manganese is another naturally occurring contaminant in groundwater that has health concerns, but these are less visible than the affects of arsenic as this can affect the brain. Studies showed areas with higher manganese consumption had lower test scores and hyperactive children¹¹. However, lower concentrations can be unpleasant to drink and causes discolouration to rice but causes no major health problems.

Fluoride can be added to the water supply in developing countries for dental hygiene advantages, but also naturally occurring so it is present in the groundwater, which at high concentrations can cause dental and skeletal problems. Iron is another naturally occurring contaminant that has been detected in Cambodian groundwater, this however, has no damaging health effects but will look cloudy, have a horrible taste, stain clothes and discolour rice.

2.4 Why We Chose The Project

As attention is normally concentrated on African projects when the developing world is thought about, the group decided to focus their attention on an Asian country. Cambodia was chosen as it is ranked 137th of 182 countries for its Human Development Index¹² and so is classed as a developing country. We contacted several non-government organisations (NGOs) to find what projects they have been carrying out in the area. The most positive response was received from Trailblazer Foundation regarding their project in Sras village.

This project met all of our objectives; it is a project on the provision of potable water, it uses well documented methods of water treatment, the community were involved in the decision making, it was undertaken by an established NGO, the project is now established. Therefore the Trailblazer Foundation had reviewed the effectiveness of the project and we were able to establish a good contact within the charity. This contact allowed the group access to additional information and the Foundation was able to answer some of our queries.

3 AIMS AND MOTIVATIONS

Water is necessary for drinking, for hygiene and for growing crops and livestock for food and commerce. The availability of clean water will improve people's health: allowing them to attend school and giving more time for farming or other jobs including taking care of their family-especially the sick and elderly. Women who previously had to walk long distances to collect water are empowered because they now have time to be educated and work alongside the men. By covering up water sources the hazard of open pit wells is removed these were previously a danger to children.

A clean, reliable source of water is a necessity for people to live and a priority for international development. This is something the Trailblazer Foundation recognised and they chose to switch their main focus from school building to providing a sustainable water supply.

Trailblazer chose initially to work with Sras village as it was the poorest in the province. They set themselves aims:

- To develop self-sustaining projects and programs that rely and depend upon local talent and skills.
- To provide opportunities for self-employment and economic independence through sustainable incomes.
- To reduce dependency on international aid.
- To provide safe drinking water supply that was reliable and that nobody should have to walk long distances to.
- Improve health in the local community.
- To provide sufficient food for the village by encouraging irrigation of crops.

The technology used to extract and treat water had to be appropriate for the village to allow the villagers to maintain it themselves. The technology had to be cheap and simple enough that it could be produced in Cambodia using local materials to a high standard.

4 TECHNICAL SYSTEMS

4.1 Design Criteria

Before any aid was given, the Trailblazer Foundation worked with the Sras villagers to find a technology appropriate to their abilities, interest, financial capabilities and needs¹². Sras village's previous water source shown in Figure 2 was unacceptable causing illness and disease within the village¹³.

The improved water provision had to be:

- *Safe* - Providing treated water without risk of infection to the village.
- *Reliable* - Humans have a continuous need for water so any break in supply would be deemed unacceptable.
- *Maintainable* - The villagers must be capable of maintaining the bio-sand filters themselves.
- *Cheap* - Most of the village lived below the poverty line so any appropriate solution had to be affordable to them.
- *Simple* - The technology needed to be simple enough that the villagers could understand it and therefore maintain it effectively.

4.2 Water Extraction - Wells & Pumps

Wells and pumps are used in conjunction with the bio-sand filter to abstract groundwater and purify it. The local practise is now to drill a well using local companies. A deep well lift pump is installed, see Figure 3¹⁴, to raise the water from the source and deliver it to a higher elevation so that the Sras community can access it easily. The wells are drilled during the dry season so that they can reach a depth sufficient enough to guarantee year-round water supply without being affected by the fluctuation of the groundwater table.

The first stage of the improved water access and quality project in Sras village is the well drilling process. Trailblazer Foundation installed 79 wells in 2005 each being used by approximately 15 people¹⁵. Thus there is considerable amount of water being withdrawn from each well. Because the wells are for communal use and due to groundwater table fluctuations the well is required to reach great depths to provide a reliable source. For these reasons the tube wells were chosen in Sras village as the most appropriate and economically viable option.

These are constructed by lowering the drop pipe and pump cylinder. Then the fissures are sealed to prevent polluted surface water from seeping into the well and the pump stand is mounted.

There are two types of lift pumps used in the village; PVC pull-pumps and a cast iron pumps. Both pumps are deep well pumps and can reach a depth of up to 50m but the wells in Sras village are 50m deep.

In this type of pump the cylinder and the plunger are located below the water level in the well. The operation of the pump is as follows:

- As the pump handle is lowered the plunger is raised. Air cannot pass the plunger due to water seal, a partial vacuum is created in the cylinder reducing the air pressure on the surface of the water in the drop pipe. The air and water is forced upward following the plunger, due to the difference between the atmospheric pressure on the water and the air pressure in the pipe.
- The plunger stops at the top of the cylinder and the check valve closes trapping water.

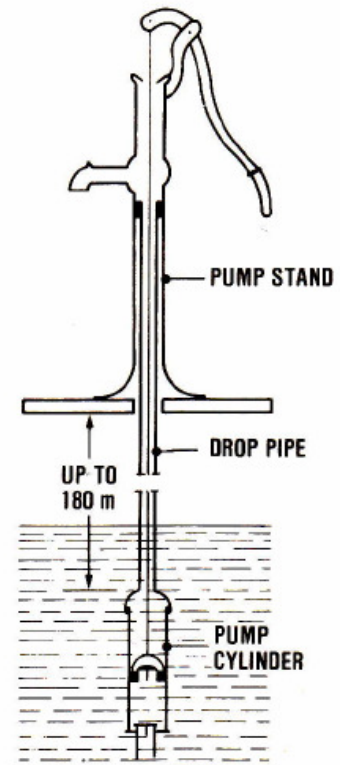


Figure 3 - Schematic Lift

- When the plunger is brought down the plunger and valve pass through the water making the plunger valve open trapping water above the plunger.
- On the next upstroke the water above the plunger is lifted up the drop pipe and out the pump while more water is forced into the cylinder through the check valve. On each successive upstroke water is water is delivered out the pump.

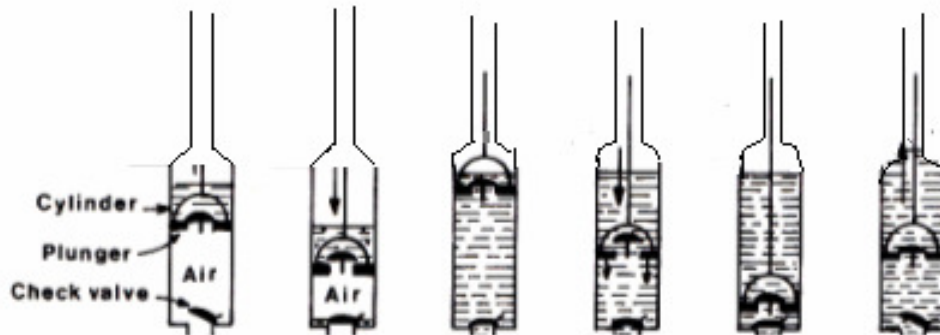


Figure 4 - Stages of the pumping process¹⁶

4.3 Water Treatment – Bio-sand Filters

According to CAWST, there are several stages to a successful water treatment process¹⁷. This is known as a multi-barrier approach. These stages are source protection, sedimentation, filtration, disinfection and safe storage. Whilst it is not always necessary to implement all stages, all must be given consideration and in order to obtain the best quality of water all of the stages should be implemented. For each treatment stage there are numerous implementation methods available. It is important that the implementation methods selected must be appropriate for the water being treated and for the community to use.

4.3.1 Source Protection

It was important to ensure that the source water was not unnecessarily contaminated by excrement, fertilisers or any other chemical or biological contaminants. Previously in Sras village water was taken from deep holes dug in the ground. These were unsanitary as they were exposed to surface run off which washed contaminants into them. In addition the holes were left uncovered thus providing a potential breeding ground for mosquitoes.

To overcome these problems a new water source was necessary in the village. Therefore the Trailblazer Foundation installed 79 pump wells⁹ so that the groundwater can be used, this water is far cleaner than water obtained from surface pits. Some of the groundwater in Cambodia is infected with arsenic see

Figure 5. Sras village is in a low risk area for arsenic so this was not a significant problem.

In addition, sanitary habits had to be investigated to ensure that these would not contaminate the water supply.

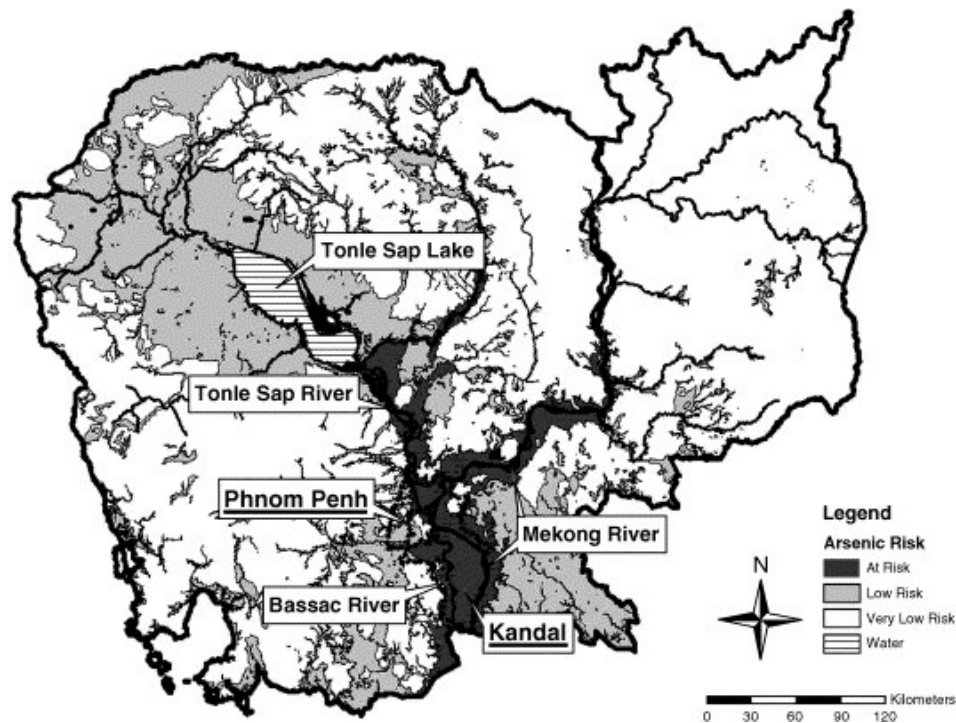


Figure 5 - Map of Arsenic Risk in Cambodia¹⁸

4.3.2 Sedimentation

Sedimentation allows larger particles to be removed and this alone can remove 50% of the pathogens in the water. This is because bacteria often grow attached to particle surfaces allowing them to be removed more efficiently¹⁹. Sedimentation also reduces the turbidity of the water which would otherwise clog up the bio-sand filter, reducing its effectiveness. This process is not necessary for groundwater taken from wells as sedimentation will already have occurred naturally underground.

4.3.3 Filtration

The process of filtration is the most technical step in the water treatment process. It removes the smaller suspended particles and the majority of pathogens. In this project the bio-sand filter is used for the filtration stage. The bio-sand filter has been found to be an effective means of treating water in developing countries²⁰. Passing water through the bio-sand filter treats the water and is a system that the community likes using.

The bio-sand filter was first developed by David H. Manz in 1990. Since then it has spread quickly and there are an estimated 200,000 bio-sand filters across 65 countries being used today²¹. They have been found to have average long-term bacterial removal effectiveness of 98.5%²² and this can reduce the incidence of diarrhoea by 40%²³. Bio-sand filters on their own will not necessarily produce water which consistently meets with WHO guidelines²⁴. This is overcome by using them as one stage of a multi-barrier approach.

80 bio sand filters⁹ have been built, each of which can process one 18litre bucket a day whilst it is being used properly. If all filters are used at their maximum this will give a flow rate of 1500L/day. One advantage of the bio-sand filter solution chosen does not need any energy input.

The majority of the filters are used by only one family however 15% of the total number of filters installed in the Sras village are used by 2-4 families⁹. This is due to the low flow rate of the output of the bio-filter therefore the majority of the filters only provide enough water for one family a day. Also, giving each family their own filter gives an improved sense of ownership of the filter and this will encourage the maintenance and care of the individual filters.

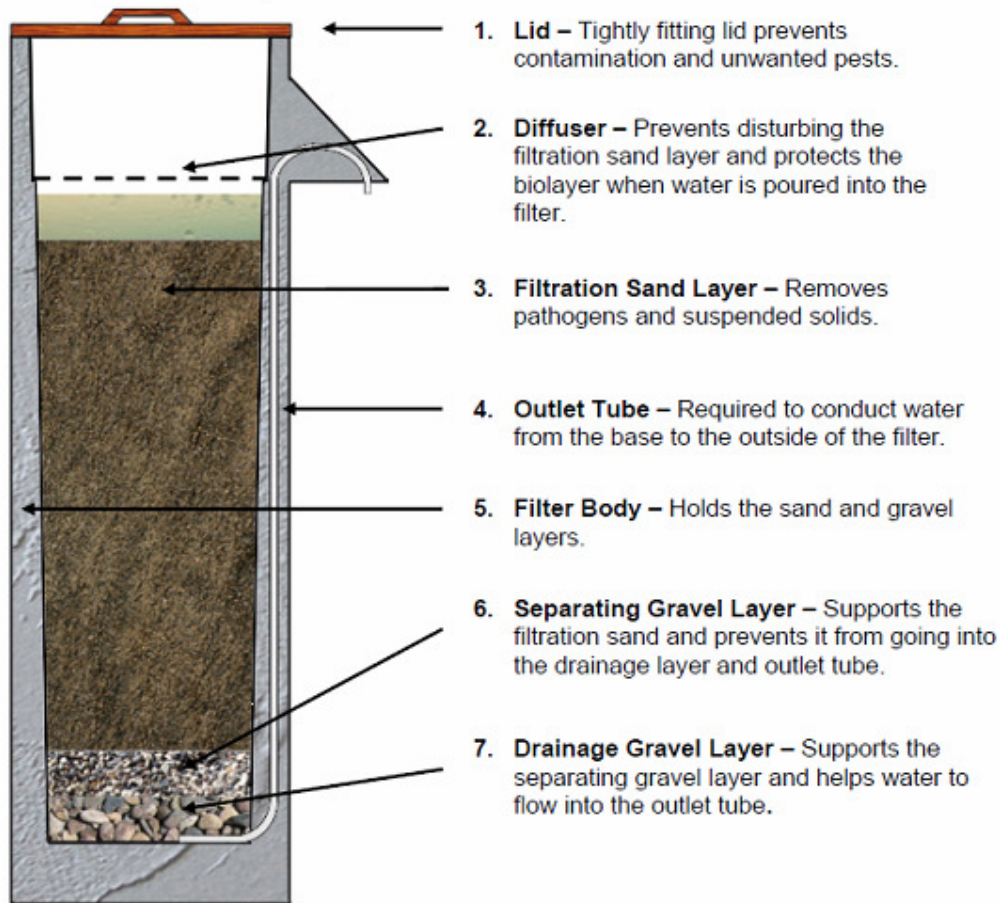


Figure 6 -After CAWST²³

Bio-sand filters can be made of concrete or plastic. A licence is required to produce plastic bio-sand filters and so this was not feasible. Concrete filters have the advantage of being easy to cast in fairly small quantities. They can be created simply and do not need any expensive machinery.

Although all bio-sand filters clean the water in using the same method various specifications are available. The Trailblazer Foundation have followed the centre for affordable water and sanitation technology's (CAWST's) specification¹⁶ and the design of this filter is shown above in Figure 6.

Treatment Process

The water is treated by opening the lid and pouring in one 18litre bucket of water sourced from the pumps installed in the village. The diffuser plate slows the water and prevents it from damaging the top of the sand layer. The lid is then replaced to prevent contamination

of the water. The addition of a large volume of water creates a pressure difference between beginning of the filter and the outlet; this causes the water to start to filter through.

The top 1-2cm of the sand is classified as the biological zone. This area is exposed to oxygen and so micro-organisms develop here which then in turn can consume the pathogens. This process is known as predation.

More pathogens are removed by adsorption. This is when the pathogens attach to each other and the sand grains. The sand grains also act like a sieve and strain out larger particles by mechanical trapping. Lower down in the sand layer there is little food or oxygen and therefore this causes micro-organisms to die naturally.

At the bottom of the sand the water passes through the separating gravel layer and drainage gravel layer to flow out of the outlet tube. A vessel must be placed below the outlet tube to collect the treated water.

Construction Method

The bio-filter main body is made from concrete. In order to achieve the required shape a purpose-built metal mould is fabricated to cast the filters. The concrete is poured into the formwork and left to set. As the mould is made from metal, the mould can be reused indefinitely meaning that, although it is initially expensive, it is economical in the long run.

To create the outlet tube a PVC pipe is inserted into the mould before the concrete is poured and left there while the concrete cures. This pipe is then cast into the concrete meaning it is within the concrete for the life of the filter.

Trailblazer has a factory in Siem Reap which produces the filter bodies not too far away from Sras village. Making them locally allows them to be easily transported to the village where they are to be used and also creates employment for those working in the factory by having to transport them. Transport costs can be kept to a minimum as the distance between the factory and the final situation is kept to a minimum.



Figure 7 - Filter Body Being Cast¹⁹

The filter media is only installed once the filter is in place and is a very important factor in the bio-sand filter. Crushed rock is most suitable as it is unlikely to be contaminated²¹. Care must be taken whilst installing the filter media. The gravel and sand must be added in stages, with some water already present. Care must be taken not to allow differential settlement of the different sizes of sand grains. Once the filter is in place it must not be moved. If it is moved the filter media may need to be taken out and replaced.

4.3.4 Disinfection

This stage removes or kills all remaining pathogens in the water. This could be achieved chemically by the addition of chlorine or iodine to the water supply or with UV light. It is easy to implement UV light as a disinfectant as water can simply be left out in the sun for a day and this should be a sufficient amount of UV to treat it.

Trailblazers have chosen not to implement disinfection in the Sras Village. Even without disinfection the water being supplied is much cleaner and a significant improvement on their previous water supply¹².

4.3.5 Safe Storage

The treated water must be stored in such a way that it eliminates the risk of the water becoming re-infected. A common problem is people washing their hands in open buckets or using scoops to retrieve the water as this allows pathogens to re-enter the water.

Ideally the water should be stored in a container with a narrow neck to discourage people from dipping things into the water. Containers may be heavy and so it may be difficult for people to lift them.

5 MAINTENANCE

5.1 Wells and Pumps

The pump design should be well thought out and carefully selected to minimise technical hitches throughout the life of the pump. Regular maintenance is essential to successful pump operation. Because the Trailblazer Foundation aims to create sustainable development much of the daily maintenance is done by villagers, who are shown how to look after the pump in terms of usage and maintenance. In addition the organisation employs two local residents, trained by the local well driller, to visit the pump regularly for a thorough check.

The maintenance activities carried out by the villagers include cleaning the well-head, pump and surroundings and oiling or greasing all hinge pins, bearings and sliding parts. More thorough maintenance activities include the following:

- If necessary, adjust the stuffing box or gland by tightening the packing nut.
- Check that all nuts and bolts are tight.

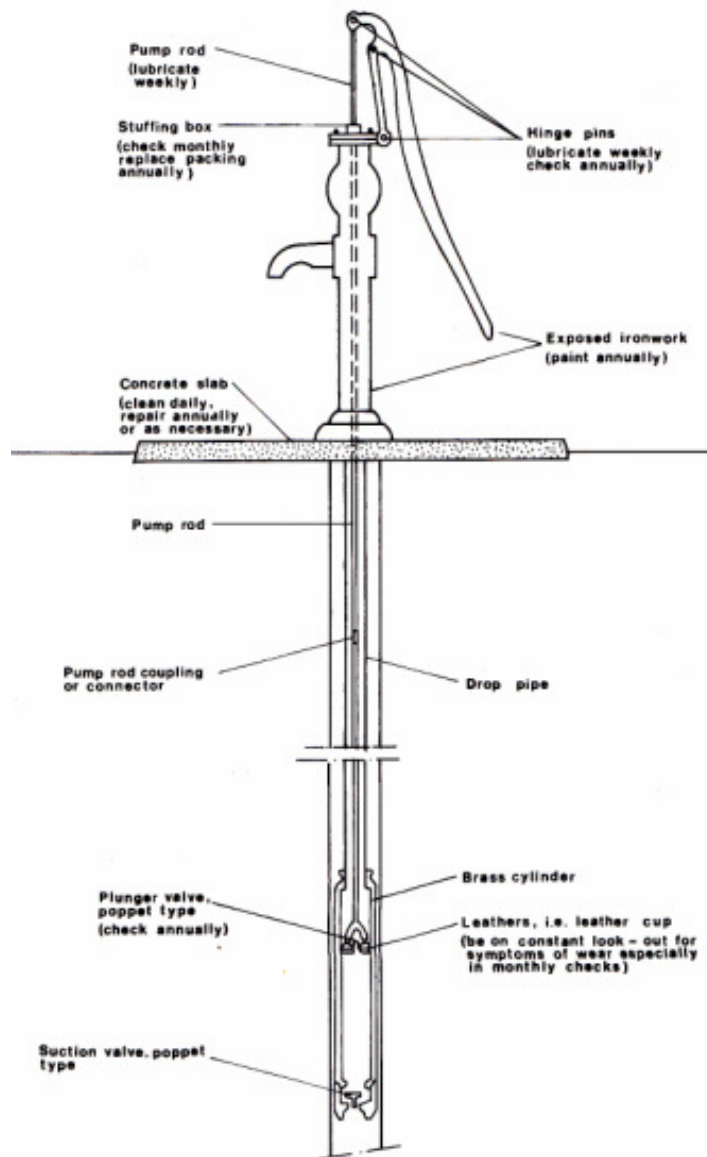


Figure 8 - Maintenance of Hand Pump Components¹³

- Check for symptoms of wear at the leathers. If necessary replace the leathers.
- Paint all exposed parts to prevent development of rust.
- Repair well-head concrete if cracked
- Check wear at handle bearings and replace parts if necessary
- Check valves and replace if found leaking
- Check pump rod and replace connectors and defective lengths if necessary

By arranging regular maintenance the organisation ensures that the pumps have an optimum working standard and that villagers have access to water.

5.1.1 Common Failures

Certain pump components have a higher probability of failing than others. When operating the pump head the most frequent points of failure include the hinge pins on which the handle pivots, breakages of the handle and wear or breakage of the nuts and bolts. Lack of lubrication and careless use has a large contribution to pump failure.

The most common failures when dealing with the pump cylinder is the wear of the leather cup seals and problems with valves. Poppet valves with rubber cushioning may erode over time and ball valves may deform the metal seat due to the pounding of the steel ball when the valves opens and closes.

5.2 Bio-sand Filters

Bio-sand filters need maintenance occasionally to ensure they continue to work at their optimum. The entire filter should be cleaned regularly: special care should be taken to ensure the outlet tube is clean.

Over time the sand will get clogged with sediment and there will be a noticeable reduction in flow rate. When this happens it is necessary to remove the top layer of sand. This will disturb the bio-layer and it will take a while for the filter to work effectively again. The flow rate should have been restored, however.

A steward is required to make sure that any maintenance required for filters can be carried out. In the case of Sras village the two stewards volunteered from the community and were then trained to maintain the bio-sand filters, the aim was that when personnel from the Trailblazer Foundation were not on site then it was still possible to resolve any problems with the filters. Each steward was entrusted to pass the knowledge onto the wider community so that more people knew how the technology worked and would eventually become more sustainable. The success of the stewards has not been as great as anticipated, the Foundation did a survey in 2009 to find out contact time between community members and the stewards. It showed that contact between the two parties was not at a satisfactory level and some homes had regular contact whereas others did not. It is an area that the Trailblazer Foundation is keen to rectify in future projects.

5.2.1 Common Failures

The biggest problem is livestock knocking the bio-sand filter over and cracking the concrete. Other problems are the user failing to maintain the filter properly: the lid was sometimes replaced with a cooking pot lid because the lid had rusted. In addition the diffuser plate was too small to fit properly into the filter in 26% of the filters¹⁵. This was due to a manufacturing problem however.

6 WATER QUALITY MONITORING

In Britain water quality has strict regulations and water is monitored frequently at various points throughout the water treatment system. These consistent and precise measurements, however, are not possible in many rural areas of developing countries, such as in the Siem Reap province of Cambodia. In Siem Reap it is the Department of Rural Water Supply and Department of Rural Healthcare that monitor the drinking water. Only basic monitoring equipment is available thus tests are only carried out occasionally for pH, iron and salinity. These agencies also help communities by educating them about water use, hygiene and maintenance of facilities and latrines. There are six organisations in Cambodia that are part of the water industry, each with their own parameters and standards, so with the introduction of a National Standard they can all work towards the same outcome, concentrating on the health issues that need explored.

6.1 Effects of Rainfall

Cambodia has a wet and dry season causing the rainfall and evaporation rates to fluctuate dramatically. Figure 9 shows the average rainfall and evaporation each month, highlighting the issue of evaporation exceeding rainfall most months. It is apparent that the driest months of February and March have as much as 200mm more evaporation than rainfall.

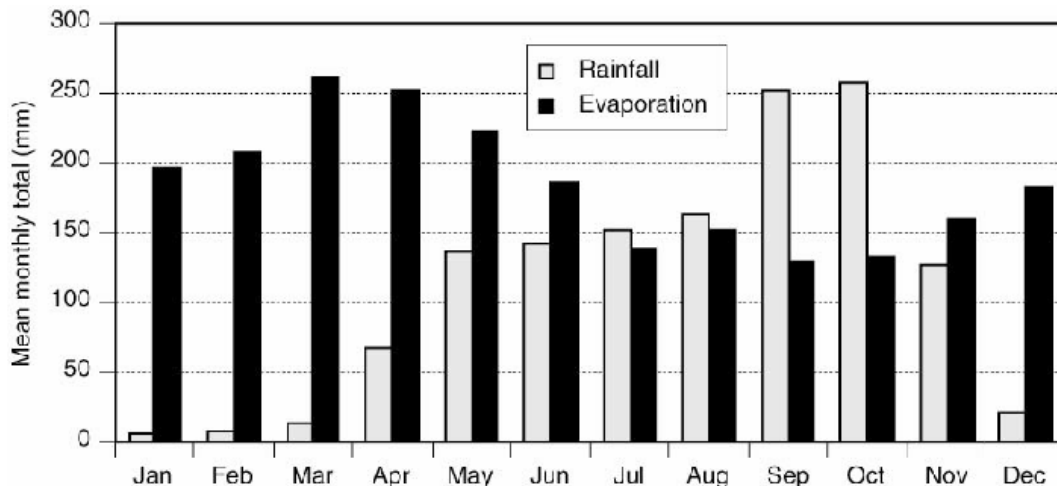


Figure 9 – Rainfall and Evaporation Rates²⁵

In the wet season water quality will increase, as the large volume of water will dilute any contaminants, but in the dry season there will be a much higher concentration. It is not only water quality issues that occur during these seasons, as with the flooding providing plenty water with nutrients that encourages rice growth and is one of the most productive freshwater fisheries in the world during wet season. However, if there is too much rain causing severe flooding, it can cause loss of crops, property and even life. The dry season is normally unproductive, with crops unable to grow.

6.2 Drinking Water Regulations

The drinking water regulations set by the World Health Organisation have been implied with the aim to provide all communities with the security of having safe drinking water in the future, thus improving the health problems they currently have. With the regulations in

place agencies are required to develop water treatment systems that can be used and operated by the users.

The water quality parameters for Siem Reap are the same as those used internationally. The main chemical problem with the water in Siem Reap is arsenic, which should not be above 0.01mg/litre²⁶. Bio-sand water filters have proved to be efficient in the removal of arsenic from water²⁷ and they are also easy to maintain once installed. As improving water quality has been the main aim of organisations there has not been a lot of testing done on the water conditions in this province. The emphasis has been on the education of the locals on hygiene and installing equipment, such as bio-sand filters. These filters have been previously tested to show they remove the necessary contaminants thus tests are carried out on site at installation and then left to provide clean water.

If a filter owner requests a water quality test to be done a member of the Trailblazer Foundation will take a sample of water and take it to a local laboratory for testing. However as tests are not carried out on the original water supply or on each individual filter it is not a clear conclusion of what is present in the water before, or after treatment. The villagers themselves must pay for any testing they want to be carried out. The trailblazer Foundation carry out test on filters at random to ensure that the water quality provided is as required.

Since the water in Cambodia has different chemical, physical and biological characteristics than the water in Britain, the same water treatment systems cannot simply be applied there, hence the use of appropriate technology.

In 1999, the World Health Organisation (WHO) did a very general water quality survey of Cambodia, with roughly 100 samples across 13 Provinces, this limited survey did show clear results that more testing was needed on the water quality²⁸. Resource Development International Cambodia (RDIC) wanted to expand on these results, deciding to begin in the Kandal Province as this had alarmingly high arsenic levels from the few test done. They have so far tested more than 4,500 wells across the Province and want to continue until they have a clear picture of the levels of arsenic, learning where and why they get released into the groundwater. Shallow wells can be safer from naturally occurring contaminants such as arsenic, but are at higher risk from human based contaminants like faecal waste. Deeper wells are less at risk from human containments but more at risk of natural contaminants. There is little human and animal waste management in Cambodia so surface water, such as river and streams, and shallow groundwater tends to be contaminated with faecal pollution. This pollution contains microorganisms such as bacteria, protozoa and viruses. These are easier to remove than chemical contaminants such as arsenic, fluoride and manganese.

7 LEGAL FRAMEWORK

The government cooperates with the Trailblazer Foundation, augments certain projects with equipment or other support and then is involved in the maintenance and monitoring of their projects. The Foundation follows the government processes and work alongside officials. Necessary government agreements are in place which ensures their permission and cooperation, and ultimately the sustainability of the Trailblazer Foundation's projects.

The Ministry of Environment (MoE), formed in 1996, is the key agency responsible for environmental protection and natural resources conservation in Cambodia. The main environmental law regarding the groundwater use is the '*Law on water resources management of the kingdom of Cambodia*'²⁹. Article 11 and 20 relate to the work carried out by the Trailblazer Foundation:

Article 20

Any person carries out drilling or digging of the wells for the professional or commercial purposes shall supply the MOWRAM [Ministry of Water Resource and Meteorology which is a subdivision of the MoE] with a detailed report on the drilling or digging operation, the technical specifications and other information.

The utilization of the ground-waters and aquifers for the professional or commercial purposes the quantity of which exceed the level as defined in Article 11 shall be subject to licensing.

Article 11

Every person has the right to use water resources for his/her vital human need including drinking, washing, bathing and other domestic purposes including watering for animal husbandry, fishing and the irrigation of domestic gardens and orchards, in a manner that will not affect other legal right of others.

To comply with this legislation the Foundation had to supply the MOWRAM with a detailed report on their drilling works. Because the groundwater is being used only for basic human needs no license needed to be obtained for the use of the water.

Water quality standards in Cambodia are based on the World Health Organisation (WHO) guidelines³⁰. The MoE works closely with all NGOs to ensure that regulations and standards are met.

The government has an annual strategic plan that the Trailblazer Foundation follow in the Sras village. The Trailblazer Foundation attends annual district integrated workshops where project needs are identified and agreements are made to support and implement specific projects. The government has an established model for sharing information including project activity and finance for commune-support projects. They work through the government's process, and therefore, the government can track and monitor what projects are happening and how much financial support is being given. The government provides information on the national standard for drinking water quality defining selected chemicals and the national guideline for user groups. The Foundation works in the same manner to cooperate with the local authority (including village, commune, district and province).

The drilling team is trained by the local pump well drillers, which in turn have been trained by the Rural Water Supply Office in the Rural Development department of Siem Reap Province. The same model is followed ensuring that the technique used is the same provided by the government.

8 PROJECT FINANCE

The capital funding required for the start up of projects is almost entirely made up of contributions to the Trailblazer Foundation; the majority of this comes from individual and corporate donors but they also receive grants from Rotary clubs and other foundations.

Costs:

Bio-sand filter	-	\$45 USD ³¹
PVC pull pump, inclusive of drilling and construction	-	\$100 USD ³²
Cast Iron Pump, inclusive of drilling and construction	-	\$150 USD ³²
Estimated total project cost	-	\$12 000 USD

The technology costs are detailed above and the total cost being that for the technologies used and labour required for installation. Each home is expected to contribute \$2.65³² to a central village fund if they are to receive a bio-sand filter and the capital funding is then made up from the donations made to the Trailblazer Foundation. The villagers are also expected to contribute \$3³² (PVC) or \$5³² (cast iron) for well construction to the Village Fund. At the time of the Sras project the Trailblazer Foundation required the assistance of a local drilling team for these wells. The capital required for this team was raised in the same manner. As of 2008 however the Trailblazers Foundation have created their own drilling team, trained by the Sras drilling team and an experienced local driller so that these costs can be cut down for future projects.

The local government do not contribute any capital funding to projects but they do help augment projects with equipment. Where the local government is predominantly involved is at the post construction stage in the maintenance and monitoring of projects as detailed in section 5 and 6.

The operating costs of the project are funded by the community itself. The TBF adopt a hands-off approach once the project has been implemented and to make sure that finances are available the Foundation encourages the villagers to set up their own funding system. The concept of a village fund is new in Cambodia but has been implemented in other villages across the country with success which is why the Trailblazer Foundation have tried to start one in Sras. It was hoped that this type of management would give the community a further sense of pride and ownership in their project. It was also hoped it would provide a platform from which they could build on in the future and potentially develop past the level of subsistence farming which they are currently living at without compromising their cultural values.

In essence the village fund is a bank: residents of the community can save money there and they can also start loan programs. These loan programs are for providing capital development funds that build equity and sustain projects. Repayment of these private loans is made to the village fund and used to create capital for other villagers to borrow at

a low interest rate; the banks committee decide who can receive these loans. At present the village fund has generated enough income to allow 30 families to borrow funds. These funds have been used to purchase food, medical help and livestock. It has been an extremely successful example of economic growth, raising some families above the World Bank poverty line definition of “very poor” purely because they now own livestock.

All the money for the village fund is contributed by local residents: it comes from repayments for small business set-ups, the \$2.65 per water filter and \$3 or \$5 per well fee. There is no international money in these reserves.

9 OPPORTUNITIES, LIMITATIONS AND UNCERTAINTIES

9.1 Opportunities

As a result of the success of the Sras village project Trailblazer is now implementing similar water treatment schemes throughout Siem Reap province. This is a brilliant opportunity for all of the near by communities to work with Trailblazer to improve their drinking water.

An opportunity for improvement can be found in the water quality in the Sras Village as the water being treated does not have a disinfectant added after treatment in the bio-sand filter. Therefore there is no residual effect to prevent the water from becoming infected again.

The village fund which has been set up definitely has potential to help even more families in the future if it is managed properly. The economic growth that has been seen since the village fund was set up can hopefully continue to establish more small businesses in the Sras area. This would increase employment figures in the area and thus increase local income.

9.2 Limitations

The wet season creates obvious limitations as access to the village is hindered and thus it is difficult to carry out work in the area during these months. Therefore the projects becoming self sufficient and not relying on aid work is vital to their success.

Trailblazer’s management come from a different culture than the communities they are trying to help. It is necessary that the Trailblazer Foundation fully understand the local culture to ensure the success of the project. Education must be an integral part of the project to teach the locals that the new water source provides them with cleaner water than their traditional way of collecting. As the success of the project relies on the input from the locals, there must be long-term incentives to keep them motivated to use and pass on the skills they have been taught. Any distrust and disagreements between families could cause problems with any communal wells and filters, with misuse or lack of upkeep.

The well drilling requires complicated equipment and considerable knowledge and experience. As this is a poor community it may be too expensive to drill any further wells but hopefully the village fund established will help with this problem.

Due to the many different organisations with overlapping responsibilities with respect to water resources it is difficult to keep track of different regulations and to get permits, licenses and training. The lack of water quality standards and the difficulty in enforcing standards also limit the ability to improve health outcomes.

9.3 Uncertainties

Long term success of the project is an uncertainty as the success of the long term aspect of the project will only be seen once aid work has retreated from the village for a long period of time.

The performance of the point-of-use household water treatment is highly dependent on the degree to which households adhere to the operation and maintenance requirements. The success of the pumps as a reliable source of water and of the bio-sand filter as an improved water quality house treatment will ultimately be determined by the villagers.

The hope is that parents will pass down their knowledge from the education they have received in sanitation and in operation and maintenance of wells to their children. However only time will tell if this knowledge will be passed on.

10 COMMUNITY INVOLVEMENT IN DECISION MAKING

The Trailblazer Foundation is very sensitive to the fact that the communities they help all have very different needs and abilities; it was no exception in Sras village where the community was involved from the very first step. The Foundation made the community aware of all the possibilities and gauged the level of the commitment the villagers would have working in partnership with them before providing any aid. The aim of holding this meeting was twofold: to make the community aware of all the technologies available and at the same time ensure the ownership of the project was not with the Trailblazers but with the Sras villagers. The project model empowered the community to manage the projects themselves once the filters and wells were implemented. The technology had to be appropriate for Sras and by taking into account the villagers abilities, interest, financial capabilities and needs an appropriate technology was chosen.

In general terms community involvement is a fundamental process for the success of water and sanitation projects, the communities are the only stakeholders in these sorts of projects who can truly determine the success or failure of the schemes³². They are the individuals who will be actively involved in the project both pre and post construction and if they don't see the new technologies as an important contributor to an improvement in their livelihoods then the chances are they will not make the effort to make the projects work. Ensuring that affected communities have true decision making authority is essential, any relevant material/information should be made available to communities before any decisions are made on what will happen³³. In doing this it allows the community to make decisions free of any pressure that could be applied by the provider or facilitator. Community involvement can be interpreted in a variety of ways, Harvey & Reed (2004)³³ name the most frequently used as;

- Prioritization and vocalization of community needs
- Selection of appropriate facilities, technologies and locations
- Financial contribution to capital costs
- Provision of labour for construction of systems and facilities
- Management of operation and maintenance
- Physical maintenance and repair activities

The needs of the "user" (those that will use the technology) might not always match the needs seen by those who wish to help, matching the needs of the "user" and the "giver" (those that intend to provide aid) is needed to successfully implement water and sanitation

projects. For example, the Edinburgh based charity *Water Works* in the summer of 2009 had been travelling to a number of rural villages in an area outside Malawi's capital Lilongwe and installing new pumps and digging new wells where required. In one village it was visible no clean source of water was available for a considerable distance and the most frequently used source was a watering hole, seriously contaminated by the many domesticated animals in the village that also used it. The most essential need stated by the community was electricity. When questioned about the water issue the response was, "the source has always been used why change it?" It is important to see examples like this where it highlights the issue of users demands and what the giver sees as the needs. The community in this example settled for a new provision of water but the enthusiasm to help seen in previous projects was not nearly as high. It reinforces the concept that the demand must be stated by the user rather than the giver, this is the starting point for bestowing the community with a sense of ownership to the projects which affect them.

Another example of poor community participation comes from Orissa, India. The area of Orissa suffers from extreme deforestation³³ partially because the wood is used an energy source. To combat this problem a Dutch based agency provided an alternative waste burning system to create the energy required for the households. This was seen as a great accomplishment when initially installed but the project was fiercely opposed by the women in the community. Traditionally the wood used for burning was a job carried out by the women in the villages. They enjoyed a freedom to talk and interact socially with the other women of their villages during these times but when the alternative was put in place this chance of social gathering was significantly reduced³⁴. As a result of this and after consultation with the communities, social clubs exclusively for women were built in each village. This is just another example of how knowing the culture and traditions of communities is essential in the outcome of the project successes.

In summation, regardless of the country, where communities are not properly involved in the work, creating a sense of ownership does not happen, nor will there be a successful outcome to the project. The decisions need to be made by the community entirely; in fact Thorpe (2002)³⁵ argues that there is a flaw in a process where there is any "handover" from agency to community. In the case of the Sras village the results are mixed. The technology has been very successful and the community has adopted it into everyday life but there are parts of the operational stage which are not going as well as expected or hoped. The community has been very involved in all stages of project so far but that does not necessarily mean it will be successful.

11 ECOLOGICAL AND SUSTAINABILITY CONSIDERATIONS

Sustainability can be split into three main categories: economic, social and environmental³⁶. In order to promote economic sustainability, The Trailblazer Foundation encourages the villagers to set up their own bank fund that is a village run micro loan program. Taking into account the needs and opinions of the villagers in this bottom up approach encourages the locals to take pride and ownership of the schemes and keeps the local culture¹³.

The Trailblazer Foundation try and provide sustainable projects in the Siem Reap province so that implemented projects can continue to run smoothly after the aid organisation leaves the area. The aim is to have successful projects that do not require ongoing international aid. Due to the rainy season villages are cut off for months at a time, therefore the success of the projects being self-sufficient is apparent³⁷. Local villagers are

used as paid labour wherever possible in the schemes to increase the local income and provide employment and training for locals.

Social sustainability refers to the quality of life which can be greatly improved with a clean water supply and improved sanitation. In order to raise awareness and communicate the importance of water borne diseases, simple cartoon leaflets are given to the villagers, as many are illiterate. These are shown in Figure 10. These leaflets stress the importance of the bio sand filters being used in their village. By constructing schools in the area the literacy rate of the local population is increasing.

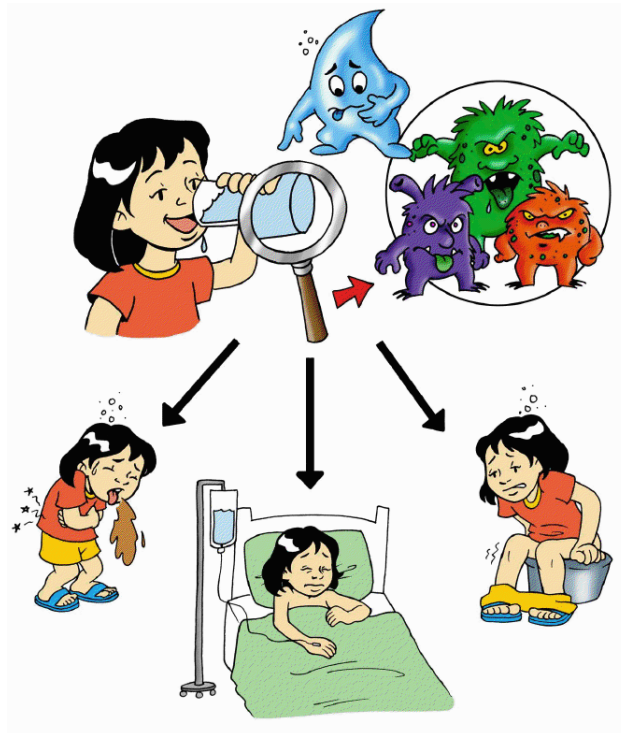


Figure 10 - example of cartoon leaflet¹⁵

The schools constructed are government supported therefore qualify for the World Food Program (WFP)³⁸. Through this program food is supplied to the school allowing basic food for the students.

The drought season causes a shortage of water for things such as irrigation causing food shortages in the area for several months of the year. The Trailblazers Foundation installed pump wells supplying sufficient volumes of water for irrigation all year round thus increasing crop production and reducing the effects of the drought on the local villagers³⁷.

Sustainable fish farming has been overseen by the Trailblazers Foundation³⁷. These supplies of fish can supplement food shortages in the months where drought occurs. The Foundation set up a committee of local villagers who manage the fish ponds.

12 CONCLUSION

The project has been very enlightening as it has shown what can be achieved by a Foundation who value their work and show the dedication needed for it to succeed. The impact that the Trailblazer Foundation has had in one of the poorest provinces in the world has so far been greatly encouraging and time will only tell how much further their actions will benefit the Sras village and the surrounding communities. The successes can be partly credited to the high level of community involvement in all aspects of design and implementation of projects that have been attempted. Further success can be attributed to the extra effort and attention that has been given to this project; required to generate experience to make sure future implementations succeed. The access to a clean water supply has been greatly improved, the bio-sand filters have proven to be an excellent addition to the community as well as the new wells that were installed.

Through studying the project in Sras Village, the group have learnt that it is essential to involve the community at all stages of the project and to implement appropriate technology. By doing this the probability of the projects success is increased and a sense of ownership is given to the villagers.

It appears that a suitable technology has been chosen for this community, linked to the level of involvement the community has had. There has been an above average population increase and there are greater opportunities for small businesses to establish themselves, so the Trailblazer Foundation is currently succeeding in the core issues that they are trying to address. The only issue so far is the stewards are not proving to be as useful in spreading knowledge of maintenance of the filters to the whole community as was hoped. The village fund system that was set up has also proved to be extremely beneficial to the Sras village, so far it has helped 30 families improve their assets and it is forecast to help many more. The project is still young and whether it turns out to be self sustaining will only become apparent in the future but the early signs are very encouraging.

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