# EVALUATION OF A DEMAND LED BIOSAND FILTER PROGRAMME IN THE COMPLEX EMERGENCY CONTEXT OF AFGHANISTAN

**by**

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# Abstract

This study evaluates the effectiveness and sustainable impact of a 'demand led' biosand filter (BSF) programme in the complex emergency context of Afghanistan.

On the whole the technical performance of the BSF was good and the filters were shown to be effective in removing on average 91.7% of the E.coli bacteria.

Users strongly believed that drinking filtered water from the BSF was resulting in a positive impact on their health. This is a key factor which has led to sustained use of the filters amongst 94% of the households surveyed.

The BSF is affordable for 55% of the population who fall within the middle to upper income bracket, and demand has been created so that all BSF manufacturers were able to supplement their income from their BSF manufacturing business.

When compared with other programmes in more stable development contexts, the research shows that, in the complex emergency context of Afghanistan a demand led BSF programme has been able to achieve a comparable level of effectiveness, impact and sustainability.



**Key Words:**

BSF, Full Cost Recovery, Commercialisation, Disaster.

# Executive Summary

## 1. Background

For both donors and implementing agencies, there is a growing recognition of the need to address the problem of aid dependency, especially in complex emergencies, and to manage the smooth transition from fully subsidized emergency relief WASH interventions through to more sustainable recovery focused interventions, which also promote economic revitalization through development of sustainable livelihoods.

This study evaluates the effectiveness and sustainable impact of a ‘demand led’ biosand filter (BSF) programme in the complex emergency context of Afghanistan. The research considers the following three key questions:

1. What was the technical performance of the BSFs?
2. What was the user perception of BSF impacts?
3. Was sustainable demand for the BSF created?

## 2. Literature Review

The literature review demonstrates that BSF can be an effective and sustainable form of household water treatment. There is growing evidence to support the use of BSF in some development contexts, and to support the use of demand-led programming approaches for increased likelihood of sustainability. It is recognised that BSF may not be an appropriate solution in the immediate aftermath of a rapid onset natural disaster, unless the population has a previous history of using BSF to treat their water. There is also recognition that in long term complex emergencies, point of use household water treatment solutions are preferable over large scale centralised water supply and treatment systems that may be vulnerable to attack or fall into disrepair. However there is a significant gap in knowledge when it comes to understanding the performance of BSF in complex emergency settings.

## 3. Field Study Methodology

The field survey, which comprised both quantitative and qualitative data gathering methods, aimed to answer the research questions and gather detailed data about the effectiveness, impact and sustainability of the Tearfund BSF programme in the complex emergency setting of Afghanistan. Four villages were selected for the field study, two from Jawzjan province (Shehraz and Yandagh) and two from Kapisa province (Bako Kham and Khamzerger). 62 households were surveyed, of which 47 had BSF.

## 4. Results, Analysis and Discussion

***BSF Filtered Water Quality***

Water quality test results from field samples collected during this study show that BSF in Kapisa up to three years old, and BSF in Jawzjan up to two years old are achieving average water treatment efficiency of 91.7% for E.coli and 83.0% for turbidity.

13.3% of the filtered water samples achieved the WHO (2011a:149) guideline value of 0cfu/100ml, while 64.4%% achieved the “low risk” level of <10cfu/100ml, and 22.2% measured greater than 10cfu/100ml and are considered “intermediate risk” (Noziac, 2002:69). 100% of the filtered water samples achieved the WHO (2011a:229) guideline value for small scale water supplies of <5NTU.

***BSF Construction, Installation, Operation and Maintenance***

Observations of the filters and responses from the households indicated that the construction of the filters was generally very good. 51% of the respondents are using and could correctly describe the wet “swirl and dump” method of cleaning the BSF, 17% indicated that they are using the “sand removal” method, and 13% either could not describe the cleaning method or described it incorrectly.

A problem of incorrect depth of water above the top surface of the sand layer was noted in 47% of the BSF surveyed. Issues identified with installation, operation and maintenance are likely to impact the filtered water quality, and may be contributing factor for the 22.2% of filtered water samples which were measured to have greater than 10cfu/100ml.

***User Perception of BSF Contribution to their Quality of Life***

Overall perceptions of the households using the BSF were strongly positive, and 100% of the existing BSF filter owners said that they had “recommended the filter to others”. Specific perceived benefits included improved health (94%), and financial savings (70%).

***Self Reported Rates of Diarrhoea***

The perceived health benefit from drinking filtered water from a BSF was further confirmed by self reported rates of diarrhoea. Only 16% of those with an operating BSF reported cases of diarrhoea in the past two weeks, while 71% of those without a BSF reported cases of diarrhoea in the past two weeks. The study confirms the general perception amongst the respondents is that drinking filtered water from a BSF has directly resulted in health improvement and financial savings.

***Rate of BSF Adoption and Sustained Use***

In the study area the rate of adoption is 96%, and the rate of sustained use is 94%. This is a high rate of sustained use for a new technology and will help create sustained demand for the product within the community.

***Ability and Willingness to Pay***

Of those surveyed without BSF, 100% stated that they would like to purchase a BSF, with the greatest barrier to purchase being stated as cost, 73%. At full cost recovery retail prices (average US$21.70) a BSF is affordable for the 55% middle to upper income households, but not for the 45% low income households. BSF manufacturers confirmed that low income buyers were only willing to pay US$7.00-$11.60, which is less than the actual production cost which ranges from US$14.00 – $17.40.

Of the households surveyed without a BSF, 47% of those fell into the middle to upper income bracket. Part of the reason why these households had not yet purchased a BSF, may be found in the cultural context. Of those that could, in theory, afford a filter, and stated that they would like to buy one, 57% were women. In the Afghan cultural context it is normally the responsibility of their husband to do the shopping and 27% actually stated that their husband either did not have time, or did not see a BSF as a priority.

***BSF Coverage***

In the study areas BSF coverage has grown from zero to 24% over a three year period. Although the rate of increase in coverage has slowed, there is still sustained growth, and with 76% of the households still not owning a biosand filter, there is significant room for growth. Initial growth in coverage was rapid during the time that Tearfund was actively engaged in promoting the filters, and this is reflected in the current strong demand for BSF in Jawzjan. In Kapisa, however Tearfund has not been actively involved promoting BSF for over one year and the BSF manufacturers report that demand for filters from individuals has slowed considerably.

***BSF Delivery Model and Sustainability of Livelihoods for Manufacturers***

A fundamental element contributing to the success of the BSF delivery model and the livelihoods of BSF manufacturers is the level of resource put into marketing and promotion of the product. And in this regard, it was evident that the manufacturers in Jawzjan were investing a larger proportion of their energy and resources into active marketing of the product, when compared with the manufacturers in Kapisa. However the research suggests that further investment in marketing would be required from external parties such as the government or NGOs in order to increase BSF demand to self sustaining levels. Despite this, it was evident that all BSF manufacturers were, at a minimum, able to supplement their income from their BSF manufacturing business.

## 5. Conclusions

Considering the wider research aim; to evaluate the effectiveness and sustainable impact of a demand led biosand filter programme in the complex emergency context of Afghanistan, the following conclusions can be drawn.

On the whole the technical performance of the BSF was good. Despite some issues being identified with construction, installation, operations and maintenance, mainly related to the depth of water above the schmutzdecke and sand cleaning methodology. The filters were shown to be effective in removing on average 91.7% of the E.coli bacteria, and 83.0% of the turbidity.

The research also found that users strongly believed the drinking filtered water from the BSF was resulting in a positive impact on their health. The perceived health impacts were confirmed to some extent by the self reported rates of diarrhoea in the past two weeks, where only 16% of those with an operating BSF reported cases of diarrhoea, while 71% of those without a BSF reported cases of diarrhoea. This is a key factor which has led to sustained use of the filters amongst 94% of the households surveyed.

It can be concluded from the research that sale of the BSF at a full cost recovery price is affordable for 55% of the population who fall within the middle to upper income bracket. However only 9.2% of this group of the population have purchased a filter. This is a result of a number of factors including, gender and cultural factors, unwillingness to pay, and lack of marketing and promotion. Despite this, all BSF manufacturers were able to supplement their income from their BSF manufacturing business.

When compared with other programmes in more stable development contexts, this research shows that, in the complex emergency context of Afghanistan a demand led BSF programme has been able to achieve a comparable, level of effectiveness, impact and sustainability.

**6. Recommendations**

Based on the findings of the study it is recommended that, where the conditions are favourable, humanitarian agencies seriously consider demand-led commercialized approaches to BSF programming as a sustainable household water treatment solution in complex emergency situations. The study has also highlighted several areas where improvements could be made to raise BSF filter performance and demand to higher levels, and thus increase the potential sustainability and impact of the programme; including improvements to construction, installation, operations and maintenance; and BSF marketing and promotion.

Another recommendation resulting from the investigations documented in this study is that additional research on BSF in emergencies and especially complex emergencies is needed to build an evidence base to demonstrate effectiveness, impact and sustainability and therefore justify further investments.

**7. References**

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## List of Abbreviations

| | |
|---|---|
| AFN | Afghani (the currency of Afghanistan) |
| BSF | Biosand Filter |
| CAWST | Centre for Affordable Water and Sanitation Technology |
| CDC | Community Development Council |
| CE-DAT | Complex Emergency Database, maintained by CRED |
| CFU | Colony Forming Unit |
| CRED | Centre for Research on the Epidemiology of Disasters |
| E.Coli | Escherichia Coli |
| EM-DAT | Emergency Database, maintained by CRED |
| HWTS | Household Water Treatment and Safe Storage |
| IASC | United Nations Inter Agency Standing Committee |
| ISAF | International Security Assistance Force |
| NGO | Non Governmental Organisation |
| NTU | Nephelometric Turbidity Units (the unit used to describe turbidity) |
| OECD | Organisation for Economic Co-operation and Development |
| POUWT | Point of Use Water Treatment |
| RTD | Relief to Development |
| UNHCR | United Nations High Commissioner for Refugees |
| UNICEF | United Nations Children's Fund |
| UNISDR | United Nations Strategy for Disaster Reduction |
| USD | United States Dollar |
| WASH | Water Sanitation and Hygiene |
| WEDC | Water, Engineering and Development Centre, Loughborough University |
| WHO | World Health Organisation |

## Glossary

Colony Forming Units - a microbiological unit of measurement - in this case to indicate the number of thermotolerant coliform bacteria or E.coli in a water sample.

Complex Emergency defined by the IASC as "*a humanitarian crisis in a country, region or society where there is total or considerable breakdown of authority resulting from internal or external conflict and which requires an international response that goes beyond the mandate or capacity of any single and/or ongoing UN country programme*" (IASC, 1994).

Demand Led: Programming approach that reflects customer choice. A range of goods or services are made available on the open market at full cost (or subsidised cost) and the customer has the freedom to choose to purchase those that meet their needs. Implementing agency involvement is normally limited to social marketing to generate demand, and supply chain support to ensure availability of products in the market.

Disaster defined by UNISDR as "*a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources"* (UNISDR, 2009). EM-DAT (2011) defines three types of disaster *'natural disasters', 'technological disasters' and 'complex emergencies'.*

Emergency: *"A crisis or emergency is a threatening condition that requires urgent action. Effective emergency action can avoid the escalation of an event into a disaster."* (UNISDR, 2009:13)

Escherichia Coli is a bacteria widely used as an indicator of faecal contamination (WHO, 2003:52)

Supply Driven: Programming approach, whereby goods or services are provided at no cost (or minimal cost) to the customer by the implementing agency. Customer choice is limited, and the choice of what and when to supply remains with the implementing agency.

Schmutzdecke – a German word meaning "dirty layer or blanket". The schmutzdecke forms on the upper layer of the sand and consists of numerous micro-organisms including algae, plankton, diatoms, protozoa, rotifers and bacteria, which entrap and digest organic matter and bacteria contained in the water passing through (Huisman, 1974:20).

Social Marketing – an approach which uses marketing principles to achieve social benefits such as changes in attitudes and behaviours which are deemed to be good for society as a whole (Wateraid, 2010).

Hazard *"A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage"* (UNISDR, 2009:17).

# 1. Introduction

## 1.1. Background

Access to safe drinking water and safe sanitation is critical for survival, and yet a vast proportion of the world's population do not have adequate access. WHO reports that globally 884 million people lack access to safe water and 2.6 billion lack access to safe sanitation (WHO/UNICEF, 2010).

The poorest and most vulnerable groups in society are the most affected by lack of access to safe water and safe sanitation, and at the same time are the most vulnerable to the effects of disasters and conflict. Annually, around 30 million people are displaced due to conflict and natural disasters; and about 200 million people are affected by natural hazards (GWC, 2009:15). Access to safe water and sanitation are critical for human survival and dignity immediately after a disaster, and during a complex emergency.

The early stages of disaster response require immediate water, sanitation and hygiene (WASH) interventions which normally use fully subsidised, 'supply-driven' methods, such as water distribution, latrine construction and hygiene kit distribution. However, when these methods are applied for a protracted period, they can result in dependency on the implementing agency, a lack of community ownership, and poor overall sustainability of interventions. For both donors and implementing agencies, there is a growing recognition of the need to address the problem of aid dependency, especially in complex emergencies, and to manage the smooth transition from 'supply-driven' disaster relief WASH interventions through to more sustainable recovery focused interventions, which also promote economic revitalization through development of sustainable livelihoods.

There is a need to grow the evidence base to support the belief that full cost recovery livelihoods based water schemes can be successfully integrated into complex emergency response and may lead to greater self determination, community empowerment and more sustainable results. These approaches address health issues relating to water and sanitation and also promote economic revitalization through development of sustainable livelihoods, which are fundamental foundations for peacebuilding (UN, 2009).

Complex emergencies are generally characterized by:

> *"Extensive violence and loss of life, damage to infrastructure, displacements of people, and breakdown of government and civil society, and the hindrance or prevention of humanitarian assistance by political and military constraints."* (IASC, 1994)

In such situations centralised systems for water treatment and distribution are rarely viable, and simple low cost household water treatment solutions often prove to be the most viable and sustainable intervention. One such technology, the Biosand Filter (BSF), lends itself towards local manufacture and distribution, and has been introduced in several disaster response and complex emergency situations.

Whilst there is a growing body of research around BSF in the development context, current estimates are that over 200,000 filters are in use in 70 countries (CAWST, 2009); very little research has been published relating to the use of BSF after disasters and during complex emergencies.

One complex emergency situation in which the BSF has been introduced is Afghanistan, where Tearfund together with Centre for Affordable Water and Sanitation Technology (CAWST) has trained local technicians to manufacture and sell BSF in a 'demand-led' commercialised model of intervention. Over the period 2008 – 2011 more than 17,000 filters have been locally produced and sold in Kapisa, Parwan, Jawzjan, Faryab and Kandahar provinces.

## 1.2. Research Aim

The research aims to evaluate the effectiveness and sustainable impact of a demand led Biosand Filter (BSF) programme in the complex emergency context of Afghanistan.

## 1.3. Research Questions

The research will consider the following three key questions and sub questions:

1. What was the technical performance of the BSFs?
    a. What was the filtered water quality?
    b. Was the BSFs construction and installation quality adequate?
    c. Have the BSFs been operated and maintained correctly?
2. What was the user perception of BSF impacts?
    d. What was the user perception of BSF contribution to their quality of life?
    e. What are the self reported rates of diarrhoea?
3. Was sustainable demand for the BSF created?
    f. What was the rate of BSF adoption and sustained use?
    g. Was ability and willingness to pay for the full cost of the BSF demonstrated?
    h. Is BSF coverage increasing?
    i. Was a sustainable BSF delivery model established and sufficient demand generated to enable sustainable livelihoods for BSF manufacturers?

## 1.4. Use to the Wider Community

The research will build the body of knowledge around the use of biosand filters in complex emergencies. The research will add to the growing evidence base to guide donors and implementing agencies in the application of demand led WASH interventions, and more specifically the use of biosand filters in the disaster response context. The research findings will be directly applicable to disaster response planning and implementation, and will contribute to the future application of specific demand-led WASH interventions in complex emergency settings.

# 2. Literature Review

## 2.1. Methodology and Limits

### 1.1.1. Approach Taken to Find Sources of Information

A comprehensive review of published and grey literature has been undertaken on biosand filter use in emergencies, in order to place the research in the context of the wider evidence base, and to support the conclusions of the research project.

Literature was identified using searches of, WEDC Knowledge Base, past WEDC MSc papers, Google and Google Scholar, Metalib data base searches of CSA Illumina – Aqualine, Environmental Sciences and Pollution Management, ASSIA and IBSS, Geobase, Web of Science and Science Direct.

### 1.1.2. Data Sources

In total, 68 sources were identified, providing information on disasters, complex emergencies and biosand filtration. In the following sections, this research is summarised through discussion and synthesis.

## 2.2. Afghanistan and the Research Area

### 2.2.1. Afghanistan Country Context

Afghanistan has experienced more than three decades of sustained conflict, beginning with the Saur Revolution (1978), and the subsequent Soviet invasion and occupation (1979 – 1989), during this period the Islamic Mujahadeen resistance grew in strength and ultimately took control of government (1992 – 1996). The rising strength of Taliban saw them wrest control of government for the period (1996 – 2001). At the same time the Northern Alliance formed in opposition and continued the civil war until the United States and its allies joined forces with the Northern Alliance to defeat the Taliban in 2001. Subsequent to 2001, International Security Assistance Forces (ISAF) have continued to fight Al Qaeda and Taliban forces, whilst equipping and training the Afghan National Army to take control of internal security. As a result there has been a period of relative peace where many refugees and internally displaced people have returned to their homes, where they set about restarting agriculture and other livelihoods (Burt and Keiru, 2011). With the current transition of internal security responsibility to the Afghan National Army, and planned international troop withdrawal in 2014, there is uncertainty about the future security of the country. It is likely that the complex emergency situation may well continue into the future.

### 2.2.2. The Tearfund Afghanistan WASH Programme

The Tearfund WASH programme began in Afghanistan with the overall aim of providing basic water, sanitation and hygiene services to support the safe and sustainable reintegration of returnees, and to improve health (Burt and Keiru, 2011). It is funded by a range of international donors and works in conjunction with the National WASH Cluster, the National Government and local Community Development Committees (CDC).

The work has focussed on the provinces of Kapisa, Parwan, Jawzjan, Faryab and Kandahar, all areas that have seen a high number of returnees as part of the UNHCR 'Assisted Voluntary Repatriation to Afghanistan' programme. In each province, Tearfund has conducted needs assessments to identify the priority needs in the most vulnerable communities, and interventions have focussed on these areas.

The WASH programme adopted a social marketing approach, systematically applying marketing principles, to achieve specific changes in attitudes and behaviours for social good. The whole community was involved in the process, although due to the cultural context events tended to be held separately for women and men (Burt and Keiru, 2011). On the basis of evidence compiled by UNICEF concluding that point of use water treatment interventions combined with sanitation and hygiene behaviour change will result in the greatest reduction in diarrhoea disease (Van-Maanen, 2009:1), the aim was to create demand for household water treatment systems, sanitation facilities and hygiene behaviour improvement by achieving three key objectives:

The first objective was for the community to understand how unsafe sanitation, poor hygiene behaviour, and contaminated water contributed to poor health (Burt and Keiru, 2011). Tearfund staff worked closely with the religious leaders to explain the connection between contaminated water, poor hygiene and sanitation practice and the high incidence of diarrhoeal disease. Together with the religious leaders Tearfund began sensitising the community to the fact that the majority of diarrhoeal diseases were caused by contaminated water and poor sanitation and hygiene practices.

The second objective was to stimulate demand for safe household sanitation facilities, hygiene behaviour improvements and appropriate household water treatment systems (Burt and Keiru, 2011). This was achieved through a number of hygiene promotion techniques, together with a hand washing campaign that stimulated demand for hand washing with soap/or ash, a 'community led total sanitation' (CLTS) campaign which stimulated demand for household latrines, and a point of use household water treatment advertising campaign, which stimulated demand for point of use water treatment systems, of which the bio-sand filter proved most popular.

The third objective was to equip and train local technicians to manufacture items to meet the new demand, thus creating livelihoods opportunities as well as addressing the health issue (Burt and Keiru, 2011). As part of the process, Tearfund together with CAWST trained local technicians to manufacture and sell BSF in a demand-led commercialised model of intervention.

#### 2.2.3. The Tearfund Afghanistan Biosand Filter Programme

The Biosand filter programme began in Kapisa in 2008, and has subsequently expanded to Jawzjan and Faryab (2009), Parwan (2010) and Kandahar (2010). Tearfund focused its efforts on facilitation, promotion, marketing and training, leaving construction, production and distribution for the local tradesmen.

Tearfund facilitators held participatory discussions with the community to consider the most appropriate water treatment intervention. Due to the fact that most households collect drinking water from the canals which pass by their houses, it was decided that household water treatment systems would be most appropriate. After considering the options, the community decided that the bio-sand filter would be most appropriate due to the local availability of the necessary materials which meant that artisans would be able to manufacture the filters locally (Burt and Keiru, 2011).

The bio-sand filter was a new technology, and local BSF manufacturers needed special training to enable them to meet the demand. Tearfund, together with the government, Community Development Committees (CDC), and the targeted communities, selected trainees based on agreed criteria. After training in conjunction with CAWST the BSF manufacturers were equipped with tools, and started producing filters and holding demonstrations in mosques and schools, where the religious leaders and teachers promoted the product and explained its health benefits to community members. Many community members bought the filters, and all buyers received training on how to operate and maintain them (Burt and Keiru, 2011).

Tearfund invested in a comprehensive marketing campaign for household water filtration with a focus on bio-sand filters, including promotion through billboards, TV, radio and leaflets. Product demonstrations were held at schools, clinics and mosques, and Mullahs promoted the filters after religious gatherings (Burt and Keiru, 2011).

During the introductory phase of the project, Tearfund signed a memorandum of understanding with the local BSF manufacturers, with various subsidies and price controls that enhanced availability and accessibility at the initial stages of the program and allowed consumers to test the product. During this period, a number of filters were purchased by Tearfund and distributed at no cost to the most vulnerable households within the target communities. This together with the marketing and promotion programme helped to generate demand for BSF sales. Since the memorandum of understanding expired, product pricing controls have been removed and BSF manufacturers have been selling filters at full cost recovery prices (Burt and Keiru, 2011).

As demand increased, many of the BSF manufacturers opened bio-sand filter shops. The first shop was established in Bako Kham on a pre-order basis. Popular government officials, religious leaders, and community leaders were invited to endorse each shop at a well-publicized opening ceremony; this proved to be very helpful for promotion and marketing of the filters. Many of the opening ceremonies were covered by local television and radio stations and newspapers; during interviews, local government officials advised communities to consider using the filters (Burt and Keiru, 2011).

Based on the success observed in Kapisa Province, the Afghan Ministry of Rural Rehabilitation and Development included BSF in the National WASH Implementation Manual (MRRD, 2010).

Over the four year period 2008 – 2011 more than 17,000 filters have been produced and sold in Kapisa, Parwan, Jawzjan, Faryab and Kandahar as shown in Table 2.1.

**Table 2.1: Number of BSF Purchased**

| Province | Project Period | BSF Purchased and Distributed By TF | BSF Purchased Privately | Total |
|---|---|---|---|---|
| Kapisa | 2008-10 | 2,170 | 4,636 | 6,806 |
| Jawzjan/ Faryab | 2009-11 | 4,704 | 2,178 | 6,882 |
| Parwan | 2010-11 | 500 | 421 | 921 |
| Kandahar | 2009-11 | 1,800 | 660 | 2,460 |
| | | | **Total** | 17,069 |

### 2.2.4. Description of the Research Areas

For security and accessibility reasons the field research focused on the two provinces of Kapisa and Jawzjan, as shown in Figure 2.1, below:

**Figure 2.1: Map of Afghanistan Provinces**


Source: ecoi.net (2011)

### *Kapisa*

Kapisa is located 60km north of Kabul, and topography is typified by high mountains in the north of the province and flat lowlands in the south of the province. Water is relatively abundant, with average annual precipitation around 340mm / year (BBC, 2011) and numerous streams, which are also fed by snow melt, run down from the mountains to the lowlands. Canals diverted off the streams, irrigate the fields and pass through the residential areas where they are used as the primary drinking water source (Burt and Keiru, 2011).

### *Jawzjan*

Jawzjan is located in the North of Afghanistan, and topography is typified by wide flat lowlands, adjacent to the Amu Darya River which forms the border between Afghanistan and Turkmenistan. The climate is semi-arid, with low annual precipitation. Water is scarce and normally sourced from canals which divert water from tributaries of the Amu Darya River. The flow of water in the canals is managed by the Rural Water Sanitation and Irrigation Department so that each canal normally receives water for several days per month. Villages normally store water from the canal in reservoirs to provide a consistent source of drinking water. In addition most villages excavate shallow hand dug wells to access ground water, this water is often high in Total Dissolved Solids (TDS) and is not normally used for drinking, but some villages have deeper borewells with handpumps, which access "sweet" water from a deeper aquifer. This water is used as a supplementary drinking water source especially during the dry season, June – September.

## 2.3. Emergencies and WASH

### 2.3.1. Categories of Disaster

The Centre for Research on the Epidemiology of Disasters (CRED) maintains the International Disaster Database (EM-DAT). Three groups of disasters are distinguished in EM-DAT (2011), "*natural disasters*", "*technological disasters*" and "*complex emergencies*". At least one of the following criteria must be fulfilled for a disaster to be entered into the database*;*

> *"Ten or more people reported killed; one hundred or more people reported affected; a state of emergency is declared; or there is a call for international assistance."* (EM-DAT, 2011)

***Natural Disasters***

Natural disasters are defined as:

> *"naturally occurring physical phenomena caused either by rapid or slow onset events which can be geophysical (earthquakes, landslides, tsunamis and volcanic activity), hydrological (avalanches and floods), climatological (extreme temperatures, drought and wildfires), meteorological (cyclones and storms/wave surges) or biological (disease epidemics and insect/animal plagues)."* (EM-DAT, 2011)

***Technological Disasters***

Technological disasters are *"catastrophic events that are caused by humans and occur in or close to human settlements"* (EM-DAT, 2011), and may be a result of environmental degradation, pollution, accidents and conflict. Technological or human-made hazards include; famine, displaced populations, industrial accidents (eg. fires, nuclear radiation) and transport accidents (eg. oil and chemical spills).

***Complex Emergencies***

Some disasters can result from *"a complex combination of both natural and human-made causes and different causes of vulnerability"* (EM-DAT, 2011). Such disasters are commonly known as complex emergencies, and normally occur over an extended time period. A complex emergency is defined by the United Nations Inter Agency Standing Committee (IASC) as:

> "*a humanitarian crisis in a country, region or society where there is total or considerable breakdown of authority resulting from internal or external conflict and which requires an international response that goes beyond the mandate or capacity of any single and/or ongoing UN country programme.*" (IASC, 1994)

Complex emergencies are generally characterized by:

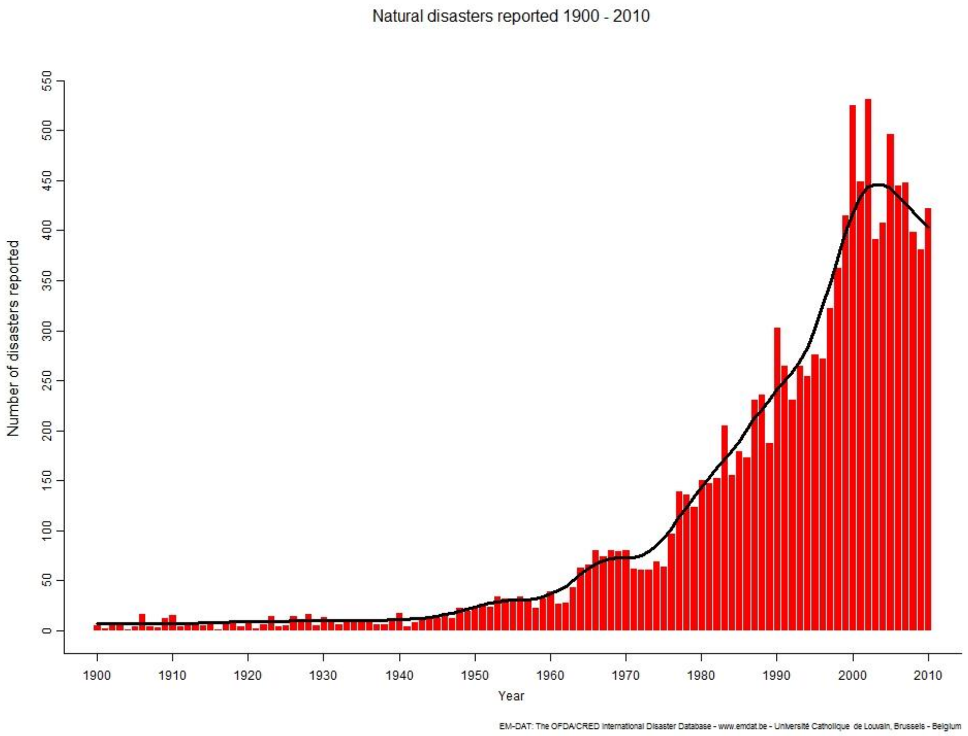
> "*extensive violence and loss of life; massive displacements of people; widespread damage to societies and economies, the need for large scale, multi-faceted humanitarian assistance, and the hindrance or prevention of humanitarian assistance by political and military constraints.*" (IASC, 1994)

Afghanistan falls under the category of complex emergency.

### 2.3.2. Disaster Trends

The Centre for Research on the Epidemiology of Disasters (CRED) has mapped disaster trends since 1900, and maintained the International Disaster Database (EM-DAT) since 1988. Figure 2.2 below shows the increasing trend of natural disasters since 1900.

**Figure 2.2: Natural Disasters Reported 1990 - 2010**




Source: EM-DAT (2011)

Natural disasters and their impacts have been increasing, due to increases in populations living in hazard prone locations, unplanned settlements, environmental degradation, and climate change causing more intense weather patterns (UNISDR, 2010).

Since 1975, the majority of the largest natural disasters, in terms of number of people affected, occurred in Asia (67%), followed by Latin America and the Caribbean (13%) (Spiegel et al, 2007:3), and the largest number of countries affected by complex emergencies are in Africa (64%), followed by Asia (30%) (CE-DAT, 2011). A significant overlap (87%) between complex emergencies and natural disasters was discovered by Spiegel et al (2007:3).

The median duration of the largest 30 complex emergencies which ended in the past ten years was 12.5 years with a range of 1 to 41 years, and the estimated number of resulting deaths ranged from 1,000 to 3 million (Spiegel et al, 2007:3).

#### 2.3.3. Emergency Response Funding Trends

In line with increases in the number of people affected by disasters, there has also been a large increase in funding for emergency response. Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee members alone are the largest single group of donors and have increased funding from US$436 million donated in 1970, to US$11.8 billion in 2010 (DI, 2011:13). The total level of humanitarian funding from all sources is estimated to be US$16.7 billion (DI, 2011:19). Increased levels of funding may be attributed to increased levels of public concern due to improvements in media coverage of disasters, and a diversity of new funding sources including many private foundations and corporations. A significant proportion of humanitarian aid is directed towards complex emergencies. For example 68% of the total US$7.1 billion humanitarian assistance funded through the 2010 UN Consolidated appeal fund was directed towards complex emergencies, and only 32% towards natural disasters (DI, 2011:57).

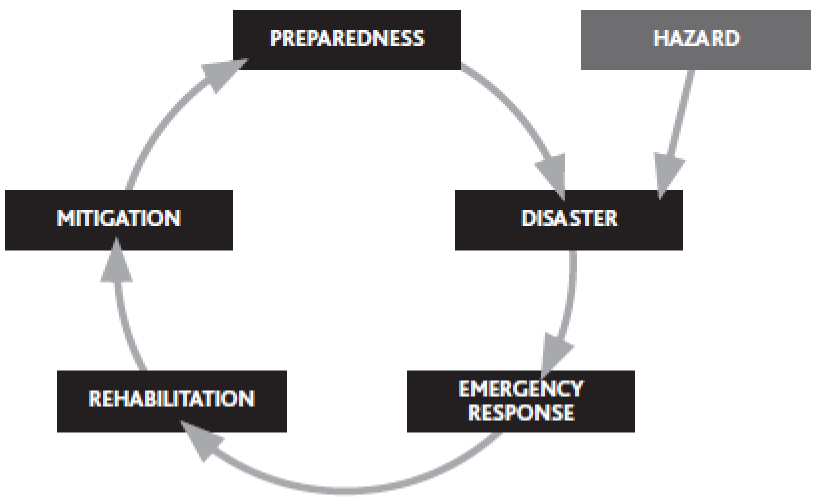
Despite increased funding, there are disparities in funding between emergencies and sectors. For example, in 2010 UN CAP appeal only 18.6% of needs were met in the least funded emergency (Mongolia dzud), compared with 74.6% of needs met in the best funded emergency (Haiti earthquake) (DI, 2011:62). The most underfunded sectors are economic recovery, health, protection, and water and sanitation (Lantagne, 2009:20).

Stoddard and Harmer (2005), argue that there is a gap between humanitarian assistance and long-term sustainable development. This gap is often exacerbated by donor and implementing agency internal structures. Donors often fund humanitarian aid and development assistance through separate mechanisms, causing incompatibilities in targets and outcomes. For their part agencies involved in providing humanitarian aid are typically different from those involved in planning for long-term sustainable development. As a result, an increasing number of agencies are developing strategies to integrate their approaches in humanitarian and development work, in order to increase their effectiveness.

### 2.3.4. Disaster Relief to Development Continuum

The 'disaster cycle' is a widely used model to show the sequence of activities which often follow a disaster. It recognises that disasters tend to recur in the same place, with a 'return period', depending on the nature of the hazard. In its simplest form the 'disaster cycle' can be expressed as shown in Figure 2.3 below.

**Figure 2.3: Disaster Cycle**




Source: Hansford (2011)

After a disaster, the progression of response is known as the relief-to-development continuum. The progression is described by Burkholder and Toole (1995) in three phases as follows:

1) *The Relief Phase*. (or 'acute emergency phase') follows immediately after a disaster; and disaster response activities are designed to save and preserve the lives of survivors, eg. search and rescue, medical care, temporary shelter, emergency food rations. Needs are particularly acute during the first 48 hours after a rapid-onset disaster; during this time, many survivors may die if not given the assistance they require. This phase is often

complicated by lack of coordination, security concerns, logistical difficulties and resource constraints.

2) *The Rehabilitation Phase*: (or 'late emergency phase') may be divided into early recovery and later rebuilding, and includes the restoration of public health programmes, housing, livelihoods, social systems and infrastructure. Activities such as restoring water supply, rebuilding schools or re-establishing medical services easily merge into development, as replacements are generally better than the ones destroyed.

3) *The Development Phase*: (or 'post-emergency phase') is when the emphasis of humanitarian assistance shifts from relief to development. Activities are forward-looking and assume a future recurrence of the hazard and seek to reduce the scale of suffering next time. Disaster risk reduction or mitigation activities might include planting alternative crops, building stronger houses or improving water supply. Preparedness might include contingency planning, warning systems or stockpiling some emergency goods.

Interest in the concept of the 'relief-to-development continuum' is increasing as humanitarian relief budgets rise and development aid resources are reduced. The concept of Disaster Risk Reduction (DRR), attempts to direct humanitarian resources towards addressing the underlying vulnerabilities of communities, with interventions closely aligned to development aid, in order to reduce the risk of disasters. In the context of complex emergencies, effective development aid can reduce vulnerability to the impact of natural hazards and contribute to a process of conflict prevention (Macrae et al, 1997).

During the transition from relief to rehabilitation after disasters, and when responding to long term complex emergencies, use of 'demand-led' (as opposed to 'supply driven') WASH interventions, will reduce aid dependency, build resilience and promote economic revitalization through development of sustainable livelihoods (Burt and Keiru, 2011), these are all factors that will contribute towards peace building and development (UN, 2009).

Harmer and Macrae (2004) present a growing body of research around the issue of bridging the gap between humanitarian aid and long-term sustainable development, and argue that to make humanitarian aid more effective it is essential that humanitarian activities are effectively integrated with strategies for long-term sustainable development.

Garnett and Moore (2010) argue that analysis of international disaster experiences indicates that responses to the immediate needs of affected populations after a disaster should be integrated with long-term development needs. Disaster response programmes that empower affected communities to take on reconstruction through local market channels address short term relief and recovery needs, while at the same time contributing towards long-term development. Planning for and promoting an early emphasis on recovery should ensure that livelihoods are restored in addition to vital services, and that short-term interventions are cost effective and promote self-sufficiency and sustainability within the affected communities.

## 2.4. Bio-sand Filtration

### 2.4.1. Biosand Filter Origins

Slow sand filters provide a combination of physical and biological removal mechanisms and their effectiveness for water treatment has been well documented (Hijnen, 2004). During the 1990's researchers led by Dr David Manz at the University of Calgary developed a small scale slow sand filter with the ability to be operated intermittently, which made it more suitable for household applications, this filter has become known as the Biosand Filter (BSF) (Buzanis, 1995).

### 2.4.2. BSF Technical Specifications

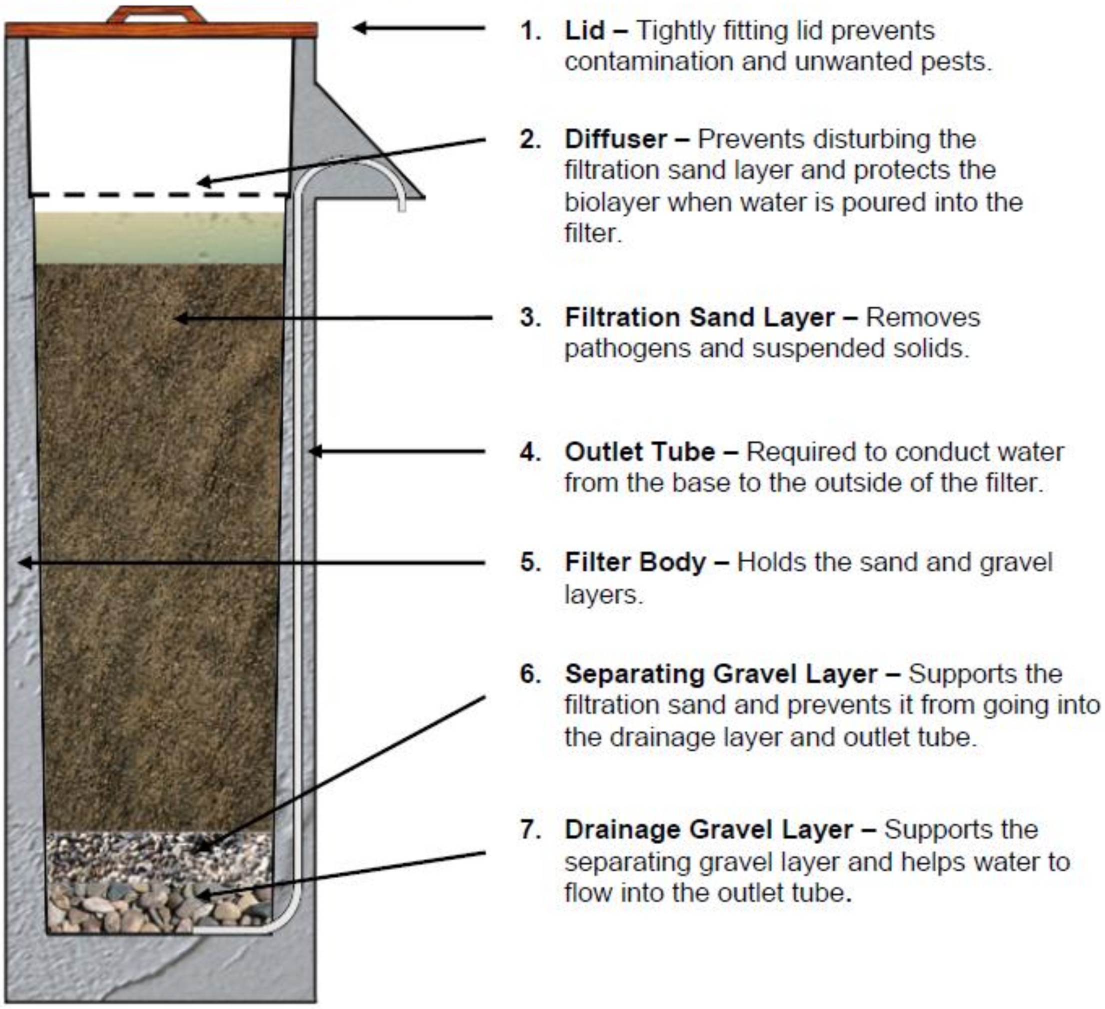
There are a range of different BSF designs, with minor differences, however they all roughly conform to similar technical specifications as generally shown in Figure 2.4.

The container itself may be made from concrete, plastic or steel, and may be round or square in shape. The BSF typically contains three layers of filter media; coarse gravel at the base, fine gravel as a transitional layer, and the bulk of the filter is filled with sand. A pipe conveys the filtered water from the base to an outlet on the outside of the filter container. A diffuser protects the top surface of the sand from disturbance when raw water is poured into the filter. The standing water level is maintained at 50mm above the sand layer by setting the outlet of the outflow pipe 50mm above the top of the sand. The 50mm of standing water is integral to the filter as it allows a biological layer known as the 'schmutzdecke' to grow on top of the sand without drying out during intermittent use. The 50mm depth is the optimum level for oxygen diffusion to the schmutzdecke to allow aerobic respiration. A water depth of greater than 50mm results in lower oxygen diffusion and therefore a thinner schmutzdecke (Buzunis, 1995:71-77). High water levels may be caused by an insufficient amount of sand installed in the filter, or the sand settling in the first few weeks of use, or by a blocked outlet tube. A water depth less than 50mm may evaporate quickly in hot climates and cause the schmutzdecke to dry out.

Research on various modifications to the BSF filter media to remove arsenic (Ngai et al, 2004) and fluoride (Hillman, 2007) from the source water are also proving successful.

The CAWST Version 10.0 BSF has been used by Tearfund in Afghanistan, and consists of layers of sand and gravel in a concrete container 940mm tall, and 304mm square.  The filter media consists of three layers, the bottom 50mm, drainage gravel (6-12mm), the next 50mm, separating gravel (1-6mm), and then 540mm of filtration sand (<0.7mm) up to 50mm below the standing water level.  A polythene tube (6-9mm diameter) is used to conduct water from the base to the outside of the filter.  A perforated diffuser box is placed above the level of the standing water to protect the schmutzdecke from damage when water is poured into the BSF. The reservoir volume is approximately 12 litres (CAWST, 2009).

**Figure: 2.4: Diagram of a Typical Biosand Filter**




Source: CAWST (2009)

### 2.4.3. BSF Operation

In order to operate the BSF, raw influent water is poured into the reservoir. The water passes through the diffuser and then percolates through the schmutzdecke, and down through the sand and gravel layers. The influent water displaces water already in the filter, which is then transmitted from the base of the filter via the outlet tube. Turbidity and pathogens and are removed from the water through a combination of physical and biological processes that take place within the schmutzdecke and the sand layer. These processes include; adsorption, predation, natural death and mechanical trapping (CAWST, 2009).

The schmutzdecke is the key component of the filter that removes pathogens. Without it, the filter removes about 30-70% of the pathogens through mechanical trapping and adsorption. The ideal schmutzdecke will increase the treatment efficiency up to 99% removal of pathogens. It may take up to 30 days for the schmutzdecke to fully form. During that time, both the removal efficiency and the oxygen demand will increase as the schmutzdecke grows. The water from the filter can be used while the schmutzdecke is being formed, however it must be disinfected during this time. Water must always be allowed to flow freely from the filter. If the outlet tube is blocked, the water level above the sand layer may increase, killing the microorganisms in the schmutzdecke due to lack of oxygen. Putting a hose or other device on the outlet may siphon or drain water out of the BSF, and the water level may drop below the top of the sand layer, which could dry out the schmutzdecke and kill the microorganisms (CAWST, 2009).

The biosand filter is most effective when operated intermittently and regularly. The recommended maximum loading rate is 400litres/hour/$m^2$. After each time the filter reservoir is filled and the water passes through the filter, a pause period should be observed before refilling the reservoir. The pause period should be a minimum of 1 hour after the water has stopped flowing up to a maximum of 48 hours. The pause period is important because it allows time for microorganisms in the schmutzdecke to consume pathogens in the water. As the pathogens are consumed, the flow rate through the filter may increase. If the pause period is too long, the microorganisms will eventually consume all the nutrients and pathogens and then eventually die off. This will reduce the removal efficiency of the filter when it is used again (CAWST, 2009).

Filtered water should be collected in a suitable narrow neck container with a lid or cover to minimise the risk of recontamination. Ideally the container used for collecting source water and pouring into the filter reservoir should not be used for collecting the filtered water, in order to reduce the risk of recontamination.

### 2.4.4. BSF Maintenance

After operating the BSF for some time the spaces between the sand grains will become clogged with suspended solids. As a result, the flow rate will slow down. A slower flow rate is not an issue in terms of water quality. In fact, the slower the flow rate, the better the water quality, however the length of time that it takes to get a container of filtered water may become too long and be inconvenient for the user.

The recommended maximum flow rate is 0.4 litres/minute, but when the flow rate becomes slower than 0.1 litre/minute, the user will need to do basic maintenance to restore it (CAWST, 2009).

The three most common methods of sand cleaning are described as follows:
(1) 'sand removal' method; in which the upper layer of sand (50 – 250mm) is removed, washed in a suitable container until clean, and then replaced in the filter. The 'sand removal' method results in significant damage to the schmutzdecke and can also result in loss of sand from the filter (Singer, 2011:34).
(2) 'wet harrowing' method (or 'stirring method'); in which water is added to the filter, the diffuser box removed, and the sand stirred to a depth of 20 – 100mm. The standing water is then decanted and the process repeated several times (Earwalker, 2006:29).
(3) 'surface agitation' method (also known as 'swirl and dump'); in which water is added to the filter, the diffuser box removed, and the water stirred so that the top of the sand is agitated to a depth no more than 10mm (Singer, 2011:34).. The standing water is then decanted and the process repeated several times. The 'swirl & dump' maintenance method promoted by CAWST (2009) was used in the Tearfund Afghanistan programme.

Research by Singer (2011) concluded that the surface agitation method resulted in the highest thermotolerant coliform removal rates and turbidity removal rates when compared with the other methods. The length of time required for filters to recover to pre-maintenance removal rates after sand cleaning was on average 4.1 days for the surface agitation method, 3.3 days for the stirring method and 12.75 days for the sand removal method.

Regardless of the method used it is recommended to disinfect the filtered water during the time it takes for the schmutzdecke to recover (CAWST, 2009).

In addition to cleaning the sand users also need to clean the outlet tube, safe storage container, diffuser, lid, and outside surfaces of the filter on a regular basis.

### 2.4.5. BSF Treatment Efficiency

A review of previous laboratory studies has been undertaken as summarised in Table 2.2, and detailed more fully in Appendix 1. These studies indicate that the BSF is capable of removing up to 99% bacteria (Stauber, 2007), 99% viruses (Elliot, 2008), 99% protozoa (Liang, 2010), and 95.5% turbidity (Buzunis, 1995) after the schmutzdecke has fully ripened, which may take up to 30 days (CAWST, 2009). In general the expected E.coli removal rate for a ripened BSF is 90 – 99% (Liang, 2010:3). Whereas the expected E.coli removal rate in an unripened filter is 30 – 70% (CAWST, 2009). The majority of the studies focussed on measuring bacteria (E.coli) reduction. A few studies considered virus and protozoa removal rates, but no studies were found that considered helminth removal rates, however helminths are considered too large to pass through the spaces between the sand grains and therefore, up to 100% removal efficiency may be assumed (CAWST,2009).

**Table 2.2: Summary of Previous Laboratory Studies for BSF Treatment Efficiency**

| Reference | Location | Mean Removal Rate After BSF Filtration (Indicator) |
|---|---|---|
| Buzunis (1995) | University of Calgary | 96% (faecal coliform)<br>95.5% (Turbidity) |
| Palmateer et al (1999) | Alberta & Ontario | *83% heterotropic bacteria*<br>*>99.99% Giardia Cysts*<br>*99.98% Cryptosporidium oocysts*<br>*50-90% organic and inorganic toxin* |
| Baumgartner (2007) | Harvard University | *78% (total coliform)* |
| Stauber et al. (2006) | University North Carolina | 94% (E.coli), Maximum 99% |
| Stauber (2007) | University North Carolina | 91 – 97% (E.coli), Maximum 99.4% |
| Thye (2007) | Loughborough University | Range 89.3-99.9% (E.coil)<br>91.2% - 92.1% (Turbidity) |
| Elliot et al (2008) | University North Carolina | 95.6% (E.coli)<br>*99% (echovirus 12)*<br>*70% (bacteriophage)* |
| Duke and Mazumder (2009) | University of Victoria | Range 96.6-99% (E.coli) |
| Liang (2010) | University North Carolina | 90 – 99% (E.coli)<br>90% (Virus)<br>99.9% (protozoa) |

In addition a review of previous field studies has been carried out as summarised in Table 2.3, and detailed more fully in Appendix 1. These studies indicate that even in field conditions the BSF is capable of removing 99% E.coli (Vanderzwaag, 2009), 87% viruses (Stauber, 2007), and 88% turbidity (Vanderzwaag, 2009), after the schmutzdecke has fully matured. Based on the previous field studies summarised in Table 2.3 the mean removal rate for E.coli was determined to be 92%, and the mean removal rate for turbidity 83%.

**Table 2.3: Summary of Previous Field Studies for BSF Treatment Efficiency**

| Reference | Location | Time Since Installation | Mean Removal Rate After BSF Filtration (Indicator) |
|---|---|---|---|
| Buzunis (1995) | Nicaragua | 2 months | 96.4% (faecal coliform) |
| Baughen et al (1999) | Nicaragua | 1 month | 80% (faecal coliform) |
| Mol (2001) | Kenya | 3-4 weeks | 93% (faecal coliform) |
| Lee (2001) | Nepal | 2 years | 83% (E.coli)<br>75% (turbidity) |
| Kaiser et al ( 2001) | 6 Countries | | 93% (E.coli) |
| Dejachew (2002) | Ethiopia | 2.5 years | 90% (E.coli) |
| Dies et al (2003) | Nepal | 'recent' | 95% (E.coli) |
| Bojecvska & Jergil (2003) | Mozambique | 1 month | *96% (Cyanobacteria)* |
| Fewster et al (2004) | Kenya | 2.5 – 4 years | *70.5% <10cfu/100ml*<br>*82.4% <10 NTU* |
| Maetens and Buller (2005) | Ethiopia | 2.5 years | 97.3% (E.coli)<br>85% (turbidity) |
| Duke et al (2006) | Haiti | 5 years | 98.5% (E.coli)<br>85.4% (Turbidity) |
| Earwalker (2006) | Ethiopia | 5 to 7 years | 87.9% (E.coli)<br>69% (Turbidity) |
| Stauber et al (2006) | Dominican Republic | 1 year | 93% (E.coli)<br>84% (turbidity) |
| Stauber (2007) | Dominican Republic | 0 – 1 year | 94% (E.coli)<br>*78% (MS-2 Virus)*<br>*87% (PRD-1 Virus)* |
| Vanderzwaag (2009) | Nicaragua | 3 – 8 years | 96% (E.coli)<br>88% (turbidity) |
| Liang et al (2010), | Cambodia | 0 – 8 years | 95% (E.coli)<br>82% (turbidity) |
| CAWST (2010) | Afghanistan | 0 – 2 years | 93% (E.coli)<br>86% (turbidity) |
| Singer (2011) | Uganda | 0 – 6 months | 88% (E.coli)<br>90% (turbidity) |
| OVERALL MEAN % REDUCTION | | | 92% (E.coli)<br>83% (Turbidity) |

In addition to the factors relating to BSF operation and maintenance described in the preceding section, a number of other factors relating to influent water can affect the BSF treatment efficiency. A study by Buzunis (1995) observed that after the E.coli concentration in the raw water increased, there was a parallel decrease in E.coli removal rates by the filter. This was explained because the micro-organisms within the BSF need time to adapt to different conditions. They are not able to consume large influxes of influent bacteria, until the required predator micro-organism population increases accordingly. In a similar way if there are changes in the raw water source due to environmental factors, or simply because the BSF user is obtaining raw water from a different source, then the filter treatment efficiency is likely to drop, until the predator micro-organisms within the filter adjust their populations to match the new range of bacteria within the influent water.

The BSF does also have some technical limitations. It cannot operate at freezing temperatures, and its ability to treat water is dependant on the turbidity of the source water. Generally source water with NTU greater than 50 is not suitable, as the filter will become easily clogged, causing the flow rate to be reduced (CAWST, 2009). Highly turbid source water should be pre-treated using a settlement / sedimentation method prior to treatment in the BSF.

#### 2.4.6. BSF Health Impact

BSF health impact studies estimate a 30-47% reduction in diarrhoea among all age groups (Stauber, 2007). However, a recent review of water, sanitation and hygiene prevention interventions raises doubts about the validity of some of the Household Water Treatment (HWT) evidence base and stresses the need for more rigorous objective examination of HWT (Cairncross et al, 2010:202). The authors of this review argue that, reported disease reductions associated with HWT may be the result of the courtesy bias or placebo effect, wherein survey respondents who have received HWT products under-report diarrhoea in order to please those conducting the study. Another study by Walker et al (2010) suggests that a more realistic figure of disease reductions associated with HWT, taking into account imperfect use and the multiple pathways of diarrheal disease, is likely closer to 17 %.

#### 2.4.7. Review of BSF Programme Implementation Practice

BSF programmes have been implemented through two main strategies; ‘supply driven’ and ‘demand-led’. (1) In the ‘supply-driven’ model; the filters are provided to community members at no cost (or minimal cost), by an external agency which also promotes BSF use within the community. (2) In the ‘demand-led’ model, the filters are constructed and made available on the open market by local entrepreneurs at full cost (or subsidised cost). The implementing agency engages in social marketing to generate demand, and provides training and start-up materials to local BSF manufacturers to produce BSF and develop small businesses to sell BSF within their communities. This model of implementation is less common but potentially more sustainable. Case study examples of the two implementation methods are presented below.

***Supply-Driven BSF Implementation Model***

There are a wide number of examples of BSF programmes using the ‘supply driven’ implementation model. In general the common theme amongst all the examples described in literature is the issue of sustainability after the implementing agency moves out of the location or the programme runs out of money. Two case study examples are summarised below:

In Cambodia, 25,000 filters have been distributed by an NGO (Hagar Cambodia) using the supply driven model. After providing information about the BSF at a community meeting; interested community members were invited to participate on the programme. Programme participants were asked to contribute US$3 towards the cost of the BSF (this is only 4.5% of the full cost US$67, or 19% of the BSF materials cost US$15.50); attend focus group trainings on hygiene and use of the BSF, and to assist with the construction and transportation of the BSF. The results showed average BSF usage of 87.5% after ownership of between 6 months to 8 years. The working filters showed an average E.coli reduction rate of 95% and turbidity reduction rate of 82% (Liang, 2010). It was reported that a further 75,000 families have expressed an interest in participating in the programme, but lack of funding has limited the ability of the implementing agency to meet this need (Lantagne, 2006). When questioned about availability of BSF on the local market, 74% of the households reported that BSF could not be purchased in the area, while 15% of respondents did not know. Also the majority of the respondents (65%) said they would seek help from the implementing organization if the filter was broken or not working (Liang, 2010). This calls into question the sustainability of such a heavily subsidised model of programme implementation.

In Ethiopia, the Kale Heywet Church has distributed around 8,000 filters using a supply driven model. Earwalker (2006) examined 57 households from three villages to assess filter performance, maintenance practices, user perceptions and the supporting environment. The results showed varied levels of usage in each village from 44% to 100%. The working filters showed an average E.coli reduction rate of 87.9% with 75.7 % of filtrate samples achieving E.coli rates of <10cfu/100ml and 81.2% achieving turbidity values of <5TU. The poor performance BSF and low usage rates in some villages was attributed to the lack of support provided to BSF users, the lack of reinforcement of educational messages, and the resulting poor maintenance. The study also found the subsidised model of adoption used by the implementing agency resulted in doubt over the continued adoption of the BSF. It was concluded that without the clear definition of an exit strategy, most likely including at least some commercialisation, the benefits gained by current users seem unlikely to extend to others in Ethiopia.

***Demand-Led BSF Implementation Model***

A ‘demand-led’ implementation model requires an assessment of the local enabling environment including; an understanding of access to capital and markets for suppliers of BSF; purchasing power of households; and the support mechanisms and motivators that encourage correct and consistent use of BSF. In the demand-led model BSF often fail to reach the poorest households, which are also in many situations the households that have the least access to improved water supplies (Rosa and Clasen, 2010).

Many in the development community advocate against providing BSF for free, citing lack of ownership and reduced incentives to use and maintain BSF (WHO, 2011b), and Harris (2005) considers that the adoption of the ‘demand led’ commercial approach has been proven to be highly successful in recovering the production costs of the BSF products themselves. The demand-led model of implementation should lead to sustainability; however there are few documented examples of demand-led BSF programmes to support this assumption (WHO, 2011b:6). Only one example of a ‘demand led’, full cost recovery commercialised implementation approach was discovered during this literature review and is summarised below:

Fewster et al. (2004) describes a demand led full cost-recovery model of BSF implementation in Kenya. After an NGO supported one-year biosand filter project had finished at the end of 2000, the BSF manufacturers trained by the NGO continued to produce filters and established a small commercial enterprise, which sold more than 2000 filters in its first four years. The BSF manufacturers produced each BSF for US$10 and sold at a retail price of US$22, yielding a significant 220% profit. The Fewster et al. (2004) follow-up study of 51 household-based biosand filters purchased 4 years earlier found mean reductions of faecal coliforms of 98% for 70.6% of the filters (reduction from 462 cfu/100ml to <10 cfu/100ml); a further 23.5% of the BSF improved the water quality but still produced water with >10 cfu/100ml. In terms of user perceptions; 97% of respondents who had purchased their filters four years earlier, stated that they were “generally satisfied” with the filters; all 51 respondents stated that the BSF had been a “worthwhile” purchase; and only one family had stopped using the filter.

### 2.4.8. Applicability of BSF in Disaster Response

The majority of research on BSF has occurred in development and not disaster response situations, and it is questionable whether BSF results from development settings are relevant in disaster settings. The differences in implementing principles between humanitarian organisations with a ‘life saving’ mandate and development organisations with a ‘poverty reduction’ mandate can have a significant impact on projects. There are also health differences between disaster and development contexts. Disasters generally have higher rates of crude mortality; a higher likelihood of epidemics due to population movement and concentration in camps; and a higher level of funding which can affect the decision for which WASH intervention to select (Lantagne, 2009).

However, there is clearly a role for household water treatment (HWT), including BSF, in disaster response, and especially in long term complex emergencies, and that is why HWT is now specifically mentioned as an intervention option for disaster response in the 2011 edition of Sphere (Sphere, 2011). But the relative appropriateness of BSF will differ with different types of disaster and during different phases of disaster response (Lantagne, 2009).

After the 2004 Tsunami, an evaluation of HWT in India, Sri Lanka and Indonesia was conducted by Clasen and Smith (2005). It was reported that during the relief phase, small numbers of ceramic filters were distributed for point of use water treatment, and BSF was not used until the rehabilitation phase. The conclusions from the Clasen and Smith (2005) report highlight the need for appropriate assessment prior to commencement of HWT projects, and that HWT options may not be appropriate during early phases of disaster relief. It was recommended by Clasen and Smith (2005) that further evaluation of HWT interventions during disaster response be conducted to clarify the conditions under which proven approaches to HWT may be useful in disaster response. Following the Tsunami, in response to the significant interest in using HWT during disaster response, the World Health Organization issued a fact sheet to provide an overview of the options for water treatment during disaster response, and some information on how to use the various products (WHO, 2005). Later work by Lantagne (2009:74) concluded that HWT interventions are not normally effective during the early stages of natural disaster relief, unless the affected population has a history of using a particular HWT solution before the disaster. However they can be effective in protracted complex emergencies.

The Clasen and Smith (2005) report, and a subsequent report by Lantagne (2009) highlight that there is relatively little published evidence regarding use of HWT in emergencies, and even less specifically concerning the use of BSF in emergencies. During this literature review, only one piece of published literature and a small amount of grey literature was found regarding use of BSF in complex emergencies, and is summarised below.

Lantagne (2011) documents the use of BSF after the January 2010 Haiti earthquake. After the magnitude 7.0 earthquake, an estimated 222,517 people died and 310,928 were injured and an estimated 3 million people were affected by the earthquake (OCHA, 2010). Before the earthquake, numerous HWT products were promoted in Haiti, including BSF. Over the seven years preceding the earthquake, one Haitian based NGO (Clean Water for Haiti) had distributed about 11,000 BSF at a subsidised price through a network of community volunteers, who also provide operation and maintenance training. Within six weeks after the earthquake, they had distributed, free of charge, a further 238 filters through the community volunteers in Port-au-Prince. A survey was undertaken during March 2010 of 51 households who had received a BSF after the earthquake. Of those surveyed 90.2% reported that they were still regularly using the BSF as their primary water treatment method, which is a reasonable rate of adoption, but does not prove that this will translate into sustained use. Only 58% of the filtered water samples were found to be below 10cfu/100ml, which brings into question the effectiveness of the programme.

Fletcher (2008) documents a Tearfund BSF programme in Eastern DRC. The programme started in 2005 with 100 BSF built by NGO staff, at a cost of US$82 each, and distributed to beneficiaries in Uvira who contributed US$3 towards the cost. After an initial positive uptake, the NGO produced and distributed a further 200 filters in 2006, and then the project was expanded south into Fizi territory, where local associations were trained to produce a further 720 filters. An evaluation in 2008 found a high level of filter use observed in communities collecting water from Lake Tanganyika and communities situated close to large rivers. In most other locations, and where gravity fed water schemes had been constructed, the BSF was poorly used. At the time of the evaluation approximately 60% of BSF were being used, and of the filters in use only 45% of these BSF had below 10 cfu/100ml. Of the sub-sample that used their BSF daily only 18% had more than 10 cfu/100ml. Of those that did not use their BSF daily, 95% had more than 10 cfu/100ml, which indicates that lack of daily use was preventing the schmutzdecke from maturing effectively. The evaluation also considered why filters were not being used and not producing potable water. In several villages, the filters had fallen into disuse because an alternative water system had been installed. While users in Malinde, Swima and Sanja stopped using their BSF because the source water was highly turbid, and the filters had become blocked. A number of BSF in Uvira had fallen into disuse because of cracking and leaks due to poor construction. Some beneficiaries complained that they smelt something bad in the filtered water and so they stopped using their filters, this was due to infrequent use of the filter resulting in anaerobic conditions within the filter. This problem was wide spread in Lusenda, leading to rejection of all 45 filters. The projects were funded through humanitarian mechanisms and due to tight (12 month) project funding timeframes and delays with procurement, filter production was often rushed, and delivery of the filters to the beneficiary households, was often in the closing days of the project. Many of the problems identified were as a result of the short project timeframe, which resulted in lack of adequate training for BSF manufacturers in construction techniques, and lack of training for BSF users in operation and maintenance procedures.

#### 2.4.9. BSF Monitoring and Evaluation Frameworks and Indicators

Household water treatment and safe storage (HWTS) is one specific public health improvement strategy that is increasingly called upon to justify and better strategize further investments for achieving wide-spread, sustainable use among vulnerable populations (WHO, 2011b:1). The growing demand for accountability and pressures to verify program outputs and impacts in the public health and WASH sectors are driving forces behind obtaining reliable evidence on BSF programs (WHO, 2011b:2).

The evaluation framework for assessing the effectiveness of a BSF programme should consider the following aspects (Waddington et al, 2009):

1. Market Study: The study should answer the question, is BSF appropriate and are materials locally available? The study should consider hardware availability and supply chain (eg. Cement, gravel, sand, steel) and software (eg. User preferences, demand, social marketing, hygiene promotion)
2. Outputs and Outcomes: BSF functionality, knowledge transfer and desire to use. The study should observe the that the BSF is being used and functioning correctly, and test beneficiary knowledge about correct operations and maintenance, together with water quality testing.
3. Impacts: Social, Health, Technical, Economic, Financial, Institutional, Environmental. Impacts may be assessed through various means including self reported diarrhoea, anthropometrics (weight, height, etc), clinical diagnosis, change in assets or income, livelihood development and business growth, increased demand for filters, change in school attendance or cognitive ability, change in environment.

While measuring impact may require research methods beyond what is practical to many BSF implementers, measuring outputs and even outcomes is, in many cases, feasible. Outputs provide a direct reflection the amount resources that are invested while outcomes provide more detailed information on how these resources were utilized and the potential for impact. Positive outputs and outcomes, such as improved drinking water quality, are necessary for achieving realizing positive programmatic impacts. However, outcomes alone are not sufficient to associate BSF with health and socio-economic impacts (WHO, 2011b:7).

Measuring the consistent use of BSF and consumption of treated water over time is important for assessing sustainability. Although there is no specific "rule" for a length of an evaluation, measuring use at intervals (4-6 months) over several years (2-5) would greatly improve upon data collected over shorter-periods or only in one instance. Longitudinal data would also help determine "trigger" points that lead to increased or decreased use. For example, households may only treat water during the rainy season when there is a real or perceived risk of microbial drinking water contamination and diarrheal disease. Or households may only treat water for the few weeks or months following the harvest when they are more likely to have expendable income and/or time to engage in water treatment activities. Investigating the underlying factors that drive BSF use will inform more effective program implementation (WHO, 2011b:18).

### 2.5. Knowledge Gaps

The literature review demonstrates that BSF can be an efficient and sustainable form of household water treatment. There is a growing evidence base to support the use of BSF in some development contexts, and to support the use of demand-led programming approaches for increased likelihood of sustainability. It is recognised that BSF may not be an appropriate solution in the immediate aftermath of a rapid onset natural disaster, unless the population has a previous history of using BSF to treat their water. There is also recognition that in long term complex emergencies point of use household water treatment solutions are preferable over large scale centralised water supply and treatment systems that may be vulnerable to attack or fall into disrepair. However there is a significant gap in knowledge when it comes to understanding the performance of BSF in complex emergency setting. While there is some documented evidence of the use of BSF after acute natural disasters, only one piece of published literature was found to document the use of BSF during complex emergencies.

More specifically the gaps in knowledge relate to the following issues, identified by Lantagne (2009):

1) There is a lack of documentation about how organizations select BSF as an intervention in disaster response, and what are the key behavioural determinants for adoption of BSF after a disaster, as compared to development determinants;

2) There are a lack of published BSF project evaluations to measure programme effectiveness, and understand the benefits, drawbacks, and appropriateness of BSF use in disaster response;
3) There is a lack of knowledge around sustainability, and whether use of BSF in disaster response stimulates long-term uptake of the technology in the post-disaster situation, together with understanding what motivates users to purchase and use a BSF, and how rates of sustained BSF use correlate with waterborne disease prevalence.

Therefore, a main result from the investigations documented in this literature review is that additional research on BSF in emergencies and especially complex emergencies is needed. The following research will attempt to build the body of knowledge by evaluating the effectiveness and sustainable impact of a demand-led BSF programme in the complex emergency context of Afghanistan.

# 3. Field Study Methodology

## 3.1. Overview

Following the literature review, a field survey of a BSF programme in Afghanistan was conducted by the researcher during the month of August 2011. The field survey targeted communities where Tearfund has implemented demand-led, livelihoods based BSF interventions in the provinces of Kapisa and Jawzjan.

The field survey, which comprised both quantitative and qualitative data gathering methods, aimed answer the research questions and gather detailed data about the effectiveness, impact and sustainability of a specific BSF programme in a complex emergency setting. In particular the field survey aimed to:

1. Investigate the technical performance of the BSFs, considering effectiveness of filtration, quality of BSF construction and installation, and user knowledge about operation and maintenance procedures. Data was gathered through household surveys / observations, water sampling and quality testing, village level focus group discussions, and key informant interviews.
2. Examine the user perceptions of the impacts of the BSF on their well-being, considering user perception of BSF contribution to improved quality of life, self reported rates of diarrhoea and whether BSF users promoted the product to no-users. Data was gathered through household surveys / observations and village level focus group discussions.
3. Investigate whether sufficient demand for the BSF had been created for sustainability, considering rate of adoption, rate of sustained use, ability to pay, willingness to pay, BSF coverage trends, demand assessment, and assessment of delivery model, and opinions from BSF manufacturers about sustainability of their livelihoods. Data was gathered through interviews with BSF manufacturers, village level focus group discussions, household surveys and key informant interviews.

## 3.2. Sampling Methodology

Tearfund provided a list with the names of all villages that had been targeted with the BSF programme from 2008 – 2011. Villages deemed inaccessible due to security risks or logistical constraints were then removed from the list. Two villages from each province (Jawzjan and Kapisa) were then randomly selected from the villages remaining on the list. The villages selected were Shehraz and Yandagh in Jawzjan, and Bako Kham and Khamzerger in Kapisa.

Within each village households were divided into three sub-groups; 1) Those most vulnerable households who had received a BSF through the Tearfund free distribution programme; 2) those households who had purchased a BSF; 3) those households who had no BSF. Each enumerator started from a central point in the village and chose a direction at random. Each household along the route was surveyed, if for some reason no one was at home and available for questioning, then the house was skipped. It was endeavoured to survey a representative sample from each sub category, by setting a quota for each sub-category and then skipping houses once the quota had been reached. In each village the enumerators were accompanied by a member of the CDC who was able to assist by directing us to households from each sub-group. Enumerators were able to locate and survey between 14 – 17 households within each village in the time available (Refer Table 3.1).

**Table 3.1: Number of Households Surveyed in Each Village**

| Province | Village | Total Number of Households | Number of Households Surveyed | Sample size |
|---|---|---|---|---|
| Jawzjan | Shehraz | 435 | 15 | 3.4% |
| Jawzjan | Yandagh | 205 | 16 | 7.8% |
| Kapisa | Bako Kham | 400 | 17 | 4.3% |
| Kapisa | Khamzerger | 270 | 14 | 5.2% |
| Total Number of Households Surveyed | | | 62 | |

Two biosand filter manufacturers were also selected from each province for interview. These technicians were selected based on availability at the time of the field survey. A third Biosand filter manufacturer was also interviewed in Kapisa, because he happened to be in Khamzerger Village and available at the time of the survey.

## 3.3. Quantitative Data Collection Methods

The quantitative research methods included household questionnaires (structured interviews), observation checklists, and water quality testing. The methods are summarised below and the detailed questionnaires, checklists and results are included in the Appendices.

### 3.3.1. Questionnaires, Observation Checklists and Water Sampling

Structured interviews using household survey questionnaires were selected so that data gathered could be easily compared and analysed. The questionnaires were pre-tested prior to use during the enumerator training on 11 August 2011, and changes completed the same day.  Two other enumerators were trained to work alongside the researcher, together with translators.  The household surveys were carried out over the period 12 – 21 August 2011.

At each house observation checklists were also completed, which allowed for rapid data collection without respondent bias and allowed for triangulation of data obtained via other methods.

Water samples were collected from the water sources and filtered water samples from each operating BSF. Source water samples were taken directly from the source, or from containers recently filled with source water.  Filtered water samples were taken directly from the BSF, after water had been allowed to flow for at least 1 minute.

Refer to Appendix 3 for the household questionnaire and observation checklist, and refer to Appendix 4 for a summary of the results.

## 3.4. Qualitative Data Collection Methods

The qualitative research methods included; key informant interviews; and focus group discussions. Both the key informant interviews and the focus group discussions took a semi-structured approach to elicit in depth responses allowing the possibility of bringing in a breadth of information to enable wide understanding of the surrounding issues. The methods are summarised below and the interview questionnaires are included in the Appendices.

### 3.4.1. Key Informant Interviews

Key informant interviews conducted with relevant stakeholders, including Mr Adane Bekele, WASH Specialist UNICEF (Kabul), Eng. Ghulam Qader, Programme Manager, Rural Water Supply, Sanitation and Irrigation Programme, Ministry of Rural Rehabilitation and Development (Kabul), Dereje Alemu Deneke, Tearfund WASH Advisor (Kabul),  and five Biosand Filter manufacturers (Khan Agha, Mustafa, Jawad, Osta Torson, Muhamad Murad) provided insights into particular aspects of the BSF programme in the complex emergency context.

Refer to Appendix 2 for the interview questions, and refer to Appendix 5 for a summary of the interviews.

### 3.4.2. Focus Group Discussions

Focus group discussions were undertaken with each village CDC and elders, and with a combined group of CDC leaders in Jawzjan, to gain a broad understanding of the context and issues in each village.

Refer to Appendix 2 for the interview questions, and refer to Appendix 6 for a summary of the discussion.

## 3.5. Data Analysis Methodology

### 3.5.1. Water Quality Testing

Water quality testing was carried out using a Del Agua field test kit to determine the following parameters:

- Thermotolerant faecal coliform forming units per 100ml of source and filtered water
- Turbidity of source and filtered water

The Del Agua kit uses the membrane filtration method. Samples were cultured on membrane lauryl sulphate broth and cfu/100ml counted after 18 hours incubation at 44 degrees Celsius to determine the number of thermotolerant faecal coliform forming units present. Blank samples were taken every 15 samples as a control.

Turbidity was measured using the Del Agua turbidity tube to determine NTU for each sample. Where turbidity was less than 5 NTU it was measured with the Wagtech hand-held digital turbidity meter.

Refer to Appendix 4 for a summary of the results.

### 3.5.2. Statistical Data Analysis

All quantitative data was transcribed from the household questionnaires into Microsoft Excel, which was used for statistical analysis. In particular, determination of statistical ranges and percentages for different data sets, determination of arithmetical means, and generation of charts and graphs.

### 3.5.3. Demand Analysis

A number of methods were used to assess demand, affordability and willingness to pay.

***Percentage of Income***

Questions were included in the household questionnaire to determine individual household income and also past and present retail cost for a BSF. From this information the affordability of the BSF was determined by analysing the proportion of household income required to purchase a BSF.

***Revealed Preference***

The revealed preference technique was used to determine what respondents actually paid for their BSF or other water treatment method and to assess individual coping strategies in terms of household water collection, treatment and storage practices. Appropriate questions were included in the household questionnaire, focus group discussions, and key informant interviews, including time taken to collect water, treatment methods, cost of BSF and medical costs associated with water related disease.

***Stated Preference***

The stated preference technique was used to estimate willingness to pay for BSF. A question was included in the household questionnaire which directly asked respondents what they would be willing to pay for a BSF in the future. BSF manufacturers were also directly questioned about customer willingness to pay.

## 3.6. Limitations

Due to limitations of time, security constraints and logistical constraints the number of villages that could be surveyed was determined to be only two in each province. The actual field survey was carried out during August 2011, which also coincided with the Islamic holy month of Ramadan; therefore field work could only be carried out in the mornings from around 8am to 12pm. This further limited the length of time available for key informant interviews, focus group discussions and the number of houses that could be visited in each village.

Each enumerator was accompanied by a local member of the community who helped to identify houses appropriate to be entered for survey. This approach to sampling was not completely randomised and results should be understood in light of this sampling methodology.

Due to the cultural context of Afghanistan, interviews, focus group discussions and data gathering exercises had to be undertaken separately for men and women to ensure that the views and participation of both men and women was facilitated. There was only one female enumerator and one male enumerator together with the male researcher therefore approximately two thirds of the data was obtained from male respondents with only one third from female respondents. This is likely to introduce some element of bias.

Translators were employed during the field data gathering exercise. There is the possibility that some accuracy and completeness of data may have been lost in translation. The small bias that this may have introduced was minimised by comprehensively training the translators before the field work, and asking them to provide a full translation rather than paraphrasing answers.

Respondents tend to be polite when answering questions, so they are likely to give answers that are positive about the implementing NGO and its programme. This is likely to introduce some ‘courtesy bias’.

The measured water quality improvement from the source to the filtered water assumes a direct relationship between the source water and the filtered water. However the BSF operates by the new intake of water pushing the existing water retained in the filter through to the outlet. Thus where water is not consistently taken from the same source there may not be a direct correlation between the source water tested and the filtered water quality. This inaccuracy was minimised by asking the beneficiaries if the source water was consistent and noting where it was not.

The filtered water samples were taken directly from the spout of each BSF. There is still potential for contamination of the water prior to consumption due to poor hygiene and household water management. This study has not critically examined the processes of water management after BSF filtration up to the point of consumption. Therefore conclusions drawn from this study are not definitive on the quality of water consumed by the users, but only on the potential benefits to water quality provided by the BSF.

# 4. Field Study Results

## 4.1. Field Study Site Description and Demographics

Four villages were selected for the field study, two from Jawzjan province (Shehraz and Yandagh) and two from Kapisa province (Bako Kham and Khamzerger). A site description of each village together with a summary of demographics is presented below.

### 4.1.1. Jawzjan

***Shehraz*** is situated in Mangagik District, Jawzjan Province, about 2 hours drive from Mazar e Sharif in Northern Afghanistan, on an extensive area of flat, semi-arid land. Water is accessed from the irrigation canals and reservoirs during the wet season and from shallow open wells during the dry season. Most houses are situated within 15 minutes walk of the canal and a well. During the time of the field survey a drought was being experienced in the area, hence the canals were not flowing, and all shallow wells close to the village were considered unpotable due to high total dissolved solids (TDS) and turbidity. All households were travelling long distances (5 – 8 hours) to collect water from neighbouring villages which had borewells accessing deeper aquifers.

The Tearfund BSF programme in Shehraz covered the period Sep 2009 – Sep 2010. The village has 435 households, with an average of 10.6 persons per household. Most had lived in the area on average for 25 years.

***Yandagh*** is situated in Acha District, Jawzjan Province, about 2 hours drive from Mazar e Sharif in Northern Afghanistan, on an extensive area of flat, semi-arid land. Water is accessed from the irrigation canals and reservoirs during the wet season and from handpump wells during the dry season. Most houses are situated within 15 minutes walk of the canal and a handpump well. During the time of the field survey a drought was being experienced in the area, hence the canals were not flowing, and all households were collecting water from local handpump wells.

The Tearfund BSF programme in Yandagh covered the period Sep 2009 – Sep 2010. The village has 205 households, with an average of 16.4 persons per household. Most had lived in the area on average for 30 years.

### 4.1.2. Kapisa

***Bako Kham*** is situated in Kohistan District, Kapisa Province, about 2 hours drive north of Kabul. It is situated on the lowlands on a main road, water is accessed from a stream that passes through the village, and from numerous canals that divert water from the stream and channel it through the village. Most houses are situated either next to a canal or have a canal running through their compound. Most householders indicated that they collected water from the main stream because it was considered cleaner and that the side canals were used for washing and wastewater disposal so were considered dirty.

The Tearfund BSF programme in Bako Kham covered the period Sep 2008 – Sep 2009. The village has 400 households, with an average of 9.7 persons per household. The average time lived in the area was 19 years, although several had left and returned after the conflict, and three were new residents living there less than 5 years.

***Khamzerger*** is situated in Kohistan District, Kapisa Province, about 2 hours drive north of Kabul. It is situated at the base of a mountain and water is accessed from large canal that passes through the centre of the village. Most houses are situated within five minutes walk of this canal. All householders interviewed said that they collected water from the large canal.

BSF programme in Khamzerger covered the period Sep 2008 – Sep 2009. The village has 270 households, with an average of 11.3 persons per household. The average time lived in the area was 23 years, although several had left and returned after the conflict.

## 4.2. BSF Technical Performance

### 4.2.1. Water Source and Collection

Of the 62 households interviewed, half (50%) collected water from a well, and half (50%) from a canal or stream (refer Table 4.1). All of those collecting from a well were in Jawzjan, and explained that currently they were experiencing a drought and that all surface water sources had dried up. Normally during the wet season they would either collect water directly from a canal, surface reservoir or a local well. Local wells were either shallow open wells or borewells with a handpump.

**Table 4.1 Water Sources in Each Province**

| | Number of Households | | | |
|---|---|---|---|---|
| Water Supply Sources | Jawzjan | Kapisa | Total No. | Total % |
| Well | 31 | | 31 | 50% |
| Canal, river, stream | | 31 | 31 | 50% |
| Total Number of Households | 31 | 31 | 62 | 100% |

The household surveys and focus group discussion indicated that the quality of the source water varied according to season, with water being cleaner and clearer in summer and winter, and being silty during the spring thaw and autumn rains.

In all villages water collection was primarily a job for the young boys, with water normally collected in plastic jerry cans and transported manually or using donkey's, bicycles or motor cycles where available. In some villages men, women, and girls were also observed to be collecting water. The round trip time to collect water in each village is shown in Table 4.2. All those taking greater than 30 minutes were in Jawzjan due to the drought being experienced in this province. All wells with potable water in Shehraz had dried up and all households surveyed were travelling long distances (5 – 8 hours) to collect water from neighbouring villages which had borewells accessing deeper aquifers.

**Table 4.2: Round Trip Time to Collect Water**

| Round Trip Time to Collect Water | Number of Households | | | | | |
|---|---|---|---|---|---|---|
| | Jawzjan | | Kapisa | | TOTAL | |
| | Shehraz | Yandagh | Bako Kham | Khamzerger | No. | % |
| 0 – 5 minutes | 0 | 6 | 14 | 8 | 28 | 45% |
| 6 – 15 minutes | 0 | 6 | 3 | 5 | 14 | 23% |
| 16 – 30 minutes | 0 | 1 | 0 | 1 | 2 | 3% |
| 30+ minutes | 15 | 3 | 0 | 0 | 3 | 29% |
| Total No. Households | 15 | 16 | 17 | 14 | 62 | 100% |

Of the 47 households surveyed that owned a BSF the majority (60%) reported treating 20-40 litres on a daily basis as shown in Table 4.3.

**Table 4.3: Volume of Water Treated by BSF on Daily Basis**

| Volume of Water Treated by BSF on Daily Basis | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| 0 – 20 litres | 5 | 3 | 8 | 17% |
| 20 – 40 litres | 11 | 17 | 28 | 60% |
| 40 + litres | 9 | 2 | 11 | 23% |
| Total Number of Households | 25 | 22 | 47 | 100% |

### 4.2.2. Water Quality

Table 4.4 shows the results from the water quality analysis. Water samples were collected from each source and from each operating BSF filter, 45 in total. The water sources for Shehraz village in Jawzjan were generally highly turbid with an average NTU of 109.5, the other villages had very low turbidity in their water sources (<5NTU), however it was noted during the focus group discussions that the source water turbidity increased for all villages during the spring thaw and after heavy rainfall.

The only water source for Khamzerger was a stream that flowed through the village. Testing indicated that this water was highly contaminated with cfu/100ml ranging from 240 to 290. The other three villages had less contaminated water sources (wells, canals) with some samples tested, as low as 1-9 cfu/100ml and averaging around 65cfu/100ml.

After filtration the water quality was improved in all samples tested. Turbidity results were all below NTU 5, and in some cases cfu/100ml was zero, but generally averaged less than 10cfu/100ml, except for Khamzerger where the filtered water samples averaged 34cfu/100ml. It should be noted that Khamzerger also had a higher level of contamination in the source water, and the BSF manufacturer normally resident in this village had been absent in Iran for the past two years and had therefore not been available for maintenance of the filters.

**Table 4.4: Water Quality Test Results**

| Water Quality Parameter | Jawzjan | | Kapisa | |
|---|---|---|---|---|
| | Shehraz | Yandagh | Bako Kham | Khamzerger |
| Source Water Turbidity (NTU) | Average: 109.5 | Average: <5 | Average: <5 | Average: <5 |
| Source Water cfu/100ml | Average: 66.4 Range:7-221 | Average:113.4 Range:9-260 | Average:63.5 Range:1-180 | Average:271.8 Range:240-290 |
| | | | | |
| Filtered Water Turbidity (NTU) | Average: <5 | Average:<5 | Average:<5 | Average:<5 |
| Filtered Water cfu/100ml | Average3.2 Range:0-8 | Average:13.3 Range:0-99 | Average:7.2 Range:0-45 | Average:34 Range:4-99 |

### 4.2.3. Construction and Installation Quality

Six specific observations were made of components of the filter in order to determine if the filter was correctly constructed, and installed. The results from the 47 households that owned a BSF, and 45 households with an operating BSF are summarised in Table 4.5.

**Table 4.5: BSF Construction and Installation Quality Observations**

| | Number of BSF Complying | | | |
|---|---|---|---|---|
| Observed Parameter | Jawzjan | Kapisa | Total No. | Total % |
| There are no leaks on the concrete filter body. | 25 | 22 | 47 | 100% |
| Lid is in place and covers top of filter | 25 | 21 | 46 | 98% |
| Original diffuser plate is in place and undamaged | 24 | 19 | 43 | 92% |
| Filter is in a suitable location away from weather | 15 | 12 | 27 | 57% |
| Depth of the water above the sand is between 4 and 6 cm | 12 | 13 | 25 | 53% |
| The flow rate of the filter is less than 0.4 litres/minute | 17 | 16 | 33 | 70% |

### 4.2.4. Operation and Maintenance

Six specific observations were made of components of the filter in order to assist with determining if the filter was correctly operated and maintained. The results from the 45 households with operating BSF are summarised in Table 4.6.

**Table4.6: Operation and Maintenance Observations**

| Observed Parameter | Number of BSF Complying | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| There is no valve or tube attached to the outlet of the filter | 22 | 21 | 23 | 91% |
| The outlet spout of the filter is clean | 23 | 22 | 25 | 96% |
| The treated water storage container has a lid | 20 | 17 | 37 | 79% |
| The storage container has a narrow opening | 22 | 19 | 41 | 87% |
| The storage container appears clean | 22 | 21 | 43 | 91% |
| The user has different containers for collecting and storing water | 19 | 22 | 41 | 87% |
| Total Number of Households with Operating BSF | 23 | 22 | 45 | 100% |

In most households (76%) it is a man who is responsible for cleaning the filter although sometimes the woman (22%) or older girl/boy (2%) is responsible. When asked how the users learnt about the correct operation and maintenance methods, responses as shown in Table 4.7 were given.

**Table 4.7: Source of BSF Operation and Maintenance Training**

| Source of BSF Operation and Maintenance Training | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| Training by Tearfund | 21 | 14 | 35 | 75% |
| Training by BSF Technician | 2 | 8 | 10 | 21% |
| None | 2 | 0 | 2 | 4% |
| Number of Households with BSF | 25 | 22 | 47 | 100% |

Tearfund taught the CAWST (2009) 'Swirl and Dump' method of BSF maintenance, however when asked to describe or demonstrate the maintenance method used, a range of responses were given, as shown in Table 4.8.

**Table 4.8: Methods for Cleaning the BSF**

| Method Used for Cleaning BSF | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| Swirl and Dump | 7 | 17 | 24 | 51% |
| Sand Removal | 8 | 0 | 8 | 17% |
| Either could not, or description was incorrect | 4 | 2 | 6 | 13% |
| Person responsible for cleaning not available | 6 | 3 | 9 | 19% |
| Number of Households with BSF | 25 | 22 | 47 | 100% |

When asked about frequency of cleaning, most respondents (79%) indicated that they were prompted to clean the filter when the flow rate reduced to a low rate; however some respondents mentioned that they cleaned the filter after a specified period of time. Details of the survey responses are shown in Table 4.9.

**Table 4.9: Frequency of Cleaning BSF**

| Reason for Cleaning Filter | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| Filter is not working / water is flowing slowly | 16 | 21 | 37 | 79% |
| The filter appears dirty | 5 | 1 | 6 | 13% |
| Every 10 days | 2 | 0 | 2 | 4% |
| Every 20 days | 1 | 0 | 1 | 2% |
| Every 1-2 months | 1 | 0 | 1 | 2% |
| Number of Households with BSF | 25 | 22 | 47 | 100% |

## 4.3. User Perceptions of BSF Impacts

### 4.3.1. Contribution to Improved Quality of Life

Both those with BSF and those without BSF were asked what they perceived to be the benefits or impacts of the BSF. For both groups the most common answer was improved health with the next the most common answer being financial savings, with many specifically stating saving on doctors bills and medication costs as a result of reduced water related sickness. The results are summarised in Table 4.10.

**Table 4.10: Perceived Benefits/Impacts of BSF Use**

| Perceived Benefits/Impacts of BSF Use | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| ***For Those with BSF in House*** | | | | |
| Improved Health | 24 | 20 | 44 | 94% |
| Save Money | 17 | 16 | 33 | 70% |
| Save Time | 7 | 1 | 8 | 17% |
| Improved Taste of Water | 1 | 0 | 1 | 2% |
| Number of Households with BSF | 25 | 22 | 47 | 100% |
| ***For Those without BSF in House*** | | | | |
| Improved Health | 6 | 9 | 15 | 100% |
| Save Money | 1 | 6 | 7 | 47% |
| Number of Households without BSF | 6 | 9 | 15 | 100% |

### 4.3.2. Self Reported Rates of Diarrhoea

Respondents were also asked to report the number of people within the household, both adults and children, who had diarrhoea in the past two weeks. The results are summarised in Table 4.11.

**Table 4.11: Self Reported Rates of Diarrhoea**

| Number of people within household who had diarrhoea in the past 2 weeks | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| ***Those with Operating BSF in House*** | | | | |
| ***Average Number of cases of Diarrhoea*** | ***0.12*** | ***0.41*** | ***0.26*** | |
| 0 cases of diarrhoea | 20 | 18 | 38 | 84% |
| 1 case of diarrhoea | 3 | 2 | 5 | 11% |
| 3 cases of diarrhoea | 0 | 1 | 1 | 2% |
| 4 cases of diarrhoea | 0 | 1 | 1 | 2% |
| Number of Houses with operating BSF | 23 | 22 | 45 | 100% |
| ***Those without Operating BSF in House*** | | | | |
| ***Average Number of cases of Diarrhoea*** | ***2.0*** | ***3.2*** | ***2.7*** | |
| 0 cases of diarrhoea | 3 | 2 | 5 | 29% |
| 1 case of diarrhoea | 1 | 3 | 4 | 24% |
| 2 cases of diarrhoea | 1 | 0 | 1 | 6% |
| 3 cases of diarrhoea | 3 | 0 | 3 | 18% |
| 4 cases of diarrhoea | 0 | 2 | 2 | 12% |
| 8 case of diarrhoea | 0 | 1 | 1 | 6% |
| 10 cases of diarrhoea | 0 | 1 | 1 | 6% |
| Number of Houses without operating BSF | 8 | 9 | 17 | 100% |

## 4.4. BSF Demand Assessment

### 4.4.1. Rate of Adoption and Sustained Use

All households surveyed had owned their filter for more than six months, most households had owned their filter for between one and two years (57%), a small number (15%) had owned the filter for more than two years, as detailed in Table 4.12.

**Table 4.12: Duration of BSF Ownership**

| Duration of BSF Ownership | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| 6 – 12 months | 13 | 0 | 13 | 28% |
| 12 – 24 months | 12 | 15 | 27 | 57% |
| More than 24 months | 0 | 7 | 7 | 15% |
| Number of Households with BSF | 25 | 22 | 47 | 100% |

Table 4.13 shows that when asked whether they had used the BSF today, overall 91% responded in the affirmative. On further questioning why they had not used their filter, one stated that it was broken; one stated that they did not use the filter during the dry season, and two others stated that they used the filter regularly but had not used it that day. Observation of the filters indicated that out of the 47 filters surveyed, 45 were in regular use. In addition 100% of the existing BSF users stated that they have recommended the BSF to other non users.

**Table 4.13: Rate of Sustained BSF Use**

| Did you use the biosand filter to treat water today? | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| Yes | 22 | 21 | 43 | 91% |
| No | 3 | 1 | 4 | 9% |
| Number of Households with BSF | 25 | 22 | 47 | 100% |

### 4.4.2. Ability and Willingness to Pay

#### *Production Cost and Retail Price*

Interviews with the BSF manufacturers revealed that the production cost and base retail rate for a BSF was slightly higher in Jawzjan when compared to Kapisa. Table 4.14 shows the range of costs for each province. Additional costs may be involved in transportation and installation of the BSF if the location is distant from the manufacturer. One BSF manufacturer stated that he had sold a few filters to upper income earners for as much as 1200AFN (US$27.90)

**Table 4.14: BSF Production Cost and Current Regular Retail Price (Based on BSF Manufacturer Interviews)**

| Parameter | Jawzjan | Kapisa |
|---|---|---|
| Historic Production costs for BSF, 2008 - 2009 | 530AFN (US$12.30) | 450 – 500AFN (US$10.50 – 11.60) |
| Current Production costs for a BSF, Aug 2011 | 750 AFN (US$17.40) | 600 - 700AFN (US$14.00 – 16.20) |
| Profit Margin | 130 – 250 AFN (US$4.20 – 7.00) | 150 – 400 AFN (US$3.50 – 9.30) |
| Current Regular Retail Price for a BSF, Aug 2011 | 880 – 1000 AFN (US$20.50-23.30) | 750 – 1100AFN (US$17.40-25.60) |

#### *Ability to Pay*

In order to measure ability to pay respondents were asked to report on weekly income levels, the source of their biosand filter and the cost price if they had purchased it. The results are summarised in Table 4.15 and 4.16. Of the 15 households surveyed who had privately purchased a filter, historic purchase prices ranged from 600 – 1200AFN (US$14.00 – 27.90), as shown in Table 4.17. Current regular retail prices at the time of the survey were 750 – 1100AFN (US$17.40 – 25.60).

**Table 4.15: Self Reported Weekly Income Levels**

| Weekly household income | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| 0 - 999AFN (USD0.00 – 23.23) | 22 | 6 | 28 | 45% |
| 1,000 – 1,999AFN (USD23.23 – 46.48) | 6 | 19 | 25 | 40% |
| More than 2,000AFN (>USD$46.48) | 3 | 6 | 9 | 15% |
| Average Weekly Income (Based on Stated Income Amounts): | US$30.50pw | UW$40.10pw | US$35.30pw | |

**Table 4.16: Source of BSF Filter**

| Source of filter | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| Distributed by Tearfund (free) | 19 | 13 | 32 | 52% |
| Privately-purchased (BSF Manufacturer) | 6 | 9 | 15 | 24% |
| No filter | 6 | 9 | 15 | 24% |
| Number of Households | 31 | 31 | 62 | 100% |

**Table 4.17: BSF Historic Purchase Price (Based on Household Survey Results)**

| BSF Purchase Price | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| 1200AFN (USD27.90) | 0 | 1 | 1 | 7% |
| 1100AFN (USD25.60) | 1 | 0 | 1 | 7% |
| 1000AFN (USD23.30) | 1 | 0 | 1 | 7% |
| 900AFN (USD20.90) | 1 | 0 | 1 | 7% |
| 800AFN (USD18.60) | 2 | 3 | 5 | 33% |
| 750AFN (USD17.40) | 0 | 2 | 2 | 13% |
| 700AFN (USD16.20) | 0 | 1 | 1 | 7% |
| 600AFN (USD14.00) | 1 | 2 | 3 | 20% |
| Average Purchase Price: | US$20.20 | US$18.10 | US$19.00 | |

### *Willingness to Pay*

In order to measure willingness to pay, respondents were asked to report on how much they would be willing to pay to purchase a BSF in the future. Of the 15 households surveyed that had no BSF, 100% stated that they would like to buy a filter. When asked what they would be willing to pay for a BSF the answers ranged from zero to 1000AFN (US$23.30), with an average of US$9.60. Of the 32 vulnerable households surveyed, who had received a filter at no cost from Tearfund, when asked what they would be willing to pay for a filter now the answers ranged from zero to 1000AFN (US$23), as shown in Table 4.18a and 4.18b.

**Table 4.18a: Willingness to Pay**

| How much would you be willing to pay if you were to buy a BSF in the future? | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| ***For Those Without BSF*** | | | | |
| 1000AFN (USD23.30) | 0 | 1 | 1 | 7% |
| 500AFN (USD11.60) | 0 | 3 | 3 | 20% |
| 400AFN (USD9.30) | 5 | 1 | 6 | 40% |
| 50AFN (USD1.20) | 1 | 0 | 1 | 7% |
| 0 | 0 | 1 | 1 | 7% |
| Would not specify | 0 | 3 | 3 | 20% |
| Average | US$8.00 | US$11.20 | US$9.60 | |

**Table 4.18b: Willingness to Pay**

| How much would you be willing to pay if you were to buy a BSF in the future? | Number of Households | | | |
|---|---|---|---|---|
| | Jawzjan | Kapisa | Total No. | Total % |
| ***For Those with BSF Distributed Free By Tearfund*** | | | | |
| 1000AFN (USD23.30) | 2 | 4 | 6 | 19% |
| 700AFN (USD16.20) | 0 | 1 | 1 | 3% |
| 600AFN (USD14.00) | 0 | 1 | 1 | 3% |
| 500AFN (USD11.60) | 0 | 7 | 7 | 22% |
| 400AFN (USD9.30) | 6 | 0 | 6 | 19% |
| 300AFN (USD7.00) | 6 | 0 | 6 | 19% |
| 200AFN (USD4.70) | 3 | 0 | 3 | 9% |
| 0AFN (USD0.00) | 2 | 0 | 2 | 6% |
| Average: | US$8.30 | US$15.70 | US$11.30 | |

When questioned about why they had not purchased a BSF, 73% stated that cost was a barrier and 27% said that it was the responsibility of their husband to do the shopping and that either, they did not have time, or did not see a BSF as a priority. In Jawzjan, many of those interviewed said that what they would be willing to pay was directly related to how good the harvest was.

### 4.4.3. BSF Coverage

Focus group discussions at each village resulted in the following information about BSF coverage, summarised in Table 4.19.

**Table 4.19: BSF Coverage**

| Province | Village | Total Number of Households | Time Period | No BSF | BSF Distributed By TF | BSF Purchased Privately | Total BSF Coverage |
|---|---|---|---|---|---|---|---|
| Jawzjan | Shehraz | 435 | 2 yrs | 359 | 52 | 24 | 17.5% |
| Jawzjan | Yandagh | 205 | 2 yrs | 140 | 53 | 12 | 31.7% |
| Kapisa | Bako Kham | 400 | 3 yrs | 314 | 36 | 50 | 21.5% |
| Kapisa | Khamzerger | 270 | 3 yrs | 199 | 36 | 35 | 26.3% |

### 4.4.4. Sustainability of BSF Delivery Model and Livelihoods for Manufacturers

The BSF manufacturer interviews revealed the following regarding sustainability of the BSF delivery model and their manufacturing businesses, as summarized in Table 4.20.

**Table 4.20: Key Parameters for Determining BSF Manufacturing Business Sustainability**

| Parameter | Jawzjan | Kapisa |
|---|---|---|
| Number of filters sold since TF project | 4000 | 3970 |
| Average Number of Filters sold per year per Manufacturer | 2000 | 660 |
| Profit margin per filter | 130 – 250 AFN (US$3.00 – 5.80) | 150 – 400 AFN (US$3.50 – 9.30) |
| Current demand | Strong | Medium |
| Will you continue this livelihood | Yes as a primary business and main source of income | Only as a sideline business to supplement income |

- All manufacturers were previously working as masons or construction labourers, and welcomed the opportunity to supplement their income through establishment of BSF manufacturing businesses.
- Manufacturers described three types of customers, (1) other UN/NGO Agencies (UNICEF, Save the Children, Mercy Corp), (2) Commercial Companies, (3) Private Individuals.
- Manufacturers in Kapisa relied on orders from UN/NGOs to sustain their primary business, and stated that demand from private individuals alone was only sufficient to sustain BSF manufacture as a sideline business to supplement income from other sources. One manufacturer closed his factory at the end of the Tearfund contract and moved to Iran in search of increased livelihood opportunities. At the time of the survey he had just returned and stated that he will reopen his BSF factory as a sideline business. The other two BSF manufacturers interviewed had sustained their BSF business as a main income source for the past two years with substantial orders from UN/NGOs, and small orders from private individuals.
- Manufacturers in Jawzjan stated that demand was strong from all three sectors, UN/NGOs, commercial companies and private individuals. With this diversified market both BSF manufacturers interviewed were confident that they would continue their BSF business as their primary income source for the foreseeable future. Both BSF manufacturers stated that their income had increased substantially, and they had experienced improved quality of life as a result.

# 5. Analysis and Discussion

## 5.1. BSF Technical Performance

### 5.1.1. Filtered Water Quality

Faecal bacteria (E.coli) contamination is indicated by the number of thermotolerant coliforms in each 100ml water sample measured as colony forming units per 100ml (cfu/100ml). Water quality test results from field samples collected during this study show that BSF in Kapisa up to three years old, and BSF in Jawzjan up to two years old are achieving average water treatment efficiency of 91.7% for E.coli and 83.0% for turbidity. (refer Table 5.1).

**Table 5.1: BSF Filtered Water Quality**

| | Range | Average |
|---|---|---|
| Reduction in E.coli (%) | 66 – 100% | 91.7% |
| Reduction in turbidity (%) | 80 – 99% | 83.0% |

This is within the expected range of effectiveness for a BSF of 90 – 99% removal efficiency for E.Coli (Liang, 2010:3), and compares favourably with the mean reduction of 92% for E.coli recorded in previous field studies summarised in Table 5.2 and detailed in Appendix 1. Turbidity removal was on average 83.0%, which is equivalent to the mean result recorded in past field studies (Table 5.2).

**Table 5.2: Previous BSF Filtered Water Quality Results**

| Parameter | Best result recorded under optimal laboratory conditions | Best result recorded in field conditions | Mean result recorded in field conditions |
|---|---|---|---|
| Reduction in E.coli (%) | 99.9% (Stauber, 2006) | 100% (Buzunis, 1995) | 92% |
| Reduction in Turbidity (%) | 95.5% (Buzunis, 1995) | 85.4% (Duke, 2006) | 83% |

However the water quality test results showed that, 15.5% of the BSFs had E.coli removal rates below 90%, and instead lie within the range of 66 – 87% removal efficiency, which means that a small percentage of the filters are not operating effectively.

As well as percent reduction in E.Coli and turbidity, it is also important to measure the quality of the final filtered water in absolute terms.

For turbidity, the guideline value for drinking water quality for small scale water supplies described by WHO, (2011a:229), is <5NTU. In this field study 100% of the filtered water samples achieved the WHO guideline value of <5NTU.

For E.coli, the guideline value for drinking water quality described by WHO (2011a:149), is zero cfu/100ml.  While Noziac (2010:69) describes a measurement of 1-10cfu/100ml as “low risk”, and measurements of 11-100cfu/100ml are considered “intermediate risk”, 101-1000 cfu/100ml “high risk” and >1000 cfu/100ml “very high risk”.

13.3% of the filtered water samples achieved the WHO guideline value of 0cfu/100ml (WHO, 2011a:149), while 77.7% were in the ‘Good’ to ‘Low Risk’ range of <10cfu/100ml, and 22.2% measured greater than 10cfu/100ml and are considered ‘Intermediate Risk’. Most of those classified as ‘Intermediate Risk’ were from Khamzerger village where the source water was more contaminated.  No samples were measured to be above 100cfu/100ml, as detailed in Table 5.3.

**Table 5.3: Classification of BSF Water Samples Based on cfu/100ml**

| **Quality*** | **Cfu/100ml** | **No. of Samples** | **% Samples** |
|---|---|---|---|
| Good (WHO guideline) | 0 | 6 | 13.3% |
| Low Risk | 1-10 | 29 | 64.4% |
| Intermediate Risk | 11-100 | 10 | 22.2% |
| High Risk | 101-1000 | 0 | 0% |

*(Quality Classifications from WHO, 2011a and Noziac, 2010)

These results compare favourably to other field surveys in more stable development contexts, such as the Earwalker (2006) study in Ethiopia where 75.7% filtrate samples were <10cfu/100ml, and the Liang (2010) study in Cambodia where 61% filtrate samples were <10cfu/100ml.

The fact that 13.3% achieved 0cfu/100 ml and a greater than 99% E.coli removal rate indicates that if well maintained the technology is effective, although there are obviously factors, most likely linked with poor operation and maintenance that are preventing optimal performance for a large number of the filters.

However, even where filters are operating at sub-optimal levels they are still benefiting the users by improving their drinking water quality and thus reducing risk of exposure to disease causing pathogens.

The assessment of filtered water quality raises the question; what issues are causing sub-optimal filter performance and how can these issues be addressed?  The answer to this question may be found by considering the filter construction and installation quality and user understanding of operational maintenance procedures.

### 5.1.2. Construction and Installation Quality

The CAWST (2009) Biosand Filter Manual identifies optimal filter construction and installation quality as follows;

> *"The filter shall be water tight, with correctly graded gravel and sand, fitted with a diffuser box, and levels correctly adjusted to maintain a 5cm level of water over the top surface of the sand".* (CAWST, 2009)

Observations of the BSF (100% without leaks, 98% with lids in place, 92% with diffuser intact) and responses from the households indicated that the construction of the BSF was generally very good, and even after three years; few problems had been encountered by the users, and out of the 47 BSF included in the study only 1 was found to be 'broken'. The high percentage of the filters shown to still be in good condition after two to three years indicates initial excellent build quality.

However a specific problem relating to BSF installation was identified. The problem relates to the incorrect depth of water above the top surface of the sand layer which was noted in 47% of the BSF surveyed. This may be a result of an incorrect volume of sand or as a result of outlet tubing not cut to the correct length. In any case the effect is that the schmutzdecke will either be starved of oxygen if the water depth is too great or at risk of drying or damage if the water depth is not enough. Either way the potential effectiveness of the schmutzdecke to remove harmful pathogens will be reduced.

In addition some BSF (8%) did not have a diffuser box installed, and this will result in disturbance to the upper surface of the sand layer and damage to the schmutzdecke when water is poured into the filter. Protection of the schmutzdecke from unnecessary disturbance is critical for effectiveness of the filters.

A number of the filters were located outside. Given that the survey was conducted during summer this was deemed to be acceptable. Several householders explained that the reason for installing the filter outside was to make more room inside their house, and that during winter they moved the filter back inside. However it should be noted that freezing conditions during winter will render the filter inoperable if it is not moved inside during the winter months.

### 5.1.3. Operation and Maintenance

For the BSF to function correctly it is necessary for filter components to be maintained in good condition, and for the filter to be operated and cleaned correctly.

In most households (76%) it is a man who is responsible for cleaning the filter although sometimes the woman (22%) or older girl/boy (2%) is responsible. Tearfund was the source of training for 75% of the respondents; while 21% were trained by the BSF manufacturer, and 4% had not received any training at all.

The operation and maintenance methods taught by Tearfund and the BSF manufacturers were those described in the CAWST (2009) Biosand Filter Manual as follows:

- Filter shall be operated on a regular basis; the schmutzdecke shall be allowed at least two weeks to mature after initial operation and a pause period of 1 hour should be observed after each 20L of water has passed through the filter.
- When flow rates reduce below 0.1l/s the top surface of the sand layer should be cleaned by the "swirl and dump" method. After cleaning the schmutzdecke shall be allowed a few days to recover.
- Filtered water should be disinfected during the initial schmutzdecke ripening period, and after filter cleaning.

The field survey results indicate that 51% of the respondents are using and could correctly describe the wet "swirl and dump" method of cleaning the BSF. However 17% indicated that they are using the "sand removal" method for BSF cleaning. Removing and washing the sand will result in significant disturbance of the schmutzdecke and therefore sub-optimal performance of the filter for a period after each cleaning; this will expose the users to a significant risk of contamination if water continues to be consumed from the filter during this period. Research by Singer (2011) indicates that the length of time for a filter to recover to pre-cleaning removal rates after the 'sand removal' method was 12.75 days as opposed to only 4.1 days when the 'surface agitation ('swirl and dump') method is used. The 'sand removal' method of cleaning could also result in incorrect sand volume in the BSF if sand is lost during the cleaning process.

A further 13% either could not describe the cleaning method or described it incorrectly, and for 19% of the households surveyed the person responsible for cleaning was not available to answer the question.

When asked, about the frequency of cleaning the filter, 79% responded with the correct answer "when the flow rate is slow (below 0.1l/s)". However 6% stated that they clean the filter on a regular cycle of 10 or 20 days. This approach will risk disturbing the schmutzdecke unnecessarily and therefore contributing to lower water quality than that which might be achieved with timely maintenance.

Specific observations were made of the filter outlet pipe to ensure it was not tampered with and that the water was allowed to flow freely from the outlet, and to ensure the use of two containers, one for fetching water and a narrow neck container with a lid for collecting filtered water. Observed compliance with these parameters was good, ranging from 79 to 96%.

### 5.1.4. Technical Performance

Despite a significant number of issues being identified with construction, installation, operation and maintenance, which are likely to impact on the filtered water quality, the overall treatment effectiveness of the BSF was good, with only 22.2% of filtered water samples measured to have greater than 10cfu/100ml. This may be due to a number of reasons;

(1) In many cases when the researcher arrived at a house the BSF reservoir was already filled and water flowing. This made it impossible to measure the standing water level above the sand layer, until the flow had stopped. It is possible that some enumerators may have recorded the depth of water over the sand layer as being greater than 50mm, because they did not wait until the flow had stopped before measuring the standing water depth. Thus the number of filters with incorrect depth of water over the schmutzdecke may be less than what was recorded in the survey.

(2) It is also interesting to note the correlation between source water and filtrate contamination. 100% of the filtrate samples with >10cfu/100ml had source water in the range 101 – 1000 cfu/100ml, while only 26% of the filtrate samples <10cfu/100ml had source water samples >101 cfu/100ml. This indicates that while percentage reduction in E.coli is a common measure of BSF effectiveness, it is also necessary to measure the quality of the filtered water in absolute terms to ensure that filtrate is meeting basic minimum quality standards, especially where source water is highly contaminated.

(3) Those using the 'sand removal' method of cleaning all came from Jawzjan, which also had relatively uncontaminated water sources, 70% <100cfu/100ml, therefore the potential risk for contamination of the filtrate was reduced.

(4) 70% of the filtrate samples measuring >10cfu/100ml were from Khamzerger village. This village also had the most contaminated water source, and the BSF manufacturer from this village had moved to Iran for 2 years during 2009, and had only returned just before the time of the survey in August 2011. Therefore it is likely this combination of

highly contaminated source water and lack of technical support close at hand, resulted in the highest proportion of filtrate samples >10cfu/100ml.

BSF performance could be further improved by the implementing agency and government representatives ensuring BSF manufacturers understand the importance of the BSF specifications, as published in the Afghanistan Ministry of Rural Rehabilitation and Development, MRRD (2010) 'Rural Water Sanitation and Hygiene Implementation Manual'. Especially the identified issues related to trimming the outlet tubing to the correct length, and installing the correct volume of sand to ensure a 50mm standing water depth over the schmutzdecke. If possible a scheme whereby officially trained BSF manufacturers are licensed and regulated by the government, may be a way to enhance quality of construction and installation. BSF manufacturers also have a vested interest to see that the BSF are operated and maintained correctly by the users so that the potential benefits of improved water quality are fully realised. In order to achieve this objective they would benefit by comprehensively training BSF users on operation and maintenance techniques at the time the purchase the filter. Especially the importance of maintaining the 50mm standing water depth and protecting the schmutzdecke through use of the diffuser box and the "swirl and dump" cleaning procedure. Reinforcement of these educational messages to existing BSF users would be an effective way to improve the quality of water produced from up to 49% of the filters surveyed.

## 5.2. User Perception of BSF Impacts

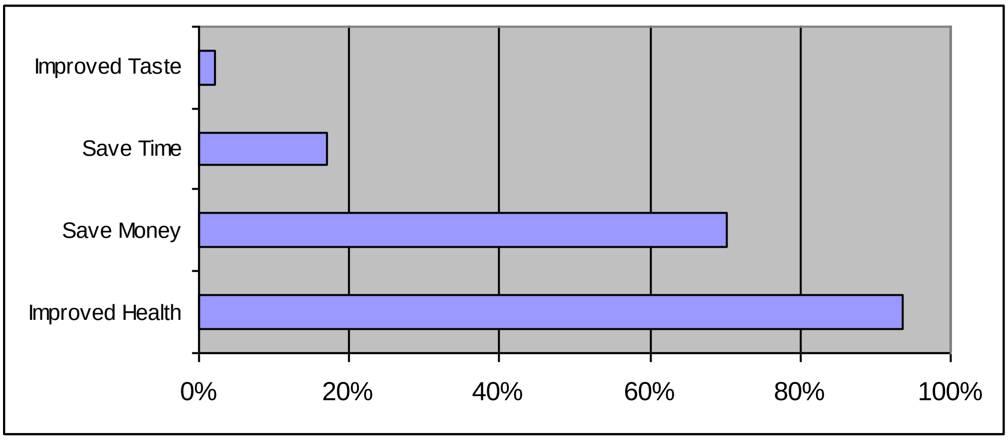
### 5.2.1. Contribution to Improved Quality of Life

User perception about the BSF is an important aspect of this evaluation, since it influences rate of adoption, sustained use and potential demand. If the current users have positive perceptions about the BSF they are more likely to recommend it to others, which will contribute towards BSF demand creation.

The research revealed that the overall perceptions of the households using the BSF were strongly positive, and 100% of the existing BSF filter owners said that they had "recommended the filter to others".

When questioned about specific perceived benefits; 94% said improved health was a benefit and many quoted anecdotal stories about how the number of visits to the doctor for water related diseases had reduced and that their expenditure on medication for water related diseases had reduced and as a result 70% respondents said that financial savings was a direct benefit of BSF ownership. And even those without a BSF stated the perceived benefits as improved health (100%) and financial savings (47%), other benefits of BSF ownership that were stated are; saves time 17%; and improved taste of water 2% (refer Figure 5.1).

**Figure 5.1: Percentage of Households Identifying Designated Item as Perceived Benefit**




These results are similar to other studies carried out in development contexts. For example, Earwalker (2006) reports in his Ethiopian study that 91.2% of respondents reported improved health as a benefit, and some noted that they had reduced medical bills.

### 5.2.2. Self Reported Rates of Diarrhoea

The perceived health benefit from drinking filtered water from a BSF was further confirmed by asking respondents about the incidence of diarrhoea in the past two weeks. Only 16% of those with an operating BSF reported cases of diarrhoea in the past two weeks, while 71% of those without a BSF reported cases of diarrhoea in the past two weeks.

This seems to be reasonably conclusive evidence that the perceived health benefits of drinking filtered water from a BSF are in fact true. However, health impact is a very difficult parameter to accurately measure, and given the range of variables involved it is difficult to absolutely determine cause and effect from a single intervention such as a BSF. In addition self reported data does not form a strong evidence base and should be triangulated with quantitative evidence from a comprehensive health study, or at least quantitative statistics from a local doctor or health clinic.

However this study does confirm the general perception amongst the respondents is that drinking filtered water from a BSF has directly resulted in health improvement and financial savings. At all focus group discussions and most household interviews the respondents were highly animated about the benefits that the BSF had bought to their lives, therefore it is highly likely that their health had actually improved. In any case all respondents were enthusiastic advocates of the BSF and 100% said that they had recommended the filter to others.

## 5.3. BSF Demand Assessment

The fact that the BSFs are performing well technically, and that the users are enthusiastic about the improvements in their health, indicates that the BSF programme has been effective in the complex emergency context of Afghanistan and has every chance of being sustainable. However the question remains as to whether the effectiveness of the filters themselves and the enthusiasm of the current users about the perceived BSF benefits is enough to translate into sustained demand, and sustainable livelihoods for the BSF manufacturers.

### 5.3.1. Rate of Adoption and Sustained Use

Of the 62 households surveyed 96% of the 47 with filters reported that they regularly used their filters. Observations during the unannounced household survey confirmed that those reporting regular usage appeared to be correct. All households surveyed had their filter for more than six months, with 57% having their filter for more than 1 year and 15% having their filter for more than 2 years.

CWAST defines the rate of adoption as *"the percentage of filters in consistent use one month after installation"*, and the rate of sustained use as *"the percentage of filters in consistent use after one year"* (CAWST, 2010) and is an indication of sustainability. Using these definitions the rate of adoption is 96%, and the rate of sustained use is 94%. This is a high rate of sustained use for a new technology and will help create sustained demand for the product within the community. A further 2% stated that they used their filter intermittently, while 2% had stopped using their filter because it was broken.

### 5.3.2. Ability and Willingness to Pay

***Ability to Pay***

The household survey results indicated that the overall average annual household income in the study area was US$1,836. The average annual household income was higher in Kapisa than in Jawzjan (refer Table 5.4), this was due to the fact that Kapisa is closer to Kabul, and the household survey revealed that many household members had jobs in Kabul. Whereas in Jawzjan most households were engaged in farming, and relied on sale of produce or carpet making in order to earn cash income.

**Table 5.4: Annual Household Income**

| Annual household income | Jawzjan | Kapisa | TOTAL |
|---:|---:|---:|---:|
| Range (USD) | US$120 – 9,674 | US$605 - 6047 | US$120 - 9,674 |
| Average (USD) | US$1,586 | US$2087 | US$1836 |

The average retail price for a BSF on the current market was US$21.70 (Refer Table 5.5), with the average price in Kapisa being slightly cheaper than Jawzjan. This is most likely due to access to cheaper raw materials, due to Kapisa's proximity to Kabul.

**Table 5.5: Current Regular Retail Price for BSF**

| | Jawzjan | Kapisa | TOTAL |
|---:|---:|---:|---:|
| Range (USD) | US$20.50–23.30 | US$17.40-25.60 | US$17.40 – 25.60 |
| Average (USD) | US$21.90 | US$21.50 | US$21.70 |

When the annual household income and current retail price for a BSF are compared then the percentage of annual income required to purchase a BSF is determined as shown in Table 5.6. The average percentage of annual income required to purchase a BSF is around 1.2%, which is an affordable amount for those households with an average, or above average income. However for a household with a below average income the cost of a BSF could be as much as 17% of the annual household income, which could make it an unaffordable item for a low income household.

**Table 5.6: Percentage of Annual Income Required to Purchase a BSF**

| | Jawzjan | Kapisa | TOTAL |
|---:|---:|---:|---:|
| Range (%) | 0.2% - 17% | 0.4% - 2.9% | 0.2% - 17% |
| Average (%) | 1.4% | 1.0% | 1.2% |

***Willingness to Pay***

Of those surveyed without BSF, 100% stated that they would like to purchase a BSF, with 73% stating that the greatest barrier to purchase was cost, and 27% said that it was the responsibility of their husband to do the shopping and that they either did not have time, or did not see a BSF as a priority.

When asked what would be an affordable price, answers ranged from US$0.00-23.30 with the majority (60%) being in the range US$9.30 – 11.60. Although many stated that other factors such as successful harvest would affect the price they were willing to pay. BSF manufacturers confirmed that low income buyers were mostly only willing to pay in the order of US$7.00-$11.60, which is less than the actual production cost which currently ranges from US$14.00 – $17.40.

BSF Manufacturers further confirmed that middle to upper income buyers were willing to pay the current retail cost of around US$17.40-$25.60, and that some were even willing to pay up to US$27.90.

The household survey results for self reported weekly income levels, indicate that 45% of the population are in the low income category US$0 – 1208 per year, while the balance 55% may be classed as middle to upper income US$1208 – 9,600+ per year.

Therefore on this basis the potential market available for sale of BSF at unsubsidised, full cost recovery prices is at best 55% of the population.

The Tearfund marketing strategy was to distribute filters free of charge to the poorest and most vulnerable households, while at the same time marketing the filters for sale at full cost recovery prices to middle and upper income households through demonstrations at mosques, clinics and schools, together with radio, TV and billboard advertising.

The total percentage of low income households that received filters in the four villages surveyed was only 13.5%, thus based on the assumptions described above 31.5% of the population will not be able to afford to purchase a BSF because they fall in the low income bracket and have not received a free filter from the Tearfund distribution. For this section of the population BSF manufacturers could consider advancing credit, and spreading payment for the full cost of the BSF over an agreed period.

Of the potential 55% who fall in the middle to upper income bracket 9.2% have already purchased a BSF at the full price, this leaves the proportion of the population that can afford a filter but have not yet purchased one at 45.8%, which is still a substantial number of households.

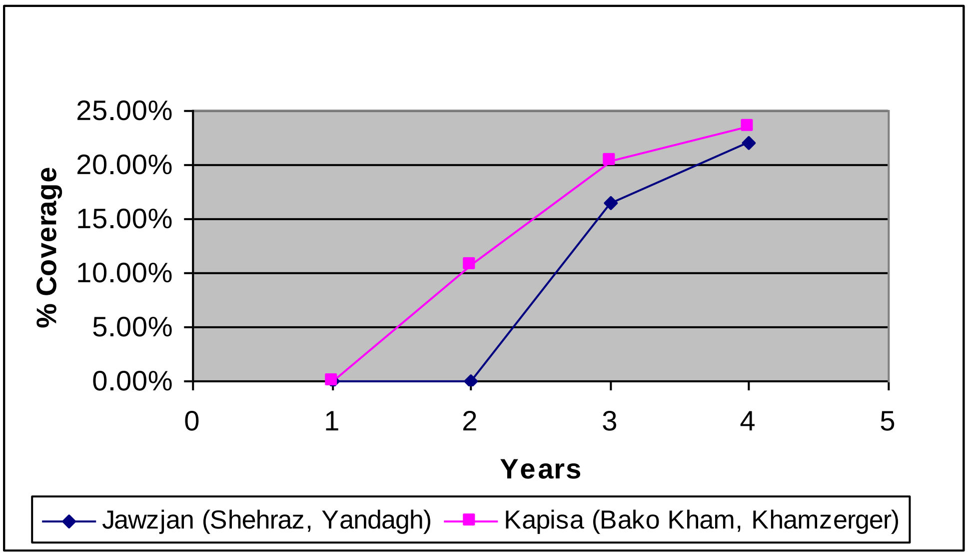
Of the households surveyed without a BSF, 46.6% of those fell into the middle to upper income bracket. So the question remains, why these households have not yet purchased a BSF, although in theory they can afford it, and they have also stated that they would like to buy one. Part of the answer to this question may be found in the cultural context. Of those that could in theory afford a filter, and stated that they would like to buy one, 57% were women. In the Afghan cultural context it is normally the responsibility of their husband to do the shopping and 27% actually stated that their husband either did not have time, or did not see a BSF as a priority. In Jawzjan, many of those interviewed said that what they would be willing to pay was directly related to how good the harvest was. In other words if they had plenty of money due to a good harvest then they would be willing to pay a reasonable price for a BSF, however during the current drought, all spare cash was being used to buy food and water, therefore at the current time purchase of a BSF was not a priority and therefore they would not be willing to purchase one no matter how low the price. These are issues that will need to be addressed with increased efforts towards promotion and marketing of the BSF by the BSF manufacturers, or consideration of advancing credit to those unable to afford the BSF now, but with the ability to pay later.

### 5.3.3. BSF Coverage

The current average coverage of BSF in the study areas is only 24%. This means that there is still a significant market open for BSF manufacturers, if demand is sustained.

In the study areas BSF coverage has grown from zero to 24% over a three year period (refer Figure 5.2). Although the rate of increase in coverage has slowed, there is still sustained growth, and with 76% of the households still not owning a biosand filter, there is significant room for growth. Initial growth in coverage was rapid during the time that Tearfund was actively engaged in promoting the filters, and this is reflected in the current strong demand for BSF in Jawzjan. In Kapisa, however Tearfund has not been actively involved promoting BSF for over one year and the BSF manufacturers report that demand for filters from individuals has slowed considerably.

**Figure 5.2: Cumulative Growth of BSF Coverage in Study Area**



Now that the Afghan Government has recognized the value of household water treatment solutions in its 'National WASH Implementation Manual' (MRRD, 2010), it could work to increase coverage by investing resources in promoting the use of household water treatment, especially in areas with easy access to contaminated surface water sources. In addition BSF manufacturers themselves could invest more heavily in product marketing and promotion to increase their sales and extend BSF coverage.

#### 5.3.4. Sustainability of BSF Delivery Model and Livelihoods for Manufacturers

The issue of sustainability after the implementing agency has exited from an area is identified as a fundamental weakness of the supply driven model of BSF programme implementation, especially where BSF are manufactured and distributed at no cost or heavily subsidised by the implementing agency. Earwalker (2006:45) in his Ethiopian study found that due to lack of establishment of sustainable BSF supply chains, the subsidised model of adoption resulted in doubt over the continued adoption of the BSF once the implementing agency closes their programme. Similarly the Liang (2010) study in Cambodia identified that 74% of the households reported that BSF could not be purchased in their area, and the majority of the respondents (65%) said they would seek help from the implementing organisation if the filter was broken or not working. This calls into question the sustainability of heavily subsidised supply driven models of programme implementation.

Commercialisation of BSF production in other countries has resulted in mixed success in recovery of costs, although the commercial approach has been proven to be successful in recovering production costs of the products themselves (Harris, 2005), and many BSF production facilities have continued long after the supporting NGO has left the area. Ultimately the success of commercialisation depends on sufficient demand and pricing that is affordable to the local population and still sufficient to cover production costs and leave a reasonable profit margin for the manufacturer.

The demand-led commercialised BSF delivery model established in Jawzjan and Kapisa relies heavily on the BSF manufacturer for all components of delivery, from manufacture, marketing, retail, and installation, to training users in BSF operations and maintenance. The only component excluded is materials supply, which comes from local merchants. It is unreasonable to expect that a single person, or business, will have the skills to carry out all these aspects of the delivery chain effectively. Several BSF manufacturers admitted weakness in the area of BSF promotion and stated that they outsourced the marketing components of their business. Most seemed to be weak on training the users in effective

BSF operations and maintenance, and this may be another contributing factor to filtrate water quality results of >10cfu/100ml in 22.2% of the households. However, despite these weaknesses, the BSF delivery mechanism was observed to be performing well in Jawzjan and had continued in Kapisa for more than one year after the implementing agency had ceased to operate in the area, which indicates some level of sustainability.

Although there were differences between Kapisa and Jawzjan in the opinion of BSF manufacturers on whether the current BSF demand was enough to enable a sustainable livelihood for BSF manufacturers. The BSF manufacturers in Jawzjan, where Tearfund is still investing resources into BSF promotion and marketing state that they are experiencing strong demand for BSF from private individuals, commercial enterprises and UN/NGOs, and they believe that they will be able to sustain long term livelihoods with BSF manufacture as their primary income source. However interviews with BSF manufacturers in Kapisa more than one year after the Tearfund marketing and promotion campaign had finished stated that the demand for BSF, whilst steady had slowed considerably and was not sufficient to sustain BSF manufacture as their primary livelihood, but only as a sideline business to supplement income derived from other sources, such as masonry work.

It is possible that differences between the two provinces are influencing factors in this difference; however it does seem that a fundamental element contributing to the success of BSF manufacture as a primary livelihood is the level of resource put into marketing and promotion of the product. And in this regard, based on the interviews with the BSF manufacturers themselves, it was evident that the manufacturers in Jawzjan were investing a larger proportion of their energy and resources into active marketing and promotion of the product, when compared with the manufacturers in Kapisa. Although another key influencing factor was that Tearfund was still currently active with WASH and other sector programming in Jawzjan at the time of the survey, while in Kapisa all Tearfund programme activities had ceased more than one year previous. This suggests that BSF manufacturers alone may not have sufficient resources to invest in effective BSF marketing and promotion to create sustained demand for the product, and that additional investment in BSF marketing and promotion would be required from an external implementing agency or government, in order to generate sufficient self sustaining demand to enable sustainable livelihoods for the BSF manufacturers.

However, despite this, it was evident that all BSF manufacturers interviewed were at a minimum able to supplement their income from their BSF business. All stated that they would continue to operate their businesses and produce BSF while the demand was sustained, and four out of five stated that they were better off now than before the programme. Therefore, the research indicates that, even in the complex emergency context of Afghanistan a demand led programme has been able to establish a commercialised BSF delivery model, and that at a minimum, sufficient demand has been generated to enable BSF manufacturers to supplement their income from their BSF manufacturing business. Although, it is questionable whether this demand will be sustained after the implementing agency ceases operation, unless additional resources from government, NGOs or BSF manufacturers themselves can be invested in BSF marketing and promotion.

## 6. Conclusions

Considering the wider research aim; to evaluate the effectiveness and sustainable impact of a demand led Biosand filter programme in the complex emergency context of Afghanistan, the following conclusions can be drawn.

On the whole the technical performance of the BSF was good. Despite some issues being identified with construction, installation, operations and maintenance, mainly related to the depth of water above the schmutzdecke and sand cleaning methodology. The filters were shown to be effective in removing on average 91.7% of the E.coli bacteria, which compares very favourably with the average result of 92% recorded in previous field studies. Turbidity removal was on average 83.0%, which is also very good and is equivalent to the average result of 83% recorded in past field studies. 13.3% of the filtered water samples achieved the WHO guideline level of 0cfu/100ml, while 64.4%% achieved the “low risk” level of <10cfu/100ml. 100% of the filtered water samples achieved the WHO guideline value for small scale water supplies of <5NTU.

These results compare favourably to other field surveys in more stable development contexts, and show that the BSF was effective for improving the quality of drinking water in the complex emergency context of Afghanistan.

The research also found that the perceptions of the BSF users were strongly positive, with 94% stating improved health was a benefit and 70% stating that financial savings on medical expenditure was also a direct benefit of BSF ownership. These perceived health impacts were confirmed to some extent by the self reported rates of incidence of diarrhoea in the past two weeks, where only 16% of those with an operating BSF reported cases of diarrhoea in the past two weeks, while 71% of those without a BSF reported cases of diarrhoea in the past two weeks. As a result of the perceived positive impacts of drinking water from the BSF, 100% of current BSF owners had recommended the filter to others.

This result also confirms that the users strongly believed that drinking filtered water from the BSF was resulting in a positive impact on their health. This is a key factor which has led to sustained use of the filters amongst 94% of the households surveyed.

It can be concluded from the research that sale of the BSF at a full cost recovery price is affordable for 55% of the population who fall within the middle to upper income bracket.

However only 9.2% of this group of the population have already purchased a filter. This is a result of a number of factors including, gender and cultural factors, inability to pay, unwillingness to pay, and lack of marketing and promotion.

In the study areas BSF coverage has grown from zero to 24% over a three year period. Although the rate of increase in coverage has slowed, there is still sustained growth, and with 76% of the households still not owning a biosand filter, there is significant room for growth. Initial growth in coverage was rapid during the time that Tearfund was actively engaged in promoting the filters, and this is reflected in the current strong demand for BSF in Jawzjan. In Kapisa, however Tearfund has not been actively involved promoting BSF for over one year and the BSF manufacturers report that demand for filters from individuals has slowed considerably.

A fundamental element contributing to the success of the BSF delivery model and the livelihoods of BSF manufacturers is the level of resource put into marketing and promotion of the product. And in this regard, it was evident that the manufacturers in Jawzjan were investing a larger proportion of their energy and resources into active marketing of the product, when compared with the manufacturers in Kapisa. Although, it is questionable whether this demand will be sustained after the implementing agency ceases operation, unless significant additional resources from government, NGOs or BSF manufacturers themselves can be invested in BSF marketing and promotion. Despite this, it was evident that currently all BSF manufacturers were, at a minimum, able to supplement their income from their BSF manufacturing business.

When compared with other programmes in more stable development contexts, this research shows that, in the complex emergency context of Afghanistan a demand led BSF programme has been able to achieve a comparable, level of effectiveness, impact and sustainability.

# 7. Recommendations

## 7.1. General Recommendations

Based on the findings of the study it is recommended that, where the conditions are favourable, humanitarian agencies seriously consider demand-led commercialized approaches to BSF programming as a sustainable household water treatment solution in complex emergency situations.

The study has also highlighted several areas where improvements could be made to raise BSF filter performance and demand to higher levels, and thus increase the potential sustainability and impact of the programme.

BSF filter performance could be improved in a number of ways as recommended below:

- Reinforcement of educational messages and distribution of promotional material on correct construction, installation, operation and maintenance practices, by the implementing agency, government, and BSF manufacturers would be an effective way to improve the quality of water produced from up to 49% of the filters surveyed.
- In particular the implementing agency and government need to ensure BSF manufacturers understand the importance of the BSF specifications, especially trimming the outlet tubing to the correct length, and installing the correct volume of sand to ensure a 50mm standing water depth over the schmutzdecke.
- And BSF manufacturers need to ensure BSF users understand the correct operation and maintenance techniques. Especially the importance of maintaining the 50mm standing water depth and protecting the schmutzdecke through use of the diffuser box and the “swirl and dump” cleaning procedure.

BSF demand and coverage could be improved in a number of ways as recommended:

- Now that the Afghan Government has recognized the value of household water treatment solutions in its National WASH Implementation Manual, it could invest resources in promoting the use of household water treatment, especially in areas with easy access to contaminated surface water sources.
- In addition BSF manufacturers themselves could invest more heavily in product marketing and promotion to increase their sales and extend BSF coverage. More comprehensive training on business and marketing principles by the implementing agency would also assist the BSF manufacturers to understand how they can best improve their BSF sales.

- For the 45% of the population falling into the low income bracket BSF manufacturers could consider advancing credit, and spreading payment for the full cost of the BSF over an agreed period.

## 7.2. Recommendations for Further Research

Both humanitarian and development programmes are increasingly under pressure to demonstrate effectiveness and justify further investments. This is certainly true in the WASH sector where there is increasing emphasis on 'evidence-based' decision-making, and the need for standardized data collection and analysis procedures (WHO, 2011b:1). A main result from the investigations documented in this study is that additional research on BSF in emergencies and especially complex emergencies is needed to build such an evidence base.

Based on the information documented in this report, further research on BSF in emergencies should focus on:

- Conducting further BSF project evaluations for both natural disaster situations and long term complex emergencies to understand how organizations select BSF as an intervention, and using appropriate metrics to measure programme efficacy, to gain an understanding of the appropriateness for specific types of disaster and stages of emergency response. Development of an option selection framework to guide implementing agencies in this decision making process would be valuable.
- Comparing BSF to other options to reduce diarrheal disease after a disaster or during a complex emergency, and understanding the potential role for BSF as part of a larger water and sanitation strategy at various stages of disaster response;
- Understanding what motivates sustained use of BSF after a disaster or during a complex emergency, including consideration of different demographic, socio-economic, and cultural groups, and how sustained use correlates with waterborne disease prevalence rates and financial benefits.
- Understanding economic sustainability of different demand-led delivery models after a disaster or during a complex emergency, including what motivates users to purchase and use a BSF, and documenting successful BSF business models.

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# 9. Appendices

## Appendix 1: Summary of Previous BSF Test Results

### Summary of Previous Laboratory Test Results

| **Reference** | **Location** | **Mean Removal Rate After BSF Filtration (indicator)** | **Notes** |
|---|---|---|---|
| Buzunis (1995) | University of Calgary | 96% (faecal coliform)<br>95.5% (Turbidity) | 1 filter, over 32 days, 25L/d |
| Palmateer et al (1999) | Alberta & Ontario | *83% heterotropic bacteria*<br>*>99.99% Giardia Cysts*<br>*99.98% Cryptosporidium oocysts*<br>*50-90% organic and inorganic toxin* | 2 BSF over 30 days |
| Baumgartner (2007) | Harvard University | *78% (total coliform)* | 16 trials<br>Time water was sampled not statistically significant<br>81% 10L 12h pause<br>78.3% 10L 36h pause<br>79.1% 20L 12h pause<br>73.7% 20L 36h pause |
| Stauber et al. (2006) | University North Carolina | 94% (E.coli) | Range 63% to 99% (E.coli) reduction |
| Stauber (2007) | University North Carolina | 91 – 97% (E.coli) | 2 filters tested 17 days with 40L per day<br>Max 99.4% |
| Thye (2007) | Loughborough University | Range 89.3-99.9% (E.coil)<br>91.2% - 92.1% (Turbidity) | Range 89.3-99.99% (E.coil) 91.2% - 92.1% (Turbidity) 2 filters continuous flow, 2 filters surge flow<br>Turbidity influent 5.6-7.8NTU, effluent 0.492-0.615NTU |
| Elliot et al (2008) | University North Carolina | 95.6% (E.coli)<br>*99% (echovirus 12)*<br>*70% (bacteriophage)* | 89.5% (E.coli) reduction first 30 days, 4 filters tested over 43-54 days, 3 plastic, 1 concrete, charged with 20L or 40L. |
| Duke and Mazumder (2009) | University of Victoria | Range 96.6-99% (E.coli) | Quarry sand outperformed other sand sources (ocean, river) |
| Liang (2010) | University North Carolina | 90 – 99% (E.coli)<br>90% (Virus)<br>99.9% (protozoa) | |

**Summary of Previous BSF Field Test Results**

| **Reference** | **Location** | **Time Since Installation** | **Mean Removal Rate After BSF Filtration (Indicator)** | **Notes** |
|---|---|---|---|---|
| Buzunis (1995) | Nicaragua | 2 months | 96.4% (faecal coliform) | Range 86.67-100%<br>55 filters<br>97% (faecal coliform) after 3 weeks |
| Baughen et al (1999) | Nicaragua | 1 month | 80% (faecal coliform) | |
| Mol (2001) | Kenya | 3-4 weeks | 93% (faecal coliform) | |
| Lee (2001) | Nepal | 2 years | 83% (E.coli)<br>75% (turbidity) | 14/39 tested did not have favourable results |
| Kaiser et al ( 2001) | Mozambique, Kenya, Vietnam, Cambodia, Nicaragua Honduras | | 93% (E.coli) | 585 households from 5 countries, 98.4% using filter on regular basis<br>Honduras 100%<br>Nicaragua 99%<br>Mozambique 98%<br>Kenya 94%<br>Cambodia 83%<br>Vietnam 81% |
| Dejachew (2002) | Ethiopia | 2.5 years | 90% (E.coli) | |
| Dies et al (2003) | Nepal | 'recent' | 95% (E.coli) | |
| Bojecvska & Jergil (2003) | Mozambique | 1 month | *96% (Cyanobacteria)* | |
| Fewster et al (2004) | Kenya | 2.5 – 4 years | *70.5% <10cfu/100ml*<br>*82.4% <10 NTU* | 50/51 still using filter on regular basis<br>3-4 weeks after prog start 80.7% below 10cfu/100ml |
| Maetens and Buller (2005) | Ethiopia | 2.5 years | 97.3% (E.coli)<br>85% (turbidity) | 50 BSF houses, 50 Control houses,<br>Self reported 82% less occurrences of diarrhoea |
| Duke et al (2006) | Haiti | 5 years | 98.5% (E.coli)<br>85.4% (Turbidity) | 107 BSF tested, filters in use for 2.5 years |
| Earwalker (2006) | Ethiopia | 5 to 7 years | 87.9% (E.coli)<br>69% (Turbidity) | 39 filters tested, 71.8% >99% reduction, 54.1% 100% reduction (0CFU), 75.7% <10CFU.<br>82.1% <5NTU, 87.2% <15NTU |
| Stauber et al (2006) | Dominican Republic | 1 year | 93% (E.coli)<br>84% (turbidity) | Range 0 – 99.7% (E.coli)<br>55 filters 4-11 installed months prior |
| Stauber (2007) | Dominican Republic | 0 – 1 year | 94% (E.coli)<br>*78% (MS-2 Virus)*<br>*87% (PRD-1 Virus)* | Range 63 – 98.9% (E.coli). 47% reduction in diarrhoea in comparison to non BSF users, 81 filters |
| Vanderzwaag (2009) | Nicaragua | 3 – 8 years | 96% (E.coli)<br>88% (turbidity) | Range 78-99.9% (E.coli) |
| Liang et al (2010), | Cambodia | 0 – 8 years | 95% (E.coli)<br>82% (turbidity) | 336 BSF households surveyed. 88% continued usage<br>44% less diarrhoea in households with filters |
| CAWST (2010) | Afghanistan | 0 – 2 years | 93% (E.coli)<br>86% (turbidity) | 25 BSF households surveyed in Kapisa. BSF installed 1 year previous. 84% regular usage |
| Singer (2011) | Uganda | 0 – 6 months | 88% (E.coli)<br>90% (turbidity) | Overall removal rate surface agitation method |

## Appendix 2: Semi Structured Interview Questions

### Questions for Individual Interviews with Key Project Stakeholders

**Expected Interviewees**: Tearfund Programme Director, Tearfund Area Coordinator, Tearfund WASH Advisor, National WASH Cluster Member, National Government Representative, Local Government Representative

1. How was the programme implemented?
2. How were the needs of the most vulnerable addressed?
3. How was the project integrated with the activities of other agencies / organisations in a coordinated and coherent fashion?
4. Describe the market / demand driven approach?
5. How were public policy barriers overcome?
6. How were national and regional governments involved?
7. What was the role of civil society?
8. Was the programme effective?
9. Was the programme relevant?
10. Is the programme sustainable?
11. What were the outcomes and impacts? (social / cultural / technical / economic /political / institutional / environmental / health)

### Questions for Individual Interviews with Bio Sand Filter Manufacturers

**Expected Interviewees**: Bio Sand Filter Technicians.

1. What was your livelihood was before you were approached by Tearfund and selected to be trained in manufacturing bio sand filters? Did you make a sufficient income from the livelihood? Was it a sustainable (long-lasting) livelihood?
2. Please can you tell me about the bio sand filter technician training that you received? Where was the training held? What did the training 'cover'? How long was the training?
3. As part of Tearfund's project, you were employed by Tearfund to manufacture bio sand filters which were to be distributed to targeted vulnerable households in several villages. How many filters were you contracted to make? Did you complete the order?
4. How many filters have you sold since completing the initial Tearfund order?
5. What is the current cost to produce one biosand filter?
6. What is the current retail price for one biosand filter?
7. What is your profit margin for each biosand filter?
8. Do people have the ability to pay this amount?
9. Are people willing to pay this amount?

10. What is the current demand for biosand filters – do you have any future orders? – are there seasonal differences?
11. Is there much competition from other producers?
12. What methods do you use for marketing and advertising?
13. What after sales service do you provide?
14. To date, have any of the Tearfund project beneficiaries who had received a bio sand filter requested assistance from you to 'fix' their filter if they are experiencing problems with it?
15. Do you anticipate that you will continue with this livelihood, now that Tearfund's project has come to and end?
16. What Issues and difficulties have you faced?
17. What are your future business plans?
18. Do you have any other comments, recommendations or observations?

**Questions for Focus Group Discussion at Village Level with Community Members and Beneficiaries and/or Tearfund Project Staff**

Name of village / district / province:

GPS coordinates:

Total number of households:

Focus group participants:

**General Project Questions (Effectiveness, Impact, Relevance)**

1. What has been the greatest benefit of this project?
2. Are there improvements you would recommend for future projects of a similar nature?
3. What links are there between this project and others working in the community or area?

**Water / BSF-focus Questions (including Relevance, Sustainability)**

4. What are the current water sources for this village?
5. Was BSF a good option for this village to solve the drinking water quality problem?
6. What is the BSF coverage in this village?

Distributed Free by Tearfund?

Purchased Privately?

Total Number of Households?

7. Are BSF readily available in the local markets?
8. What is the cost of a BSF?
9. Are people able to pay, willing to pay this amount?
10. Is there enough support for maintenance and operation?
11. Do you have any other comments, recommendations or observations?

## Appendix 3: Household Survey Questionnaire

### Bio Sand Filter Monitoring and Evaluation Form

**Date of Visit**
**Field Visit Location (e.g. Village Name / Community Name)**
**Name of Person Facilitating Interview of Focus Group Discussion (e.g. Evaluator Name)**
**Name of Person(s) being Interviewed (including role in family / household)**
**Signature or print to confirm that consent was given to conduct interview / focus group discussion**

**Household Demographics**

a. How many people live in this household?
b. How long have you been living here?
c. Does anyone in the household have paid employment, if so who and what?
d. What is your weekly household income?

0 – 1,000 Afghani
1,000 – 2,000 Afghani
More than 2,000 Afghani

**Household Observations**

**Welfare Index**

a. Type/quality of housing?
Mud dwelling
Brick dwelling
1 room dwelling
Multiple room dwelling (what number of rooms?)
b. Basic assets?
Car
Motorcycle
Bicycle
Carpet present in room
Number of Animals owned (eg. Cows, goats, sheep, camels, donkeys, horses, chickens)
Land owned
Furniture – expensive?

**Water Observations**

| | | | | | |
|---|---|---|---|---|---|
| a. Source Water Sample Collected | Yes | ☐ | No | ☐ | Sample ID: |
| b. BSF Water Sample Collected | Yes | ☐ | No | ☐ | Sample ID: |

**Bio Sand Filter Observations**

| | | | | |
|---|---|---|---|---|
| a. Is the filter present in the household | Yes | ☐ | No | ☐ |
| b. Does the Filter appear to be in use? | In Use | ☐ | Not in Use | ☐ |

Quality of Construction:

- ☐ There are no leaks on the concrete filter body
- ☐ There is a lid which covers the entire opening of the filter
- ☐ There is the original diffuser plate without cracks or damage

Proper Installation:

- ☐ The filter is in a suitable location away from weather (e.g. inside household), animals and latrines

- The depth of the water above the sand is between 4 and 6 cm
- The flow rate of the filter is less than 0.4 litres/minute

Proper Use:

- There is not a valve or tube attached to the outlet of the filter
- The outlet spout of the filter is clean

Safe Water Storage:

- The treated water storage container has a lid
- The storage container has a narrow opening/ tap to get water out
- The storage container appears clean (free of dirt and algae)
- The user has different containers for collecting and storing water

**Water Supply Questions (Quantitative)**

a. Where do you get water from? (Tick appropriate box/es)

Well
Canal, river, stream
Rain
Reservoir
Other, please specify

b. Is there seasonal variation in the source water quantity and quality?

c. How long does it take to get water? (e.g. number of minutes it takes to go, collect water and return)

0 – 5 minutes
6 – 15 minutes
16 – 30 minutes
30+ minutes

d. Do you do anything with the water before you put in into the filter?

Let it settle
Pour it through cloth
Other (eg. Boil)
Nothing

**Bio Sand Filter Questions (Quantitative)**

e. How long have you had the filter? Where do you get it from?

| | |
|---|---|
| Duration | 6 – 12 months |
| | 12 – 24 months |
| | More than 24 months |
| Source of filter | Distributed by Tearfund (free) |
| | Privately-purchased (BSF Tech) |
| | Other |

f. How much did it cost? / How much would you be willing to pay?

Specify Amount (Afs)

g. Who is responsible for cleaning the filter?

Man
Woman
Girl
Boy

h. How did this person learn about the maintenance and cleaning of the filter?

Training by Tearfund
Training by BSF Technician
Other (please specify)

i. Can the respondent describe or demonstrate how to clean the bio sand filter?

Swirl and Dump Competent and Correct
Other Method
Either could not, or description was incorrect
Person responsible for cleaning not available

j. When you have cleaned the filter, what was the reason that prompted you to clean it?
The filter appears dirty
Filter is not working / water is flowing slowly
Other
k. Did you use the bio sand filter to treat water today?
Yes
No
l. How much water do you treat using the bio sand filter each day?
0 – 20 litres
20 – 40 litres
40 + litres
Other amount

**IF NO FILTER PRESENT:**

m. What do you see as benefits of BSF?

n. Would you like a BSF?
Yes
No
o. How much would you be willing to pay for a BSF? (in the future)
Specify Amount (Afs)

**Qualitative Questions (Impact-driven questions)**

**Impact - BSF**

a. What have been the benefits of the BSF programme? (Interviewer should ask for answers in terms of a) health, b) financial, c) time, and d) clean environment, and e) other
b. Have you recommended the filter to others?
Yes
No
c. How many children / adults had diarrhoea in the past 2 weeks?
0 cases of diarrhoea
1 case of diarrhoea
2 cases of diarrhoea
3 cases of diarrhoea
4 cases of diarrhoea
5 cases of diarrhoea
6 cases of diarrhoea
7 cases of diarrhoea
8 cases of diarrhoea
9 cases of diarrhoea
10 cases of diarrhoea

## Appendix 4: Summary of Household Questionnaire Answers

| | | *Jawzjan* | | *Kapisa* |
|---|---|---|---|---|
| | **Shehraz** | **Yandagh** | **Bako Kham** | **Khamzerger** |
| **Survey Date** | 14/08/2011 | 16/08/2011 | 18/08/2011 | 21/08/2011 |
| **Demographics** | | | | |
| No. in household? | Average: 10.6 | Average: 16.4 | Average: 9.8 | Average: 11.4 |
| Time in dwelling? (yrs) | Average: 25.8 | Average: 30.1 | Average: 18.9 | Average: 23.4 |
| Weekly household income? | Average: 1277 | Average: 1463 | Average: 1412 | Average: 2107 |
| 0 - 999AFN (USD0.00 – 23.23) | 12 | 10 | 4 | 2 |
| 1,000 – 1,999AFN (USD23.23 – 46.48) | 2 | 4 | 11 | 8 |
| More than 2,000AFN (>USD$46.48) | 1 | 2 | 2 | 4 |
| **<u>Welfare Index</u>** | | | | |
| a. Type/quality of housing? | | | | |
| Mud dwelling | 15 | 14 | 11 | 13 |
| Brick dwelling | 0 | 2 | 6 | 4 |
| 1 room dwelling | 0 | 5 | 0 | 0 |
| Multiple room dwelling (what number of rooms?) | 54 | 85 | 57 | 38 |
| b. Basic assets? | | | | |
| Car | 1 | 0 | 4 | 3 |
| Motorcycle | 14 | 3 | 3 | 7 |
| Bicycle | 0 | 5 | 2 | 3 |
| Carpet present in room | 7 | 1 | 9 | 8 |
| Animals owned | 0 | 0 | 1 | 0 |
| Donkey | 3 | 0 | 0 | 8 |
| Goat | 11 | 124 | 0 | 0 |
| Cow | 7 | 7 | 22 | 16 |
| Horse | 3 | 5 | 0 | 0 |
| Camel | 0 | 0 | 0 | 0 |
| Sheep | 23 | 30 | 6 | 3 |
| Chicken | 0 | 47 | 0 | 9 |
| Land owned | 0 | 2 | 3 | 2 |
| **<u>Water Observations</u>** | 0 | 0 | 0 | 0 |
| a. Source Water | | | | |
| NTU Other | Average: 109.5 | Average: 5 | Average: 5 | Average: 5 |
| cfu | Average: 66.4 Range:7-221 | Average:113.4 Range:9-260 | Average:63.5 Range:1-180 | Average:271.8 Range:240-290 |
| PH | Average: 7.8 | Average:7.7 | Average: 7.6 | Average: 7.8 |
| c. Filtered Water | | | | |
| NTU | Average: 2.9 | Average:1 | Average:1 | Average:1 |
| cfu | Average3.2 Range:0-8 | Average:13.3 Range:0-99 | Average:7.2 Range:0-45 | Average:34 Range:4-99 |
| PH | Average:7.8 | Average:7.8 | Average:7.4 | Average:7.9 |
| **<u>Bio Sand Filter Observations</u>** | | | | |
| a. Is the filter present in the household (yes) | 12 | 13 | 11 | 11 |
| b. Does the Filter appear to be in use? (yes) | 10 | 13 | 11 | 11 |
| after six months | 1 | 12 | 0 | 0 |
| after one year | 9 | 1 | 11 | 11 |
| <u>Quality of Construction</u>: | 0 | 0 | 0 | 0 |
| No leaks on the concrete filter body? | 12 | 13 | 11 | 11 |
| Lid which covers the entire | 12 | 13 | 10 | 11 |

| | | | | |
|---|---|---|---|---|
| opening of the filter? | | | | |
| Original diffuser plate without cracks or damage? | 11 | 13 | 10 | 9 |
| Proper Installation: | 0 | 0 | 0 | 0 |
| Filter is in a suitable location away from weather? | 7 | 8 | 5 | 7 |
| Depth of the water above the sand is between 4 and 6 cm? | 7 | 5 | 5 | 8 |
| The flow rate of the filter is less than 0.4 litres/minute? | 8 | 9 | 6 | 10 |
| Proper Use: | | | | |
| There is no valve or tube attached to the outlet of the filter? | 10 | 12 | 11 | 10 |
| The outlet spout of the filter is clean? | 10 | 13 | 11 | 11 |
| Safe Water Storage: | 0 | 0 | 0 | 0 |
| The treated water storage container has a lid? | 8 | 12 | 7 | 10 |
| The storage container has a narrow opening? | 9 | 13 | 10 | 9 |
| The storage container appears clean? | 9 | 13 | 10 | 11 |
| The user has different containers for collecting and storing water? | 6 | 13 | 11 | 11 |
| **Water Supply Questions (Quantitative)** | 0 | 0 | 0 | 0 |
| Where do you get water from? | 0 | 0 | 0 | 0 |
| Well | 15 | 16 | 0 | 0 |
| Canal, river, stream | 0 | 0 | 17 | 14 |
| b. Is there seasonal variation in the source water quantity and quality? | 0 | 0 | 0 | 0 |
| c. How long does it take to get water? | | | | |
| 0 – 5 minutes | 0 | 6 | 14 | 8 |
| 6 – 15 minutes | 0 | 6 | 3 | 5 |
| 16 – 30 minutes | 0 | 1 | 0 | 1 |
| 30+ minutes | 15 | 3 | 0 | 0 |
| d. Do you do anything with the water before you put in into the filter? | 0 | 0 | 0 | 0 |
| Let it settle | 4 | 1 | 5 | 4 |
| Pour it through cloth | 0 | 5 | 0 | 1 |
| Combination | 3 | 0 | 0 | 0 |
| Nothing | 3 | 7 | 6 | 6 |
| Those with no filter: | 0 | 0 | 0 | 0 |
| Boil | 0 | 1 | 5 | 0 |
| Nothing | 5 | 2 | 1 | 3 |
| **Bio Sand Filter Questions (Quantitative)** | | | | |
| . How long have you had the filter **Duration** | | | | |
| 6 – 12 months | 1 | 12 | 0 | 0 |
| 12 – 24 months | 11 | 1 | 9 | 6 |
| More than 24 months | 0 | 0 | 2 | 5 |
| **Source of filter** | 0 | 0 | 0 | 0 |
| Distributed by Tearfund (free) | 9 | 10 | 6 | 7 |
| Privately-purchased (BSF Tech) | 3 | 3 | 5 | 4 |
| No filter | 3 | 3 | 6 | 3 |
| f. For those who purchased How much did it cost? | | | | |
| 1200AFN (USD27.90) | 0 | 0 | 1 | 0 |
| 1100AFN (USD25.60) | 1 | 0 | 0 | 0 |

| | | | | |
|---|---|---|---|---|
| 1000AFN (USD23.30) | 0 | 1 | 0 | 0 |
| 900AFN (USD20.90) | 0 | 1 | 0 | 0 |
| 800AFN (USD18.60) | 1 | 1 | 1 | 2 |
| 750AFN (USD17.40) | 0 | 0 | 0 | 2 |
| 700AFN (USD16.20) | 0 | 0 | 1 | 0 |
| 600AFN (USD14.00) | 1 | 0 | 2 | 0 |
| Distributed Free by Tearfund , 0 | 9 | 10 | 6 | 7 |
| For those distributed free by TF, how much would you be willing to pay for replacement BSF in future: | | | | |
| 1000AFN (USD23.30) | 0 | 2 | 4 | 0 |
| 700AFN (USD16.20) | 0 | 0 | 0 | 1 |
| 600AFN (USD14.00) | 0 | 0 | 1 | 0 |
| 500AFN (USD11.60) | 0 | 0 | 1 | 6 |
| 400AFN (USD9.30) | 4 | 2 | 0 | 0 |
| 300AFN (USD7.00) | 3 | 3 | 0 | 0 |
| 200AFN (USD4.70) | 2 | 1 | 0 | 0 |
| 0 | 0 | 2 | 0 | 0 |
| g. Who is responsible for cleaning the filter? | 0 | 0 | 0 | 0 |
| Man | 8 | 7 | 10 | 9 |
| Woman | 2 | 5 | 1 | 2 |
| Girl | 0 | 0 | 0 | 0 |
| Boy | 0 | 1 | 0 | 0 |
| h. How did you learn about the maintenance and cleaning of the filter? | | | | |
| Training by Tearfund | 9 | 12 | 7 | 7 |
| Training by BSF Technician | 1 | 1 | 4 | 4 |
| None | 2 | 0 | 0 | 0 |
| i. Describe or demonstrate how to clean the bio sand filter? | 0 | 0 | 0 | 0 |
| Swirl and Dump | 4 | 3 | 9 | 8 |
| Sand Removal | 4 | 4 | 0 | 0 |
| Either could not, or description was incorrect | 2 | 2 | 0 | 2 |
| Person responsible for cleaning not available | 2 | 4 | 2 | 1 |
| j. What was the reason that prompted you to clean it? | | | | |
| The filter appears dirty | 3 | 2 | 1 | 0 |
| Filter is not working / water is flowing slowly | 5 | 11 | 10 | 11 |
| Every 10 days | 2 | 0 | 0 | 0 |
| Every 20 days | 1 | 0 | 0 | 0 |
| Every 1-2 months | 1 | 0 | 0 | 0 |
| k. Did you use the bio sand filter to treat water today? | 0 | 0 | 0 | 0 |
| Yes | 9 | 13 | 10 | 11 |
| No | 3 | 0 | 1 | 0 |
| l. How much water do you treat using the bio sand filter each day? | | | | |
| 0 – 20 litres | 5 | 0 | 0 | 3 |
| 20 – 40 litres | 3 | 8 | 11 | 6 |
| 40 + litres | 4 | 5 | 0 | 2 |
| **IF NO BSF PRESENT** | | | | |
| What do you see as benefits of BSF? | | | | |
| Improve Health | 3 | 3 | 6 | 3 |

| | | | | |
|---|---|---|---|---|
| Save money | 1 | 0 | 4 | 2 |
| Save time | 0 | 0 | 0 | 0 |
| Clean Water | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 |
| Would you like to buy a BSF filter? | 0 | 0 | 0 | 0 |
| Yes | 3 | 3 | 6 | 3 |
| No | 0 | 0 | 0 | 0 |
| m. How much would you be willing to pay if you were to buy a BSF in the future? | 0 | 0 | 0 | 0 |
| 1000AFN (USD23.30) | 0 | 0 | 1 | 0 |
| 500AFN (USD11.60) | 0 | 0 | 2 | 1 |
| 400AFN (USD9.30) | 3 | 2 | 0 | 1 |
| 50AFN (USD1.20) | 0 | 1 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 |
| Would not specify | 0 | 0 | 2 | 1 |
| **Qualitative Questions (Impact-driven questions)** | 0 | 0 | 0 | 0 |
| **Impact - BSF** | 0 | 0 | 0 | 0 |
| a. What have been the benefits of the BSF programme? | | | | |
| Improved Health | 11 | 13 | 9 | 11 |
| Save Money | 8 | 9 | 9 | 7 |
| Save Time | 3 | 4 | 0 | 1 |
| Improved Taste | 0 | 1 | 0 | 0 |
| b. Have you recommended the BSF filter to others? | | | | |
| Yes = 1, No = 0 | 12 | 13 | 11 | 11 |
| c. How many children / adults had diarrhoea in the past 2 weeks? (With Operating BSF) | | | | |
| 0 cases of diarrhoea | 8 | 12 | 10 | 8 |
| 1 cases of diarrhoea | 2 | 1 | 1 | 1 |
| 2 cases of diarrhoea | 0 | 0 | 0 | 0 |
| 3 cases of diarrhoea | 0 | 0 | 0 | 1 |
| 4 cases of diarrhoea | 0 | 0 | 0 | 1 |
| c. How many children / adults had diarrhoea in the past 2 weeks? (Without Operating BSF) | 0 | 0 | 0 | 0 |
| 0 cases of diarrhoea | 3 | 0 | 0 | 2 |
| 1 cases of diarrhoea | 0 | 1 | 2 | 1 |
| 2 cases of diarrhoea | 1 | 0 | 0 | 0 |
| 3 cases of diarrhoea | 1 | 2 | 0 | 0 |
| 4 cases of diarrhoea | 0 | 0 | 2 | 0 |
| 8 cases of diarrhoea | 0 | 0 | 1 | 0 |
| 10 cases of diarrhoea | 0 | 0 | 1 | 0 |

## Appendix 5: Summary of BSF Manufacturer Interviews

| Date | 15/08/2011 | 15/08/2011 | 21/08/2011 | 21/08/2011 | 18/08/2011 |
|---|---|---|---|---|---|
| | Jawzjan | | Kapisa | | |
| Location | Acha | Murdian | Parwan | Khamzerger | Bako Kham |
| Interviewer | Murray | Amin | Murray | Murray | Murray |
| Interviewee (Manufacturer) | Osta Torson | Muhamad Murad | Khan Agha | Mustapha | Jawaad |
| Previous livelihood | Construction Labourer | Mason | Mason | Mason | Mason |
| Was income sufficient and sustainable | Marginal | Marginal | Marginal | Marginal | Yes |
| Description of BSF training | 3 days theory, 2 days practical | 3 days theory, 2 days practical | 7 days Kabul | 7 days Kabul | 3 days theory, 2 days practical |
| No Filters contracted by TF | 1000 TF | 690 TF | 700 Kapisa, 500 Parwan | 216 TF, 1400 UNICEF | 600 TF |
| No Filters sold since initial contract | 1000 in Mazar | 3000 Sarpul, and Mazar | 150 Kapisa, 70 Parwan | 250 | 3500 |
| Current Production cost | TF 530, Now 750 | 750 | Kapisa 500afs, Parwan 600afs | 450 TF, 600 UNICEF | TF 500, Now 700 |
| Current retail price | TF 730, Now 900 | 880 | Kapisa 600afs, Parwan 750afs, Private 800-1000afs | 600 TF, 800 Private | TF 600, 1000 Now |
| Profit margin | 200 - 250afs | 130afs | 150 - 400afs | 150 - 200afs | 150 - 300afs |
| Ability to Pay? | Yes for middle to upper income, No for low income | Yes for middle to upper income, up to 1200afs. No for low income | Yes for middle to upper income, No for low income | Yes for middle to upper income, No for low income | Yes for middle to upper income, No for low income |
| Willingness to pay? | Yes for middle to upper income, No for low income | Yes for middle to upper income, No for low income | some | some (300 - 500 if poor) | yes if cash available |
| Current demand, future orders | just finished 700, now 500 on order, demand is not an issue | 280 for Save the Children, 60 for private company, 350 for private individuals, demand is not an issue | 10 per month | No | 2000 on order for an NGO, corporate demand is intermittent, private demand volume is not enough to sustain business |
| Competition? | yes, but quality sells | No | none | none | no |
| Methods for marketing | TV, radio, billboards, interviews/demonstrations | demonstrations in mosques and schools | radio, billboard, demonstrations in school and mosque | radio, distribute photos | billboards, radio, |
| No After sales service calls | 4 only | many | 15 Kapisa, 6 Parwan | no - been in Iran | 2 per week |
| Will you continue producing BSF | Yes | Yes | Yes | Yes if there is demand | Yes if there is demand |
| Issues and difficulties? | achieving adequate quality | high price of cement, poor quality sand, lack of local expertise to produce more moulds (only has 4) | | Travelled to Iran after TF project, just returned | marketing |
| Future business plans? | Continue to scale up production | Continue to scale up production | Continue as sideline business, income is not enough alone | Continue as sideline business, income is not enough alone | Continue as sideline business, income from private sales is not enough alone, large NGO orders are better |
| Has your income increased/ quality of life improved? | Yes, about 1000afs more pw (now 6000 afs pw) | yes now 3000afs pw, quality of life has improved | Yes, additional sideline income | Travelled to Iran after project | No same as before |

## Appendix 6: Summary of Focus Group Discussions

| | | | | | |
|---|---|---|---|---|---|
| Village | | Sheraz | Yandagh Aregh | Bako Kham | Khamzerger |
| District | Acha | Mengagic | Acha | Kohistan | Kohistan |
| Province | Jawzjan | Jawzjan | Jawzjan | Kapisa | Kapisa |
| GPS-UTM | | 4100369, 425-0247112 | 3885789, 425-0530915 | 3885502, 425-0527277 | 4081212, 425-0254611 |
| Population | | 435 HH | 205HH | 400HH | 270HH |
| FGD Leader | Murray | Murray | Murray | Murray | Murray |
| FGD Attendees | Combined CDC Leaders | Village Leaders | Village Leaders/Men/Boys | Village CDC Members | Village Leaders/Men/Boys |
| No Participants | 18 | 11 | 14 | 5 | 8 |
| Date | 15/08/2011 | 14/08/2011 | 16/08/2011 | 18/08/2011 | 21/08/2011 |
| | | | | | |
| Greatest benefit of project | Clean water, Improved health, reduced medical bills, saving money | Clean water, improved health, reduced diarrhoea, reduced medical bills, reduced transport bills to see doctor, saving money | Clean water, improved health, reduced diarrhoea, reduced medical bills, saving money | Clean water, Improved health, reduced health expenditure | Clean water, improved health, reduced diarrhoea, reduced medical bills, saving money |
| Recommended improvements | Need to address water quantity as well as quality, especially in dry season - eg. Wells | Need to address water quantity as well as quality, especially in dry season. Only 1 open well in village with sweet water | Need to address water quantity as well as quality, especially in dry season. Need canal cleaning | Need wells for dry season when surface supply is reduced | Distribute more filters for free, |
| Collaboration with others | German Agro Action - water and latrines, Save - flood protection, Red Cross - reservoirs, RRD - water tankering, | GOAL - reservoirs, RRD - water trucking | German Agro Action - hand pump well, RRD - open wells | Mercy Corp - canal cleaning, RRD electricity and roads | Nil |
| Current water sources | Canal - wet season, Wells - dry season | Canal - wet season, Wells - dry season | Local wells in village - dry season, canals and wells - wet season | Canal or stream | Canal and river |
| Was BSF a good solution for drinking water quality | Yes, low operating cost, improved taste when compared with boiling, | Yes, BSF is ideal for treating drinking water from our wet season water source - canals and also our dry season water source - open wells | Yes, 25% have BSF is ideal for treating drinking water from canals and open wells | Yes, BSF is ideal for treating drinking water from our primary water source - canals / streams | Yes, BSF is ideal for treating drinking water from our primary water source - canals / river |
| BSF Coverage in village | | | | | |
| TF | | 27 | 53 | 36 | 36 |
| Private Purchase | | 25 | 12 | 50 | 35 |
| Total No Households | | 500 | 205 | 400 | 270 |

| | | | | | |
|---|---|---|---|---|---|
| Are BSF available in local market | Yes from BSF manufacturers in Morden, Acha, Alam Roch, Hanoch | Yes, from BSF manufacturer in Acha | Yes, from BSF manufacturer in Acha | Yes, from BSF manufacturer in Bako Kham | No, local BSF manufacturer closed business and moved to Iran, and has only just returned |
| What is cost of BSF | 600 - 900AFN depending on location | 600AFN | 800 - 900AFN plus transport (100AFN) | 1000 AFN | 800AFN |
| Are people willing to pay | Yes, according to means | Yes, according to means - difficult for poor when harvest is bad like this year | Yes, according to means - difficult for poor when harvest is bad like this year | Yes for middle to upper income, No for low income | Yes for middle to upper income, No for low income - only willing to pay 300AFN |
| Support for ops and Maint | Yes, from BSF manufacturer | Yes, from BSF manufacturer, and local village training | | Yes, from BSF manufacturer | Yes, from BSF manufacturer now he has returned |
| Other comments | | | | | |