DISTRIBUTION OF ARSENIC BIOSAND FILTERS IN RURAL NEPAL

SLOAN SCHOOL OF MANAGEMENT

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THE G-LAB TEAM

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TABLE OF CONTENTS

A. INTRODUCTION

As part of the G-Lab course, our team completed a study of an Arsenic Bio-sand Filter (ABF) distribution in the South Nepal Terai region. This study was completed through site work in Kathmandu and Birgunj in Nepal and follow-up analysis in Cambridge, USA. This report presents a summary of our findings and recommendations.

1. The Water Problem in Nepal and Arsenic Contamination

Nepal is a developing country in south central Asia landlocked between China to the north and India to the south. The land area is 140,000 km^2 and the year 2000 population is 23 millions, of which 20 million is rural. Nepal is one of the world's poorest and least developed countries. The average annual income per capita is $210 US. About 42% of the people live below the national poverty line. Due to the poor economic conditions and ineffective government institutional programs, proper water and sanitation services are often lacking, resulting in serious health concerns. Furthermore, due to the recent outbreak of a civil war between the so called "Maoists" and the Government, represented by the King, the efforts to address the various health and sanitation problems have been harder than ever. The severity of water problems is even more prominent in remote rural villages. The infant mortality rate is very high at 74/1000 live births, compared with 5/1000 in the U.S. The under-five mortality is even higher at 105/1000 births. 54% of the children suffer from moderate to severe stunting on account of water-borne diseases. Diarrhea diseases kill 44,000 children annually[1].

Recently many water tube wells in the Terai (lower plains in Nepal) tested positive for arsenic, which leads to serious health problems when taken in steady quantities. MIT, Rural Water Supply and Sanitation Support Program (RWSSSP) in Butwal, and the Environment and Public Health Organization (ENPHO) in Kathmandu are working in partnership to help solve the arsenic problem in this region. They have developed two different versions of household Arsenic Biosand Filters (ABFs) that families can use to get rid of arsenic before they use their water for drinking, cooking, washing, etc. Prominent NGOs in Nepal, like the Nepali Red Cross, consider the ABF as a good short-term solution towards the alleviation of the limited access to clean water problem in the South Terai region of Nepal. The Department of Water and Sanitation, a.k.a. DWSS, has already allocated funds to distribute 500 ABFs. In this region, it is estimated that 25+% and 40+% of all tube wells are contaminated with arsenic and pathogens respectively, causing severe health consequences such as cancer and stunting[1]. The project has recently been awarded a World Bank prize of $115k to work further on finding solutions to self-sustainable filter distribution in Nepal.

2. Project Scope

Our team was originally tasked with working on three main areas:

- Evaluate and compare concrete ABFs vs. plastic ABFs in terms of distribution and sustainability;
- Build a business case for local entrepreneurs who can sell/distribute these filters;
- Estimate the cost of expanding filter implementation program to new districts.

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[1] Paragraph taken with permission from The Arsenic Biosand Filter (ABF) Project paper by Tommy Ngai

As we investigated further into what has already been done and the main issues facing the sustainable distribution of these filters, our team expanded and redefined our scope:

- Assessment of the two available ABF types (concrete and Hilltake plastic) and designing an alternative filter with improved cost structure and ease of distribution;
- Prioritization/clustering of districts by various criteria to phase the required activities and investments in certain regions;
- Assessment of adoption and willingness to pay to analyze the required subsidy levels in certain regions;
- Defining the roles and responsibilities of key players in the distribution of ABFs;
- Assessment of the earning potential of local entrepreneurs.

3. Methodology

In writing our report and collecting data to draw our conclusions we used the following resources:

- Database on registered tubewells (level of contamination, number of users, number of households, regions with arsenic problems etc.)
- Field trip to Birgunj and interviews with
    - Local users of already distributed filters
    - The Nepali Red Cross who is the regional NGO in that region
    - Local plastic container retailers
    - Local healthcare workers in the health post
    - Local government
    - Villagers who do not have filters
- Interview with NEWAH, the regional NGO in the far west region
- Interview with UNICEF Nepal
- Interview with IDE, an NGO who sells filters for microbial removal through a private/profit driven distribution network around Kathmandu region
- Interview with GEM, largest plastic container manufacturer and distributor in Nepal
- Data from the National Statistics Bureau

4. Important MIT contacts/lead people for various work streams

ABF Distribution Project On-Site Contact – Tommy Ngai (tommy.ngai@alum.mit.edu)
ABF Product Design and Unit Costs – Basak Yildizbayrak (basaky@sloan.mit.edu)
VDC Segmentation – Nikos Moschos (nmoschos@sloan.mit.edu)
ABF Subsidy Model – Tamer Tamar (tamertamar@sloan.mit.edu)
ABF Distribution Network – Yann Letallec (letallec@mit.edu)

B. EXECUTIVE SUMMARY

1. Short-Term Recommendations

- **Freeze implementation of concrete filter**
  - Concrete filters are not sustainable in the long run due to their high cost; they cost about 60% more than a filter made out of locally available plastic bins.
  - The molds for the concrete and plastic filters that are budgeted for in the World Bank Project should not be manufactured; instead the money should be used to improve the product design, or subsidize promotional filters to be distributed during the awareness workshop.
- **Substitute the green plastic filter with locally available GEM bin**
  - Cut back on spending for plans on implementing the green plastic filter.
  - Green plastic filter is the most expensive filter and costs almost two times the cost of a filter made out of locally available plastic bins.
  - Green plastic bin has a large volume; hence raw materials are not easy for users to carry back home due to the heavy weight of sand.
  - Test the GEM filter in the field as soon as possible. If validated, it should be the short-term technology to be implemented in large scale, contrary to the current plans of Nepali Red Cross and RWSSSP.
- **Segment/prioritize VDCs [2]and attack districts/VDCs based on:**
  - Market size (total number of ABFs needed)
  - Relative income levels
  - Awareness of the arsenic problem
  - Impact
  - Security (put on hold regions where work cannot be completed effectively)
  - Nawalparasi and Rautahat have the priority on the district level, having large potential market for ABFs and the high disposable incomes that contribute to their importance

2. Long-Term Recommendations for Sustainable Filter Distribution

- **Product design should be improved to reduce unit cost**
  - The major cost drivers are the ABF bin and the amount of nails used.
  - Reduce size of ABF (reduce flow rate to 10-15L/hr, while keeping the same arsenic and microbial removal performance) to reduce raw materials required; this will make it both cheaper and easier to produce a filter.
  - Assess performance of proposed alternative designs with custom bins
  - Explore creative substitution of expensive parts in the piping system.

- **Use local NGOs as assemblers and promoters of filters**
  - Some selected local NGOs should be assembly centers and retailers of the ABF filters.
  - These local NGOs should prepare "ready-to-assemble" filter kits (constituted of the assembled parts with the necessary quantities of sand and nail in bags) for users to buy and assemble at home

[2] VDC stands for Village Development Committee, the local administrative unit of the Nepali government.

    - Central purchasing of sub-components combined with the utilization of manufacturers' local agents would be the sourcing alternatives.
    - Promoting should be independently done through radio, newspapers, local agents (healthcare, educational, NGO personnel) and targeted workshops. In the long run, and when and if demand picks up, for-profit organizations can take over.

- **Sustain a large educational and promotional effort of the filter**
    - The current awareness level is low. Moreover, the aware villagers are not necessarily ready to change their attitude and, *a fortiori*, their practice of drinking water.
    - Education provides a compelling reason to buy ABF filters and supports ABF sustainability.
    - Build the critical mass of awareness of the ABF filter so that it promotes itself efficiently by word-of-mouth.
    - Tap into the active network of health NGOs to sustain the education effort about the arsenic problem in the long run.
- **Charge full price to users who can pay**
    - The better-off 10% of the population should be targeted to pay the full cost of the ABF filters to save subsidies for the poorer.
    - Commercial availability (at local merchants) of ABFs at full price will make sure that higher income users will have the opportunity to obtain a filter without putting burden on the subsidy system.
    - Increase willingness to pay by providing opportunity to pay in installments (number of installments should depend on the price of the ultimate filter).

- **Subsidize the rest of the households in VDC's based on their willingness to pay (derived from household income and awareness indices)**
    - The huge gap between filter unit cost and households' average willingness to pay (WTP) requires subsidy support for the ABF distribution to achieve greater health impact and sustainability.
    - By giving a 10% reasonable margin to Local NGO's/entrepreneurs, we will need to have 19M NRs ($273K) worth of subsidy to serve the 17 districts analyzed.
    - Districts that will buy the highest number of filters and require the most level of subsidy are Nawalparasi, Rautahat, Sarlahi and Siraha in order of required subsidy, but this does not mean that they have priority over other districts. The VDC segmentation analysis in this report includes other factors to accurately assess which VDC's have priority over others. (For detailed VDC level of subsidy information, please see Appendix IV)
    - ENPHO should use the detailed VDC level of subsidy analysis (as well as the VDC segmentation analysis) when approaching NGO's to show them how exactly their funds will be used.

C. THE WORLD BANK PROJECT

MIT and two local partners, ENPHO and RWSSSP, have recently been awarded a World Bank prize of $115k to work further on finding solutions to self-sustainable filter distribution in Nepal.

The funding is used to provide startup capital to a pilot technology transfer model. MIT is leading the management of this project among partners and is developing a monitoring and evaluation system. The partners are:

ENPHO: ENPHO is an independent research laboratory and research institute established in Kathmandu in 1990. Their main objectives are to conduct research on public health, water, wastewater, soil, air and sound pollution; to disseminate research findings through public media; and to develop and promote appropriate technologies on water and wastewater treatment, solid waste management, and air emission control. Within the World Bank Project, ENPHO has already started to establish ABF technology centers for enhanced training and research, and to coordinate in-country ABF implementation efforts. They are the providers of technical know-how in ABF making. Finally, they have funding for a parallel Arsenic testing and remediation program with the Nepali Redo Cross[3].

RWSSSP: RWSSSP is a program that is run by a consultant, Plancenter Ltd, in cooperation with the government of Nepal and the government of Finland. Since its initiation in 1990, RWSSSP is working in eight Arsenic affected districts and is currently headquartered in Butwal. This regional NGO, is building capacity in local villages toward safe water provision through training and education of users, technician/ entrepreneurs and authorities. They have already started work on building and distributing filters in their regions. About 500 filters have been distributed so far with some support from Village Development Committees (VDC)[4].

Within this broad project our task is four-fold:

I. Assist with new ABF product design to increase adoption and reduce unit cost
II. Segment VDC's based on various criteria to help target (with funds and time) those that require immediate attention
III. Figure out the VDC-level subsidies required to sustainably distribute ABF's
IV. Identify a distribution network to help with training and filter distribution

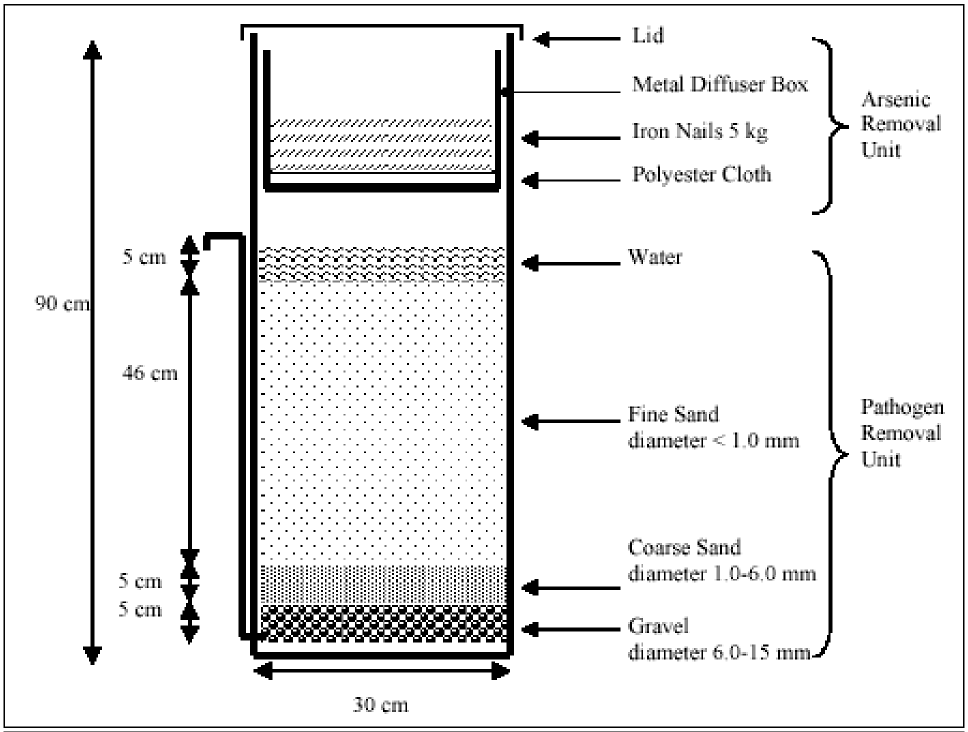
The following sections summarize our findings from each of the four work streams.

[3] Paragraph taken with permission from The Arsenic Biosand Filter (ABF) Project paper by Tommy Ngai
[4] Paragraph taken with permission from The Arsenic Biosand Filter (ABF) Project paper by Tommy Ngai

D. PRODUCT DESIGN AND UNIT COSTS

The arsenic biosand filter mostly consists of a large bin, fine sand, gravel and iron nails in a basin. The media for water filtration is locally available in most areas in Nepal. The sand and gravel need to meet certain specifications and need to be transported in large quantities from riverbanks. The nails are locally available almost everywhere in Nepal.

Diagram 1: The Arsenic Biosand Filter (ABF) Diagram[5]



The MIT/ENPHO/RWSSSP partnership has two different types of ABF in the field: the concrete ABF and the green plastic ABF. The concrete filter has been more actively implemented due to the fact that it is easier to implement locally with the help of the users themselves whereas the green ABF needs to be manufactured in Kathmandu and distributed to the districts. Both filters perform very well and it has been up to the regional NGO to decide which type of filter they wish to distribute under their jurisdictions. For example, RWSSSP is continuing the distribution of concrete filters whereas the Nepal Red Cross has indicated that they would only consider the green plastic ABF.

Both filters have certain advantages; and their technical performance is agreed to be superior to six other alternatives that have been tested so far in Nepal[6].

[5] The Arsenic Biosand Filter (ABF) Project: Design Of An Appropriate Household Drinking Water Filter for Rural Nepal, July 2003, by Tommy Ngai & Anil Sophic Walewijk
[6] See http://ceemeng.mit.edu/~waterdocuments for prior work on arsenic in Nepal

1. Existing Filters

Diagram 2: The Concrete Arsenic Biosand Filter and the Metal Diffuser Basin Used for Nails

Diagram 3: Green Plastic ABF

Both types of filters have certain disadvantages. Although both filters' technical performance is extremely good, the manufacturing processes are not commercially very feasible. Further analysis of ABF costs reveal the high costs involved in making these filters.

Table 1: Comparison of Concrete and Green Plastic ABF

	Advantages	**Disadvantages**
Concrete Filter	• All materials are locally available • Users can contribute to the building of the filter with their labor[7]	• Takes time to build the cement body for the filter • Requires investment in steel molds (2 per VDC) • Heavy and difficult to move • Metal basin is custom manufactured; hence expensive • Requires skilled labor training in using molds and manufacturing concrete bodies for the filters
Green Plastic Filter (Hilltake)	• Is light and easy to carry around • Looks more pleasant to the eye • Does not require too much training in filter assembly • More durable than concrete bin • Has a higher flow rate and larger capacity	• Requires distribution to all districts because it can only be produced in Kathmandu • Requires more raw materials due to larger size • Costs more than the concrete filter

Considering the fact that a poor rural household can have an income anywhere between NRs 30,000[8] to NRs 70,000 in the Terai region, the cost of these filters is significant. So far these filters have been distributed to households thanks to donors, but in the long run the high cost will hinder adoption.

Table 2: Unit Costs of Concrete and Plastic ABF

Filter Unit Costs (NRs)	**Concrete Filter**	**Green Plastic Filter**
Bin + lid	445	1300
Diffuser basin	250	75
Piping (materials)	98	174
Piping (labor)	0	12.5
Raw Materials (RM)	387	389
Fine Sand	1.3	2.3
Coarse Sand	0.6	1.1
Gravel	0.9	1.6
Iron nails	350	350
Chlorine liquid	34	34
RM Transportation Costs	23	41

[7] This advantage is not being utilized with the current distribution model where VDCs centrally manage and manufacture filters

[8] 1US$ = NRs 73.7

Filter Unit Costs (NRs)	Concrete Filter	Green Plastic Filter
Local Bin Distribution Costs	30	50
Educational Documentation	25	25
RM Packaging [9]	15	15
Labor (Piping & RM Preparation)	210	68
Total Variable Unit Cost	**1,483**	**2,137**
Contribution to Fixed Costs		
Molds	150	0
Tools	24	5
TOTAL UNIT COST	**1,657**	**2,142**

2. Alternative Filter Designs

Initially our task was to compare these two different types of ABF and recommend one of them for feasible distribution. However, considering the cost of the filters and the users' capacity to pay, it was clear that both filters were expensive. Our team believed that more work was required in product design to improve the cost of the ABF that is needed by so many people. Even if certain donors have the financial capacity to subsidize these filters for some households, given a donor's budget, a lower-cost filter means that more people can benefit from this technology to improve their drinking water.

Combining the cost structure of existing filters and technical expertise on the filter, high level insights can be drawn as follows:

- Major cost drivers are the filter bin, the amount of nails and sand used
- To reduce the cost of the filter, we need a smaller filter that has comparable performance which is possible
- A smaller ABF is likely to have a slower flow rate; however, the current rate of 25L/hr is a very good flow rate compared with those of other types of household drinking water filters. This can be compromised to the 10-15 L/hr level. This trade-off is required to achieve a more cost effective ABF.

Before we considered new alternative ABF designs, we identified five criteria to use in improving the product/filter design:

- Reduced unit cost
- Locally available plastic containers if applicable
- Slower flow rate; target of 10-15 L/hr vs. 25L/hr for original ABF
- Comparable arsenic and microbial removal
- At least 5 L of basin capacity for ease of use

[9] This can be a deposit – users can get back their money when they bring back packaging materials to be reused

After a few shopping trips to the local stores to see available bin types and also a meeting with GEM, the largest plastic manufacturer in Nepal, we decided to further investigate two different ABF designs.

Diagram 4: Alternative ABF Designs with Locally Available Plastic Containers

The GEM 505 Bin Filter (no lid)

Shresta Bin Filter

The plastic containers in both these alternative designs are locally available in most small towns. However, we also met wit GEM, the leading manufacturer in Nepal, to discuss the possibility of buying these materials in bulk to reduce unit costs. Although GEM quoted wholesale prices for 500 pieces or more, during our field trip we found out that local dealers would also quote prices similar to the wholesale price if 10 or 15 units were purchased. Hence the real cost of a GEM bin filter is likely to be closer to NRs 1200. Moreover, if the expensive lid can be replaced by a cheaper cover solution (e.g. hard cardboard) the cost of the filter would further be reduced.

Table 3: Unit Costs of Alternative Filters Made with Locally Available Plastic Materials

Filter Unit Costs (NRs)	**GEM Bin Filter (Retail)**	**GEM Bin Filter (Wholesale)**	**Shresta Bin (Retail)**
Container	500[10]	303	200
Lid		102	0
Diffuser basin	90	75	60
Piping (materials)	133	133	133
Raw Materials (RM)	387	387	388
Fine Sand	1.0	1.0	0.9
Coarse Sand	0.9	0.9	1.2
Gravel	1.3	1.3	1.7
Iron nails	350	350	350
Piyush	34	34	34
RM Transportation	20	20	20
Local bin distribution	15	15	30

[10] Includes price of lid

Filter Unit Costs (NRs)	GEM Bin Filter (Retail)	GEM Bin Filter (Wholesale)	Shresta Bin (Retail)
Labor (Piping & RM prep)	54	54	54
Educational Docs.	25	25	25
RM Packaging	15	15	15
Variable Unit Cost	**1,239**	**1,129**	**925**
Contribution to Fixed Costs			
Filter mold	0	0	0
Tools	5	5	5
TOTAL UNIT COST	**1,244**	**1,134**	**930**

Moreover, in the future this same design can be used in other parts of the country just for filters for removing pathogens. This filter without the nails could be sold as a microbial removal filter and would cost about NRs 830. Then the local entrepreneurs can apply their expertise in building the ABF filter to building regular biosand filters for a wider geography to include regions where there is only microbial contamination. The calculated above filter cost is an estimate. Entrepreneurs will have a slightly different costs because of different transportation and labor costs, or bargaining skills.

Table 4: Comparison of Alternative Filter Designs

	Advantages	**Disadvantages**
GEM 50L Bin (Model 505)	• All materials are locally available • Very little skilled labor required to assemble filter • Fast to assemble filter • High flow rate of 15 L/hr • Is light and easy to carry around • Local perception of closer to a water container than a garbage can • Cheaper than original filters	• Performance is untested; height could be an issue in microbial removal efficiency • 6 months of field test required before wide distribution
60L Black Bin	• All materials are locally available • Very little skilled labor required to assemble filter • Fast to assemble filter • Cheaper than original filters	• Is not very pleasant to the eye • Performance is untested • 6 months of field tests required before wide distribution • Small water basin; would require more often water replenishment • Not as good quality plastic materials as the GEM 50L bin filter

Although these two alternative designs can be assembled much more cheaply and the plastic containers are themselves light weight, they both are still heavy when raw materials are included. As a next step in the analysis we also investigated yet smaller filter bins that could be custom manufactured and would require much less raw materials. Unfortunately, the analysis revealed that not a significant amount of iron nails (major cost driver of raw materials) could be eliminated if an acceptable level of performance were to be sustained in the custom bin filters.

The custom-made bins would require initial investment in a plastic mold that can be used to produce the bins of the required dimensions. This mold is estimated to be around $2000-$3000 based on earlier quotes given to ENPHO. However, given the new dimensions of the custom bins another set of meetings with plastic manufacturers are necessary to find out exactly the cost of the mold and the unit price of custom made bins. A cost model has been set up and given to the project team to update the analysis as more information becomes available through discussions with mold and plastic manufacturers.

Table 5: Comparison of Original and Alternative Filter Designs

Filter Type	**Flow Rate (L/hr)**	**Size of Diffuser Basin (L)**	**Total Cost (NRs)**
Custom Bin v1.a	10	6	897
Black Bin Retail	15	5	930
Custom Bin v2.a	10	9	942
Custom Bin v1.b	12	6	974
Custom Bin v2.b	12	9	1,024
Custom Bin v1.c	15	6	1,081
New GEM Filter Wholesale	15	19	1,134
Custom Bin v2.c	15	9	1,137
New GEM Filter Retail	15	19	1,244
Concrete Filter	15	23	1,657
Green Plastic Filter	25	19	2,142

The custom bin dimensions have been determined so that locally available small plastic containers can be used as diffuser basins eliminating the need for custom-made diffuser basins. Several alternatives have also been explored based on 3 different flow rates and 2 different diffuser basin sizes. A preliminary and aggressive estimate of costs of filters with custom bins can be seen in Appendix I. Unless significant cost improvements can be achieved through custom bins – which looks highly unlikely – the additional hidden cost of complicating the distribution system cannot be justified.

Our short-term recommendation is to test the GEM Model 505 50L bin as soon as possible and substitute concrete and green plastic filters with this new design if performance test results are satisfactory. In the long term a cheaper and easier-to-use alternative can be investigated although the incremental savings in cost will be marginal. The GEM filter is currently the best alternative both from cost and ease-of-use perspectives.

E. VDC SEGMENTATION

In order to better understand the different regions' needs and the level of arsenic problem we segmented the regions by using currently available data. Since the ABF implementation program has limited resources, these should be used in VDCs and Districts where the need is the greatest.

To prioritize the regions our team came up with a set of criteria, based on which we compared and graded the VDCs. This quantitative approach coupled with two qualitative criteria, civil unrest and existence of local partners, helped form the final list. We discussed our choice of the criteria with ENPHO; however, the weight of each criterion, as it appears in the current database, is our best judgment and can be easily changed in the model should ENPHO or partners see fit.

Table 6: Key Criteria Used in VDC Prioritization – Main Categories

Weight	Criteria & Descriptions
37.5%	**Market size:** Number of filters necessary per VDC. The existing tested tubewells database by ENPHO was used and the market was sized based on number of households drinking from tubewells where the arsenic contamination was above 50 pbb
27.5%	**Disposable income per household:** Due to lack of concrete data, this criterion was calculated as a function of average salaries per region and percentages of employed people per region
22.5%	**Awareness:** Split into three sub-criteria: (i) Degree of awareness about the arsenic problem, as qualitatively provided by local experts, (ii) Literacy levels, (iii) Proportion of households having radio facility
12.5%	**Impact:** Split into two sub-criteria: (i) Percentage of children below the age of ten, over total population, (ii) Proportion of malnourished children under 3 years of age, the later as a proxy for general health conditions

We were requested to view the whole problem from a business prospective. Therefore, we gave "Market size" and "Disposable Income" the biggest weights. Obviously, the bigger the potential demand for a product and the higher the ability of the potential customers to pay for it, the higher the adoption rate of this new product. Nevertheless, if the whole concept is seen from an "Impact" perspective, i.e. giving higher priority to regions where the severity of the problem is highest, then weighting would be different and the last criterion would be weighted higher.

Finally, "Awareness" is a factor that catalyses the diffusion of the product and hence it was given a moderate weight.

Furthermore, as mentioned above, two qualitative criteria are necessary, in order to have a more complete approach to the regions' prioritization. The first one involves civil unrest. The current Maoist/government security issue is one of major importance to the implementation of any initiative in Nepal. Therefore, VDCs should first be selected based on the severity of this problem in the region, as it is anticipated that it will be much harder to launch the ABF initiative where unrest is high.

The second qualitative criterion has to do with the existence of local partners. In case there are local players in a District who can act as local entrepreneurs, then it makes sense to use the above quantitative criteria and prioritize the District's VDCs.

Method used
In order to grade each VDC as per the above criteria, we used an indexed method, i.e., for each criterion, we calculated the average and the standard deviation and then scored each VDC based on the following function: Criterion weight x (Score-AVG) / STDEV. To illustrate this further let's take the following example:

> The average Market size was 51 filters necessary per VDC (see explanation below about actual market size and market size as per current testing). The standard deviation was about 92. Mahottari Sonaul VDC had a score of 55, i.e. 55 filters were found necessary for that VDC. This gave this district a grade for the Market criterion of 1.83 = 37.5 x (55 – 51) / 92. This approach was followed for the rest of the criteria.

Sources used
The number of ABFs was calculated based on the ENPHO tubewell database. It should be noted that this database is not complete, but rather it reflects the current information available, which covers about 7% of all the Tubewells in the Terai region. UNICEF is currently engaged in comprehensive testing of all Tubewells in the Terai region. It is expected to be finalized by end of May. Once the UNICEF blanket testing is finalized, then the relevant information can be added to the database and allow for far more accurate results. The above explains why some VDCs have a very low market score, as it might very well be that in the regions of these VDCs the current state of the database is less up-to-date than that in other regions.

The "Degree of Awareness" is as per the relevant interview with NEWAH and ENPHO experts. The raw data show a qualitative grade of each district with regard to the people's awareness about the arsenic problem. Furthermore, the "Degree of Awareness" is considered as a combination of mass media advertising and local workshops.

"Unemployment level", "Children bellow 10", and "Literacy level" are as per Census 2001 data.

Proportion of malnourished children under 3 years and proportion of households having radio facility are as per the Central bureau of statistics "District Level indicators of Nepal for Monitoring overall development" study.

Results
For the results of the VDC segmentation see Appendix II. As a general remark one can identify that, as expected, the VDCs where the demand is high and/or the disposable income is high, tend to take the highest positions in the overall ranking. Ramgram N.P. from the Nawalparaisi District got the highest rank among all VDCs, mainly due to the very high "Market size". Balubari in the Japa District got the absolutely lowest rank because they ranked 6th from the end in terms of "Market size", last in terms of "Income" and fourth from the end in terms of "Impact". Nawalparasi and Rautahat ranked the highest on a District level, having a large ABF market and a very high disposable income.

It should be noted again that these results are based on the current data availability and should be updated when the UNICEF blanket testing is finished and maybe when additional disposable income data emerges.

F. ABF SUBSIDY MODEL

Segmentation of VDCs based on immediacy of action gives us a plan to start targeting villages and districts to mitigate arsenic contaminated water problems within constraints. However, we also need to gain an understanding of the overall levels of funding required to support the ABF project. By coming up with a model that identifies the level of subsidy required by VDC (subsidy determined here is only applicable to filter manufacturing and distribution, excluding training and promotion), we aimed not only to figure out the uses of funds, but also to have a ready model to use while negotiating with NGO's such as UNICEF and Nepal Red Cross. We also incorporated the entrepreneur's distribution profit margin into the model to monitor what happens to subsidy required per VDC/District when profit margin is altered.

The ABF Subsidy Model has many complex components that are outlined clearly in the file "Subsidy Model Final V3.xls"; however, here we will briefly go over the main drivers of level of subsidy per VDC. There are four major drivers to calculate subsidies:

Filter Cost: ABF cost is an input into the subsidy model to determine the "Uses of Funds". As mentioned earlier in the paper, there are 11-12 different versions of the ABF depending on the bin size, the diffuser basin size and the flow rate. The ABF cost varies from NRs 916 to NRs 2,142. We assume for the purposes of our calculation that the filter used will be GEM 505 (at wholesale price) that costs NRs 1,149. This can easily be modified in our model to see the impact on subsidy requirements. The filter cost will be the base from which all the sources of funds will be subtracted from to determine subsidy level. (Sources of funds are NGO subsidy, household payments and VDC support which for now we assume zero.)

Market Size: As mentioned earlier in the paper, Market Size is the number of filters necessary per VDC. The existing tested tubewells database by ENPHO was used and the market was sized based on number of households drinking from tubewells where the arsenic contamination was above 50 pbb. The Required Filters number was extrapolated from the sample data to the population by using the affected number of people as a percentage of total households. This number is vital, as it gives us the maximum number of filters we can sell in each VDC. However, we still need to treat it with caution. Although the sample data contains about 7% of the population's tubewells, we still need to update these figures as data from additional tubewells become available. Currently, in the 17 districts that we have analyzed, the total number of Required Filters is more than 40,000 and the average number of filters per VDC is 275.

Adoption & Willingness to Pay: Now that we have the maximum number of filters that could be sold in each VDC based on current knowledge, we need to take it one step further and assess how much we can sell. Ideally, we should have an income segmentation for each VDC, find out how many people in each income bracket are willing to buy at their reservation prices. This methodology, although solid, requires a lot of data currently not available. Therefore, we chose a more basic approach to this problem. The data that we collected showed us what percentage of their income people were willing to give up on average for the ABF. Based on the Goini and Jawa villages, these percentages are 0.3% and 0.4% (of annual income) respectively. These percentages are realistic; based on a survey done on ABF willingness to pay in Nepal, the willingness to pay ranges from 0.2% to 1% of income (Our field studies also confirmed that households –except very wealthy ones– are willing to pay up to NRs 600 /1.0% of income)

Now that we know the ranges of how much people could pay as a percentage of their annual income, we can use this information along with total household income and adoption rate (% of target households buying filters) to find estimated number of filters sold and the NR/$ value of purchases. We first assumed an adoption rate of 50% for all VDC's (this was derived from the adoption rate of 66% from the Goini village where arsenic awareness is very high) to find the maximum number of filters we can sell in the 17 Terai districts. This meant that of all the affected households, we can hope capture up to 50% of them. To convert the number of filters sold to NR/$ value of purchases, we used Willingness To Pay and Household Income figures. Using the conservative floor number of 0.2% of annual income and the ceiling number of 1.0%, and the VDC household income figures (obtained by using a combination of % employment, literacy rates, skilled and unskilled labor wage numbers by VDC), we estimated by VDC the floor and ceiling numbers for the total NR/$ amount households would be willing to pay. In this calculation, VDC's took on Willingness To Pay values between 0.2% of household income and 1.0% of income based on an awareness figure called ABF Awareness Index (calculated using Literacy rates at the VDC level, and radio facility and general awareness levels at the district level). VDC's were divided into quartiles (1 being the most aware and 4 the least aware) based on this index, with the best quartile getting Willingness To Pay percentage of 1.0%, and the lowest quartile getting 0.2%.The matrix below summarizes the Willingness To Pay percentages we used to calculate the total income we expect to get from selling of filters in each VDC:

ABF Awareness Index Quartile	**1**	**2**	**3**	**4**
Price/Income % - Realistic Scenario	0.5%	0.4%	0.3%	0.2%
Price/Income % - Optimistic Scenario	1.0%	0.8%	0.6%	0.4%
Adoption of Target Households	50%	50%	50%	50%

We applied the above percentages under the realistic scenario to the households in VDCs (except the rich 10% of households, 50% of which would be willing to buy the ABF at full cost) to find the total capturable income from ABF sales. Additional sources of funds could be VDC (as an organization)-contribution, which could be as high as NRs 25,000/VDC. However, we take the conservative route of assuming these will be zero in the foreseeable future due to Maoist-government conflict.

Putting all these together we get the basic formula for required subsidies:

<u>Total subsidy required is **Total Filter Cost – Total Filter Income – Total VDC support**</u>.

However, there is one more variable that impacts the subsidy levels, which is Entrepreneur Profit Margin.

Entrepreneur Gross Profit Margin: For the ABF distribution to work sustainably, we need to have local NGO's/entrepreneurs incentivized to sell the ABF. This means profit opportunity. At a reasonable rate of 10% margin (on the total cost of filter) entrepreneurs can make a decent living based on the adoption and Willingness To Pay assumptions we have laid out, and also on how many entrepreneurs cover one district. The 10% margin gives us a required subsidy for the 17 districts of NRs 19M ($273K), resulting in total entrepreneur profit of NRs 2.3M ($33K). Districts that will buy the highest number of filters and require the highest level of subsidy are Nawalparasi, Rautahat, Sarlahi and Siraha in order of magnitude.

The assumptions and data we have laid out above should be continually updated with:

- — Accurate (but very hard to get) VDC-level household incomes
- — Adoption rates and Willingness To Pay in pilot villages
- — Changing VDC awareness levels
- — More tube well test data
- — Changing ABF costs
- — VDC contribution under stable conditions

What we have outlined above and the Summary Table below (under the assumptions of 10% entrepreneur margin and realistic adoption Willingness To Pay) should help ENPHO estimate funding needs and resources for different scenarios, therefore equipping them well before subsidy meetings with NGO's.

Table 7: Summary of ABF Subsidies Required – by District

Filter	*Gem 505*					
Basin	Gem 1700	**Flow Rate (L/hr)**	15	**Diffuser Basin Volume**	19	
DISTRICT	**Required # of Filters**	**Assumed Filter Unit Sales**	**ABF Quartile**	**Cost of Filters**	**Total Required Subsidy**	**Gross Margin for District Entrepreneur**
Banke	1,854	927	2	1,065,502	861,110	106,550
Bara	1,767	883	3	1,015,229	873,634	101,523
Bardiya	2,723	1,361	2	1,564,480	1,266,596	156,448
Dhanusa	1,543	771	4	886,652	805,382	88,665
Jhapa	159	80	1	91,597	75,870	9,160
Kailali	3,565	1,782	1	2,048,379	1,564,303	204,838
Kanchanpur	2,316	1,158	2	1,331,127	1,077,503	133,113
Kapilbastu	1,065	532	2	611,798	489,661	61,180
Mahottari	229	114	4	131,433	119,452	13,143
Morang	842	421	1	484,030	377,708	48,403
Nawalparasi	7,600	3,800	1	4,367,316	3,308,396	436,732
Parsa	955	477	3	548,740	471,173	54,874

Rautahat	6,166	3,083	3	3,543,069	2,937,814	354,307
Rupandehi	1,515	758	1	870,630	695,444	87,063
Saptari	258	129	3	148,106	123,282	14,811
Sarlahi	4,092	2,046	4	2,351,179	2,118,987	235,118
Siraha	3,760	1,880	4	2,160,704	1,954,219	216,070
TOTAL (NRs)	**40,408**	**20,204**		**23,219,970**	**19,120,532**	**2,321,997**
TOTAL ($)				**$331,714**	**$273,150**	**$33,171**

The district-level subsidy required above is further detailed at the VDC level in Appendix IV.

Subsidy Analysis Conclusion

We believe that the ABF filters cannot be distributed sustainably without subsidy support. Given the relatively low level of awareness in villages concerning the arsenic contaminated water problem (and the existence of ABF to resolve this problem) and the inability of VDC's to contribute funds due to Maoist issues, the full cost of these filters can not be recovered from villagers in the near to medium-term. Therefore, we need to ensure that we have a subsidy plan, whereby we know by VDC how much subsidy would be required to supply the required filters given the entrepreneur's profit needs.

Our model indicates that NRs 19M ($273K) worth of subsidies are needed to provide Terai population with the 40,408 filters that they need, including a 10% margin per filter to entrepreneurs. ENPHO should use this and the detailed VDC level of subsidy analysis (as well as the VDC prioritization analysis) when approaching NGOs and other donors to show them how exactly their funds will be used. We believe that this approach will signal credibility with MIT/ENPHO/RWSSSP partnership, and encourage NGOs to lend money knowing where the funds will be used.

We urge the MIT/ENPHO/RWSSSP team to update the model based on new accurate information that will be received in the future. Also one key decision will be to determine how many entrepreneurs will be serving a district. We leave that decision to ENPHO, as based on entrepreneur's selling ability, it will be easier to understand how many will be needed with the money that they will be making (currently set at 10% gross margin).

G. DISTRIBUTION NETWORK

1. Supply chain architecture

An important motivation for the new ABF filter designs (with GEM and black bins), beyond the reduction of the operational costs, is the availability of the parts in all major marketplaces in Nepal. As a result, the distribution network can be very simple to set up and operate.

The supply chain is comprised of three layers:

- Manufacturers who produce the parts needed for the ABF.
- Distributors who make these parts available in the main marketplaces of Nepal.
- Local entrepreneurs who collect from dealers the parts needed for the construction of the ABF filter. In addition, they are responsible for the assembly of an easy-to-assemble ABF kit for customers. In compensation, they collect the full price of the filter, which includes parts costs, labor costs and a reasonable fixed profit per filter.

2. Size of the distribution network

Although the Terai region covers almost one third of Nepal, it is a relatively small region, and there will be only a handful of distributors to supply parts for the filters. All of them will probably be concentrated in 2 to 5 marketplaces in the south of Nepal.

On the other hand, the network of local entrepreneurs should make the product available locally. More precisely, any villager should be able to visit a local entrepreneur during one of its weekly trips to near-by towns or marketplaces.

Let us consider the example of Nawalparasi District. It would be enough to have entrepreneurs in Parasi, Sunwal, Bardaghat (or perhaps Panchanagar) and Simara, or even a subset of these places. The final decision needs to factor in the presence of reliable entrepreneurs (e.g. trusted NGOs), the availability of parts and the actual frequenting of these locations by villagers.

Extrapolating from this example, less than 5 entrepreneurs are needed per district. This small number would benefit the supply chain of the ABF because inventories, expertise and demand will be pooled in a few places. As a result, the costs are decreased, the quality of product and service increased, and the whole system is easier to manage.

3. Three supply chain scenarios:

1. A large order, probably from an NGO with money for a mass distribution of ABF filters. In this case, the number of filters to be produced and distributed is planned in advance. The entrepreneur then places an order for the parts required by the order, perhaps builds temporarily the capacity to assemble this large volume (e.g. hire workers). Moreover, the entrepreneur could arrange for the shipment of the kits where it is demanded.
2. Small uncoordinated orders of filters placed by villagers. The demand is fulfilled from a small inventory –e.g. a few filters up to 15 pieces- held by the entrepreneur. To reduce inventory costs and needed cash advances, the

entrepreneur should only rotate his or her inventory according to demand. For example, if the replenishment time for the filter is one week (i.e. there one week delay between a replenishment order is placed and the replenishment takes place) and the weekly demand amounts to 10 filters, the entrepreneur should hold an inventory of approximately 10-15 pieces.

3. Direct marketing of filters. The entrepreneur puts cash up front to assemble a larger inventory of filters and then goes to potential customers to sell his product. In this case, it is harder for the local entrepreneur to have other activities at the same time although he could push different products and services simultaneously. Moreover, he or she needs to pay fixed transportation costs (e.g. truck rental), which might not be recoverable if the filter's price and the sales volume are low.

Except for specific situations, case #3 is unlikely. On the other hand, it is not clear that any institution has any funding available now to place large orders of ABF filters. Only the second scenario could be at work in the near future to provide filters to people already willing to buy full price. Anyway, these three scenarios can be handled by the same supply chain architecture (described above), with minor modifications.

4. Local Entrepreneurs' Business case

Sustainability of the local entrepreneurs

Local entrepreneurs generally face fixed costs on the one hand and per unit costs and revenues on the other hand. Would there be no fixed cost, the activity of local entrepreneurs would be sustainable as long as they distribute the filter at a higher price per unit than the cost per unit. But usually, there are fixed costs for the premises, or when the entrepreneur is paid a fixed daily/monthly salary. As a result, an entrepreneur would be in a sustainable situation if and only if the margin per filter times the number of distributed filters is bigger than its fixed costs.

SUSTAINABLE <=> margin per unit x number of units > fixed cost

A local entrepreneur could be easily sustainable if he or she incurs no fixed costs, or more realistically, if he or she has other activities paying for these fixed costs. For example, a large NGO would pay for its premises and some staff members anyway thanks to other activities and funding. Then the organization may be compensated for its work as a local entrepreneur only on the basis of the number of ABF filters distributed.

Recruitment of local entrepreneurs

Here are some criteria that could drive the identification and selection of local entrepreneurs:

- Among solid NGO (e.g. Nepal Red Cross, NEWAH), trusted local NGOs, local retailers (e.g. plastic retailers or dealers), user groups, health clinics
- Good location (see section above on the size of the distribution network)
- Brand name trusted by villagers
- Available premises
- Other related professional activities. Because it is unlikely that, in the short-term, the volume of filter sales could sustain a full-time worker.

- Social and/or health awareness
- Reliable for quality, finance, information-sharing
- Ability to provide installment to ABF buyers is a plus
- Better if local entrepreneurs are not totally independent for management/control/communication purposes (e.g. Nepal Red Cross offices at different places).

5. Business Model

The objective of the ABF initiative is social, namely to mitigate the arsenic contamination of water. The ABF technology is the best technology available to the rural population of poor developing countries. Thus, the business model should be conceived bearing in mind the two objectives: maximizing health impact of the ABF and securing a sustainable financial solution.

<u>Need for subsidies</u>
Since Nepal is one of the poorest countries in the world, a water filter, even priced around $10, is an investment that not all villagers can afford. More importantly, the population is not aware (yet) of the deadly consequences of arsenic on their health to make this purchase compelling. As a result, part of the population will need subsidies to buy filters.

<u>Users should pay part of the production costs</u>
The level of subsidies to allocate to whom is an important issue to address. The beneficiaries of subsidized filters should gain ownership of their ABF according to the best practices in the development world. Indeed, a significant contribution from the beneficiary will prove his or her real interest for the filter and guarantee that it will be used and properly maintained. Labor payments cannot achieve this goal since villagers can only contribute very little to the assembly of ABFs. Thus, they should pay part of the production cost of the filter according to their resources.

<u>Health impact</u>
The maximum health impact will not be achieved when all the households drinking arsenic contaminated water will have an ABF, but when they will use it systematically. Obviously, this objective requires the mass distribution of filters, but also the education of the concerned populations. Awareness programs and the promotion of filters would be mostly carried out by NGOs, possibly with the help of local governmental organizations. This topic will be discussed in a latter section on the promotion of the filters.

<u>Prioritization of the villages</u>
Given the limited amount of resources available to the project, health impact should be the main driver in the prioritization of villages. In particular, this includes the severity of the contamination, the availability of alternative drinking water sources and the number of people dependent on contaminated tube wells, but also the ease of operations in this village. Moreover, the poorest households should have priority for the subsidies since they will have the most difficulties to find the resources to buy a filter.

<u>Sustainability</u>

Extrapolating from ENPHO database on contaminated water sources and preliminary results of the on-going blanket testing of tube wells, there are approximately 500,000 people drinking arsenic contaminated water in Nepal. Fully subsidizing all the needed filters (say around 100,000 ABF) would costs around $1.5 million dollars. The Nepali government ought to be held responsible for providing safe drinking water to its population and hence financing arsenic mitigation solutions in Terai. However, nothing can be expected soon given the political situation of the government and the difficult socio-economic situation of the country. Money is particularly scarce in Nepal both in the governmental and non-governmental arenas, and many important projects compete for the existing funding. As a result, the ABF initiative needs to achieve health impact and secure its sustainability with limited resources.

<u>The business model should not depend totally on subsidies</u>
In order to start mitigating the arsenic problem in Nepal in the short-term, filters should be sold even though there is little or no money available now to subsidize any of them. More importantly, the business model needs to be robust to the availability of subsidies at any time. Significant funding should be available soon from partner NGOs but such a favorable situation will not last forever, or at best, will have ups and downs. Therefore, the supply chain should not rely strongly on this funding. Nonetheless, as suggested in the previous section on local entrepreneurs, the supply chain could rely on solid NGOs to distribute ABF filters. Indeed, these organizations can easily bear the fixed costs of distributing filters (say the premises and office hour costs), while being remunerated for each assembly of filter.

<u>An exit strategy</u>
In the long run, the amount of subsidies available for ABFs will shrink. By that time, the ABF filters should penetrate the market so that all villagers would buy them at full price. A latrine project has already shown that the willingness to pay for a product increases as more people adopt the product (Tommi Ngai, personal communication, March 2004).

At the same time, the ABF could become a commodity available in stores so that the social entrepreneurs would be able to withdraw from the distribution of ABFs to focus on their new priorities.

6. Promotion of ABF

The education of the local population about the arsenic problem and the promotion of mitigation solutions needs to be at the center of the ABF initiative. The harmful consequences of arsenic exposure are not immediate, and often years pass before the first symptoms appear. As a matter of fact, the importance of the problem in Terai was unrecognized until as late as 1999 with the first tube wells testing. We should not assume any demand for arsenic filters *a priori* because most of the Nepalese population is not aware of the problem yet –although they have been living with it for decades (the exposure to arsenic increased dramatically after the massive substitution of tube wells for other surface water sources, which are usually not contaminated with arsenic)- and the rural households, who are the main victims, have little resources to buy a filter. Only a convincing awareness campaign could provide them with a compelling reason to buy a filter and to use it.

Awareness programs and the promotion of filters would be mostly carried out by NGOs. In this task, they could be helped by governmental organizations such as VDCs or health posts. Some interviews suggested that local clubs and concerned villagers could lead health initiatives, as well but they will need some additional training and guidance. More generally, an expertise pool on arsenic is needed to provide educational material and train all the possible promoters of the ABF.

The direct promotion of ABFs in villages is the most effective awareness program. For example, a workshop is organized in a village to demonstrate why and how the filter can be used. Such a direct approach was successfully used by International Development Enterprises (www.ideorg.org) to promote their irrigation system. An interview with them confirmed their conviction that it is a very efficient approach for developing countries.

Three points could increase the impact of educational arsenic-awareness workshop.

1. First, villagers need to taste the ABF filtered water to witness its better color, odor and taste. If the health argument is not convincing enough, the sight, odor and taste of the treated water could be decisive.
2. Second, the event could be used to distribute a few demonstration filters so that ABFs would stay in the village environment once the workshop is over. In this case, subsidies for these filters need to be included in the workshops budget.
3. Lastly, a local network of promoters such as teachers, health workers, government representatives or any socially aware person could be started at the workshop. These people, convinced of the advantages of the ABF and knowledgeable about arsenic, would promote the filter in their social circle. In particular, health workers would keep educating their patients and the teachers their students during the health education classes.

Unfortunately, workshops are expensive and their number will be limited. On the other hand, the current pilot projects show that education takes a long time. Thus, resources should be allocated to this effort accordingly and other awareness initiatives need to take over from the workshops. Fortunately, the Nepal Red Cross, and most likely all the major health NGOs, will be continuously present on the field and are willing to sustain the health education effort in the long run.

In addition, media campaigns could spread knowledge of the arsenic problems. However, it is not clear whether it is efficient to change people attitudes towards drinking water, and *a fortiori* their practice.

H. CONCLUSION

The arsenic contamination of drinking water has only been diagnosed recently in Nepal. At first, its scale was underestimated, but in reality it concerns most of the Terai region so that the mitigation of this problem is a major health issue of Nepal. The Arsenic Biosand Filter is one of the best technologies available to filter arsenic at the household level.

Still, the present report provides some recommendations how to improve the filter design in order to reduce production costs and increase social acceptability. In addition, it features an analysis of the different VDC's needs and the level of arsenic problem based on extensive field data. As a result, we derive a detailed subsidy model that estimates the number of filters and the amount of subsidies needed per district. A very realistic supply chain scheme is presented to distribute and promote the ABF filters at the required scale in the Terai region. Finally, the business case of local entrepreneurs and the sustainability of the whole initiative are analyzed.

If the ABF project makes all the hopes for safer drinking water a reality in rural Nepal as it is poised for, the project could scale up to different countries suffering from arsenic contaminated water such as Bangladesh.

APPENDIX I – CUSTOM BIN COST ESTIMATES

Estimating Unit Price for Custom-Made Bins

Flow Rate	Custom Bin v1 10L/hr	Custom Bin v1 15L/hr	Custom Bin v1 20L/hr	Custom Bin v2 10L/hr	Custom Bin v2 15L/hr	Custom Bin v2 20L/hr	Cost/ 1m2 S. Area (Rs)
Diameter (m)	0.22	0.25	0.28	0.22	0.25	0.28	
Height (m)	0.56	0.56	0.56	0.65	0.65	0.65	
Surface Area (m2)	0.42	0.49	0.55	0.49	0.56	0.63	512
Estimated Bin Cost	**218**	**250**	**284**	**249**	**286**	**324**	
Estimated transportation cost from Kathmandu	26	26	26	26	26	26	
Estimated Bin Price	**243**	**276**	**309**	**275**	**312**	**350**	

Underestimates unit costs; bases bin costs on surface area and current cost/m2 of existing containers
Assumes that the manufacturer will produce in large batches e.g. at least 1000 at a time
Frequent smaller batch sizes is likely to lead to a higher price per bin
Disadvantage: manufacturer is likely to argue much higher price than fair price since this is a custom product

Breakdown of ABF Costs with Custom-Made Bins

ABF Unit Costs (NRs)	**Custom Bin v1.a**	**Custom Bin v1.b**	**Custom Bin v1.c**	**Custom Bin v2.a**	**Custom Bin v2.b**	**Custom Bin v2.c**
Container	243	276	309	275	312	350
Lid	11	11	11	13	13	13
Basin	35	35	35	44	44	44
Piping (materials)	133	133	133	133	133	133
Raw Materials	256	299	369	257	299	369
Fine Sand	0.4	0.5	0.6	0.5	0.6	0.8
Coarse Sand	0.3	0.4	0.5	0.4	0.5	0.6
Gravel	0.7	0.9	1.1	0.7	0.9	1.1
Iron nails	238	280	350	238	280	350
Piyush	17	17	17	17	17	17
Sand & gravel transportation	8	10	13	10	12	15
Local bin distribution	25	25	25	25	25	27
Labor (Piping & RM prep)	40	40	40	40	40	40
Educational Documentation	25	25	25	25	25	25
RM Packaging	15	15	15	15	15	15
Variable Unit Cost	**792**	**869**	**976**	**837**	**919**	**1,032**
Contribution to Fixed Costs						
Filter mold	100	100	100	100	100	100
Tools	5	5	5	5	5	5
Total Cost	**897**	**974**	**1,081**	**942**	**1,024**	**1,137**

More analysis and assumptions can be found at in the file Filter Costs.xls

APPENDIX II – RESULTS OF VDC SEGMENTATION

District	VDC name	MARKET SIZE (# of filters needed)	MARKET SIZE Rank	Disposable Income per household (in NERs)	INCOME Rank	Degree of awareness	Literacy level	Proportion of households having radio facility	AWARENESS Rank	Children bellow 10	Proportion of malnourished children under 3 years	IMPACT Rank	Total Grade	Total Rank
Nawalparasi	RamgramN.P.	871	1	55,208	81	5	58.1%	4.13	19	25.6%	10.59	121	**330.32**	**1**
Rautahat	Sangrampur	320	2	63,790	28	5	39.2%	4.54	58	25.7%	11.91	90	**129.38**	**2**
Nawalparasi	Tilakpur	277	3	64,328	26	5	54.1%	4.13	28	26.2%	10.59	112	**117.16**	**3**
Rautahat	RampurKhap	263	4	61,373	45	5	20.2%	4.54	113	30.9%	11.91	12	**101.93**	**4**
Nawalparasi	Manari	211	8	63,203	37	5	55.3%	4.13	26	27.2%	10.59	99	**89.84**	**5**
Rautahat	Jowaha(Jokaha)	225	6	58,533	59	5	34.8%	4.54	74	30.0%	11.91	31	**82.96**	**6**
Bara	PaparpatiJabdi	10	96	91,844	1	4	31.2%	0.48	132	31.0%	7.94	106	**74.99**	**7**
Nawalparasi	Somani	75	26	77,224	5	5	37.8%	4.13	65	27.9%	10.59	89	**71.48**	**8**
Kapilbastu	Udayapur	45	44	77,856	3	5	39.3%	2.14	87	29.0%	12.10	43	**66.32**	**9**
Nawalparasi	ThuloKhairatawa	32	58	77,715	4	5	36.8%	4.13	71	29.0%	10.59	78	**58.00**	**10**
Bardiya	Gulariya N.P.	256	5	51,150	107	3	49.3%	16.10	56	28.6%	8.53	123	**57.14**	**11**
Kapilbastu	Mahendrakot	211	8	50,235	114	5	66.4%	2.14	21	25.0%	12.10	95	**50.00**	**12**
Kapilbastu	Sauraha	6	118	78,526	2	5	35.4%	2.14	96	28.8%	12.10	48	**49.98**	**13**
Nawalparasi	Pratappur	94	19	66,186	20	5	53.8%	4.13	29	26.0%	10.59	116	**47.87**	**14**
Kapilbastu	Parsohiya	11	94	75,531	7	5	46.4%	2.14	70	28.2%	12.10	54	**46.88**	**15**
Rupandehi	Devadaha	222	7	45,287	140	5	70.3%	17.00	2	25.1%	9.08	143	**46.27**	**16**
Nawalparasi	Sunwal	209	10	48,368	128	5	71.2%	4.13	9	25.2%	10.59	124	**45.13**	**17**
Nawalparasi	Panchanagar	148	12	57,264	65	5	68.3%	4.13	11	24.0%	10.59	134	**43.92**	**18**
Nawalparasi	Jahada	87	23	63,498	30	5	68.0%	4.13	12	24.4%	10.59	129	**39.73**	**19**
Rautahat	NarkatiyaGuthi	53	39	66,479	19	5	42.7%	4.54	51	28.6%	11.91	52	**38.85**	**20**
Parsa	Basantpur	124	14	58,800	56	4	35.9%	4.13	102	30.6%	11.97	19	**38.22**	**21**
Parsa	Alau	25	62	69,831	11	4	37.2%	4.13	99	32.2%	11.97	2	**38.03**	**22**
Rautahat	LaxmipurBelbichawa	65	33	63,450	33	5	38.6%	4.54	60	30.9%	11.91	12	**37.96**	**23**
Kailali	Ratanpur	3	138	76,117	6	2	55.6%	25.78	31	26.9%	8.90	132	**37.24**	**24**
Nawalparasi	GuthiSuryapura	38	49	69,971	10	5	48.3%	4.13	42	26.6%	10.59	109	**35.66**	**25**
Kanchanpur	Sankarpur	5	124	74,587	8	2	37.8%	22.93	83	29.8%	10.42	70	**34.90**	**26**
Kapilbastu	Dubiya	72	29	63,299	36	5	58.5%	2.14	40	26.5%	12.10	81	**34.72**	**27**
Parsa	ShivaWorga	88	22	61,284	47	4	36.7%	4.13	100	31.1%	11.97	8	**33.23**	**28**
Kapilbastu	Thunhiya	74	27	64,917	23	5	41.7%	2.14	79	27.1%	12.10	71	**33.14**	**29**
Parsa	ParsauniBirta	22	68	69,231	13	4	35.0%	4.13	105	29.7%	11.97	32	**27.10**	**30**
Rautahat	Bishrampur	120	15	56,300	72	5	29.1%	4.54	86	28.7%	11.91	51	**26.57**	**31**
Rupandehi	Harnaiya	5	124	63,497	31	5	55.0%	17.00	7	30.9%	9.08	85	**22.94**	**32**
Bara	Motisar	37	50	69,442	12	4	56.0%	0.48	67	29.0%	7.94	127	**22.86**	**33**
Bara	Bahuari	42	47	67,533	18	4	56.6%	0.48	64	30.0%	7.94	119	**21.65**	**34**
Nawalparasi	Rampurkha	62	34	58,410	61	5	50.2%	4.13	39	29.8%	10.59	66	**18.05**	**35**
Rautahat	Raghunathpur	147	13	51,058	108	5	20.9%	4.54	107	29.2%	11.91	47	**17.72**	**36**
Kapilbastu	Jahadi	8	108	65,146	21	5	44.1%	2.14	76	30.5%	12.10	16	**17.17**	**37**
Bara	Purainiya	71	30	61,208	48	4	39.8%	0.48	110	34.7%	7.94	56	**16.71**	**38**
Rautahat	RamoliBairiya	118	16	50,878	109	5	36.4%	4.54	69	30.3%	11.91	28	**16.66**	**39**
Kapilbastu	Barakulpur	12	90	64,597	25	5	50.6%	2.14	57	28.9%	12.10	46	**16.42**	**40**
Bara	Basantpur	20	70	69,068	14	4	41.8%	0.48	104	32.5%	7.94	87	**16.07**	**41**
Bara	Bishrampur	37	50	67,929	17	4	46.3%	0.48	91	30.3%	7.94	115	**16.05**	**42**
Nawalparasi	Makar	110	18	52,496	102	5	73.0%	4.13	8	24.0%	10.59	135	**15.69**	**43**
Kapilbastu	Ajigara	10	96	70,865	9	5	23.3%	2.14	128	26.7%	12.10	77	**14.99**	**44**
Rautahat	SakhuwaDhamaura	186	11	43,517	145	5	20.2%	4.54	112	30.6%	11.91	22	**12.89**	**45**
Parsa	Hariharpur	73	28	60,029	55	4	29.8%	4.13	120	28.5%	11.97	53	**12.52**	**46**
Bara	Matiarwa	24	66	68,400	15	4	32.5%	0.48	127	33.2%	7.94	80	**12.46**	**47**
Bara	Batara	93	20	61,325	46	4	36.4%	0.48	121	29.9%	7.94	120	**11.31**	**48**
Kapilbastu	Rajpur	20	70	64,985	22	5	30.0%	2.14	115	29.5%	12.10	33	**11.25**	**49**
Parsa	Lakhanpur	86	24	56,571	68	4	32.3%	4.13	116	29.4%	11.97	40	**10.45**	**50**
Rautahat	Santpur(Matiaun)	20	70	63,349	34	5	49.8%	4.54	36	25.1%	11.91	98	**10.06**	**51**
Banke	Binauna	5	124	60,106	53	4	46.5%	18.58	27	30.5%	11.68	30	**9.45**	**52**
Rautahat	Lokaha	89	21	52,661	99	5	32.1%	4.54	78	30.6%	11.91	21	**9.10**	**53**
Kapilbastu	Chanai	11	94	62,434	40	5	45.3%	2.14	73	29.0%	12.10	41	**6.64**	**54**
Banke	Titihiriya	14	86	61,689	44	4	47.4%	18.58	24	25.9%	11.68	91	**6.41**	**55**
Kailali	KotaTulsipur	37	50	60,792	50	2	49.9%	25.78	45	29.6%	8.90	105	**6.39**	**56**
Nawalparasi	Hakui	33	57	60,069	54	5	47.8%	4.13	43	28.3%	10.59	86	**6.19**	**57**
Nawalparasi	Sarawal	47	43	58,698	58	5	48.4%	4.13	41	27.1%	10.59	100	**4.89**	**58**
Kapilbastu	Harduona	16	80	63,469	32	5	31.0%	2.14	108	29.3%	12.10	38	**4.75**	**59**
Kanchanpur	Sreepur	10	96	62,795	38	2	57.8%	22.93	38	27.6%	10.42	97	**4.24**	**60**
Rupandehi	Chhipagada	5	124	60,380	52	5	41.8%	17.00	13	29.3%	9.08	104	**1.74**	**61**
Nawalparasi	RampurKhadauna	14	86	64,266	27	5	38.5%	4.13	63	26.2%	10.59	113	**1.30**	**62**
Rautahat	Tejapakar	10	96	64,856	24	5	38.4%	4.54	62	23.8%	11.91	117	**1.10**	**63**
Bara	Bishunpur	10	96	68,183	16	4	21.2%	0.48	143	33.5%	7.94	75	**0.66**	**64**

District	VDC name	MARKET SIZE (# of filters needed)	MARKET SIZE Rank	Disposable Income per household (in NERs)	INCOME Rank	Degree of awareness	Literacy level	Proportion of households having radio facility	AWARENESS Rank	Children bellow 10	Proportion of malnourished children under 3 years	IMPACT Rank	Total Grade	Total Rank
Parsa	BageshwariTirtrona	25	62	61,185	49	4	28.1%	4.13	122	30.3%	11.97	27	**0.51**	**65**
Rautahat	Bariyarpur	62	34	53,449	92	5	35.4%	4.54	72	29.5%	11.91	39	**(0.62)**	**66**
Bara	DharmaNagar	48	42	63,342	35	4	46.5%	0.48	89	27.7%	7.94	138	**(0.81)**	**67**
Banke	Laxmanpur	2	140	62,134	42	4	19.4%	18.58	90	30.1%	11.68	35	**(1.31)**	**68**
Kailali	RamsikharJhala	4	133	60,689	51	2	55.9%	25.78	30	30.3%	8.90	93	**(2.28)**	**69**
Kailali	Darakh	43	45	56,573	67	2	52.6%	25.78	37	29.7%	8.90	103	**(2.96)**	**70**
Rautahat	Malahi	12	90	56,344	71	5	34.5%	4.54	75	33.0%	11.91	1	**(3.03)**	**71**
Saptari	Saraswor	8	108	63,557	29	3	46.4%	8.59	81	27.7%	10.72	88	**(3.08)**	**72**
Rautahat	Mathiya	67	31	52,131	104	5	36.9%	4.54	66	28.9%	11.91	49	**(3.54)**	**73**
Parsa	HariharpurBirta	8	108	57,513	64	4	49.2%	4.13	68	31.0%	11.97	10	**(4.82)**	**74**
Nawalparasi	Swathi	114	17	47,197	134	5	61.7%	4.13	15	24.2%	10.59	130	**(5.06)**	**75**
Rautahat	Dumariya(Matiauna)	55	37	52,607	100	5	45.9%	4.54	46	27.3%	11.91	74	**(6.24)**	**76**
Parsa	Masihani	10	96	62,017	43	4	25.6%	4.13	129	29.5%	11.97	37	**(6.49)**	**77**
Sarlahi	Salempur	14	86	62,318	41	3	39.7%	2.80	130	28.1%	11.76	63	**(8.50)**	**78**
Rautahat	Bagahi	82	25	48,467	127	5	28.3%	4.54	88	30.7%	11.91	18	**(9.02)**	**79**
Bara	Chhatawa	18	77	62,637	39	4	33.5%	0.48	124	31.9%	7.94	92	**(11.23)**	**80**
Nawalparasi	Jamuniya	5	124	57,631	63	5	60.9%	4.13	16	25.4%	10.59	122	**(13.44)**	**81**
Rautahat	GamhariyaBirta	60	36	48,193	129	5	38.6%	4.54	61	30.6%	11.91	22	**(13.51)**	**82**
Parsa	Bagahi	15	81	56,415	70	4	33.2%	4.13	109	31.1%	11.97	6	**(13.77)**	**83**
Bara	Raghunathpur	35	54	58,764	57	4	39.4%	0.48	114	31.7%	7.94	94	**(13.90)**	**84**
Parsa	BeriyaBirta	25	62	58,463	60	4	20.3%	4.13	136	29.5%	11.97	36	**(14.51)**	**85**
Bara	Barainiya	67	31	55,847	75	4	38.9%	0.48	117	30.1%	7.94	118	**(14.75)**	**86**
Rautahat	Judibela	37	50	52,969	96	5	56.0%	4.54	22	23.9%	11.91	114	**(15.83)**	**87**
Kapilbastu	Jayanagar	5	124	54,465	88	5	60.6%	2.14	35	27.8%	12.10	60	**(16.08)**	**88**
Rautahat	HadiryaPaltuwa	35	54	55,970	74	5	20.3%	4.54	111	27.6%	11.91	67	**(16.78)**	**89**
Kapilbastu	Budhi	19	76	53,540	91	5	57.2%	2.14	44	27.2%	12.10	68	**(16.79)**	**90**
Kailali	Pahalmanpur	18	77	55,055	82	2	53.5%	25.78	34	29.1%	8.90	110	**(18.88)**	**91**
Rupandehi	Dudharakchhe	49	41	46,530	136	5	73.5%	17.00	1	24.9%	9.08	146	**(19.18)**	**92**
Parsa	Janakitala	20	70	55,523	78	4	26.5%	4.13	126	30.4%	11.97	26	**(20.26)**	**93**
Morang	Katahari	10	96	50,727	110	4	50.7%	17.91	14	28.0%	11.60	69	**(20.60)**	**94**
Rautahat	PatharaBudharampur	8	108	54,622	87	5	25.4%	4.54	94	30.5%	11.91	25	**(21.62)**	**95**
Banke	Nepalgunj N.P.	1	142	52,681	98	4	74.3%	18.58	6	22.1%	11.68	137	**(23.11)**	**96**
Dhanusha	Suganikash	4	133	55,773	76	3	39.7%	7.32	123	30.6%	12.29	7	**(23.39)**	**97**
Bara	Kalaiya N.P.	25	62	57,895	62	4	59.9%	0.48	55	26.4%	7.94	147	**(23.69)**	**98**
Rupandehi	Gajedi	15	81	49,251	121	5	62.8%	17.00	5	27.2%	9.08	126	**(23.86)**	**99**
Rautahat	Jethrahiya	7	113	52,220	103	5	29.6%	4.54	82	31.8%	11.91	3	**(24.02)**	**100**
Dhanusha	Basbitti	12	90	56,536	69	3	37.2%	7.32	131	28.7%	12.29	45	**(24.11)**	**101**
Kanchanpur	Pipaladi	4	133	51,792	106	2	59.4%	22.93	33	30.6%	10.42	59	**(24.45)**	**102**
Siraha	Arnamalalpur	35	54	54,890	84	3	35.3%	2.28	137	29.9%	11.03	55	**(24.87)**	**103**
Siraha	Belaha	5	124	54,759	85	3	49.9%	2.28	106	31.6%	11.03	29	**(25.09)**	**104**
Sarlahi	Musauli	15	81	55,222	80	3	36.0%	2.80	134	30.8%	11.76	24	**(25.74)**	**105**
Rupandehi	Bairghat	6	118	53,108	93	5	46.4%	17.00	10	26.6%	9.08	131	**(25.80)**	**106**
Rupandehi	Parroha	7	113	50,176	115	5	69.0%	17.00	3	25.3%	9.08	142	**(25.87)**	**107**
Sarlahi	Khutauna	28	60	54,361	89	3	34.0%	2.80	139	30.0%	11.76	34	**(26.45)**	**108**
Rautahat	Sarmujawa	6	118	52,937	97	5	25.0%	4.54	97	31.1%	11.91	11	**(26.54)**	**109**
Bara	Banjariya	31	59	54,981	83	4	42.9%	0.48	101	31.3%	7.94	102	**(26.71)**	**110**
Rautahat	Samanpur	43	45	49,111	122	5	30.9%	4.54	80	28.0%	11.91	61	**(28.52)**	**111**
Nawalparasi	Sukrauli	24	66	52,597	101	5	41.9%	4.13	54	26.6%	10.59	108	**(28.78)**	**112**
Kanchanpur	Jhalari	1	142	53,098	94	2	63.2%	22.93	25	26.7%	10.42	111	**(29.71)**	**113**
Kanchanpur	Parasan	2	140	51,966	105	2	49.6%	22.93	53	30.7%	10.42	57	**(29.72)**	**114**
Rautahat	FatuhaMaheshpur	6	118	55,399	79	5	18.3%	4.54	119	28.0%	11.91	62	**(30.43)**	**115**
Dhanusha	Inarwa	3	138	56,778	66	3	36.2%	7.32	133	27.1%	12.29	65	**(31.81)**	**116**
Mahottari	Sonaul	55	37	49,092	123	3	31.2%	3.33	145	30.9%	12.27	5	**(31.96)**	**117**
Kailali	Bhajani	1	142	55,526	77	2	44.7%	25.78	52	27.7%	8.90	125	**(32.89)**	**118**
Bardiya	Jamuni	50	40	47,847	131	3	68.2%	16.10	17	26.2%	8.53	141	**(33.33)**	**119**
Rautahat	Debahi	18	77	50,634	111	5	25.2%	4.54	95	29.3%	11.91	42	**(33.39)**	**120**
Sarlahi	Gamhariya	14	86	53,056	95	3	34.1%	2.80	138	31.0%	11.76	17	**(33.49)**	**121**
Kailali	Basauti	4	133	54,629	86	2	55.0%	25.78	32	25.9%	8.90	140	**(33.67)**	**122**
Bardiya	Sorhawa	20	70	53,980	90	3	48.0%	16.10	59	27.2%	8.53	136	**(34.31)**	**123**
Rautahat	Mithuawa	6	118	48,012	130	5	33.6%	4.54	77	31.6%	11.91	4	**(36.02)**	**124**
Kapilbastu	Motipur	7	113	49,605	117	5	67.5%	2.14	20	24.3%	12.10	107	**(36.48)**	**125**
Sarlahi	Kodena	40	48	49,679	116	3	26.0%	2.80	146	31.4%	11.76	9	**(37.02)**	**126**
Rautahat	Khesarhiya	10	96	48,562	126	5	29.5%	4.54	84	30.7%	11.91	20	**(37.43)**	**127**
Rautahat	Rajdevi	12	90	49,385	119	5	29.2%	4.54	85	28.9%	11.91	50	**(38.94)**	**128**
Rupandehi	DayaNagar	8	108	46,935	135	5	63.6%	17.00	4	25.1%	9.08	145	**(39.27)**	**129**
Bara	LaxmipurKotwali	15	81	56,231	73	4	15.7%	0.48	147	31.6%	7.94	96	**(43.33)**	**130**
Bardiya	Deudakala	22	68	49,486	118	3	53.4%	16.10	48	27.4%	8.53	133	**(44.31)**	**131**
Banke	Holiya	26	61	46,328	138	4	18.9%	18.58	92	28.6%	11.68	58	**(46.03)**	**132**
Rautahat	Basantapatti	15	81	45,891	139	5	24.7%	4.54	98	30.8%	11.91	14	**(46.13)**	**133**

District	VDC name	MARKET SIZE (# of filters needed)	MARKET SIZE Rank	Disposable Income per household (in NERs)	INCOME Rank	Degree of awareness	Literacy level	Proportion of households having radio facility	AWARENESS Rank	Children bellow 10	Proportion of malnourished children under 3 years	IMPACT Rank	Total Grade	Total Rank
Kanchanpur	Daijee	1	142	47,845	132	2	52.7%	22.93	49	28.8%	10.42	84	**(46.51)**	**134**
Sarlahi	Bhadsar	10	96	49,347	120	3	41.2%	2.80	125	29.6%	11.76	44	**(46.89)**	**135**
Dhanusha	Jhatiyahi	10	96	48,906	124	3	31.2%	7.32	141	30.2%	12.29	15	**(48.56)**	**136**
Kailali	Narayanpur	1	142	50,287	113	2	47.4%	25.78	50	27.4%	8.90	128	**(48.82)**	**137**
Parsa	Langadi	5	124	48,777	125	4	39.2%	4.13	93	27.0%	11.97	76	**(49.95)**	**138**
Kanchanpur	Dekhatbhuli	7	113	44,619	143	2	53.9%	22.93	47	30.2%	10.42	64	**(50.13)**	**139**
Sarlahi	Achalgadh	10	96	50,386	112	3	34.0%	2.80	140	27.6%	11.76	72	**(52.72)**	**140**
Bardiya	Sanashree	6	118	46,501	137	3	67.8%	16.10	18	26.5%	8.53	139	**(54.79)**	**141**
Siraha	Siraha N.P.	5	124	44,853	142	3	46.4%	2.28	118	28.3%	11.03	79	**(67.36)**	**142**
Dhanusha	RamaidaiyaBhawadi	20	70	43,884	144	3	30.8%	7.32	142	26.7%	12.29	73	**(69.93)**	**143**
Dhanusha	Baniniya	10	96	45,268	141	3	33.0%	7.32	135	25.9%	12.29	83	**(70.48)**	**144**
Sarlahi	Balara	4	133	43,141	146	3	50.2%	2.80	103	26.9%	11.76	82	**(71.21)**	**145**
Siraha	Radhopur	7	113	47,579	133	3	29.9%	2.28	144	26.4%	11.03	101	**(71.72)**	**146**
Jhapa	Balubari	1	142	39,124	147	4	54.3%	15.22	23	23.1%	10.33	144	**(83.55)**	**147**

APPENDIX III - PHOTOGRAPHS

Mass production of concrete filters in a VDC

Shopping Trip to Local Stores (Left to right Tommy Ngai, Nikos Moschos (standing), Yann Letallec)

APPENDIX IV – SUBSIDY & ENTREPRENEUR MARGIN BY VDC

VDC name (Sorted by Filters Required)	*# of Filters Required*	ABF Quartile	*Filter Unit Sales*	Cost of Filters	Subsidy per Filter	Required Subsidy	Entrepreneur Gross Margin
SirahaN.P.	2,696	4	1348	1,549,361	1,053	1,418,980	154,936
RamgramN.P.	1,847	1	923	1,061,261	876	808,492	106,126
Panchanagar	1,420	1	710	815,849	866	614,598	81,585
GulariyaN.P.	1,373	2	687	789,108	943	647,760	78,911
Devadaha	1,264	1	632	726,227	923	583,034	72,623
KotaTulsipur	993	2	497	570,659	907	450,247	57,066
Gamhariya	948	4	474	544,755	1,037	491,524	54,475
Kodena	873	4	436	501,370	1,043	455,178	50,137
Sanashree	849	1	425	488,112	917	389,420	48,811
Katahari	842	1	421	484,030	897	377,708	48,403
Dekhatbhuli	767	2	383	440,458	968	371,073	44,046
Laxmanpur	743	3	372	426,954	961	356,899	42,695
Pratappur	722	1	361	414,958	823	297,296	41,496
Tejapakar	697	2	349	400,521	891	310,628	40,052
Darakh	674	1	337	387,570	869	293,073	38,757
Sangrampur	657	2	329	377,694	895	294,254	37,769
Rajdevi	657	3	329	377,536	997	327,525	37,754
Sunwal	639	1	319	366,985	908	289,953	36,699
Dumariya(Matiauna)	624	2	312	358,410	938	292,484	35,841
RamaidaiyaBhawadi	611	4	305	351,020	1,054	322,044	35,102
RamsikharJhala	608	1	304	349,378	850	258,249	34,938
Belaha	602	3	301	346,013	982	295,567	34,601
Bhadsar	559	4	280	321,221	1,044	291,803	32,122
Salempur	474	4	237	272,521	1,019	241,719	27,252
Pipaladi	468	1	234	269,185	892	208,871	26,918
SakhuwaDhamaura	466	4	233	267,636	1,055	245,705	26,764
LaxmipurKotwali	443	4	221	254,276	1,031	228,096	25,428
Jowaha(Jokaha)	441	2	221	253,692	915	202,057	25,369

VDC name (Sorted by Filters Required)	*# of Filters Required*	ABF Quartile	*Filter Unit Sales*	Cost of Filters	Subsidy per Filter	Required Subsidy	Entrepreneur Gross Margin
Tilakpur	432	1	216	248,347	832	179,835	24,835
Khutauna	421	4	211	242,095	1,034	217,917	24,210
Manari	419	1	209	240,663	838	175,390	24,066
Makar	417	1	208	239,384	888	185,051	23,938
Basauti	401	1	201	230,429	878	176,097	23,043
Jamuni	384	1	192	220,615	911	174,782	22,062
Sreepur	373	2	187	214,364	899	167,713	21,436

SUBSIDY & ENTREPRENEUR MARGIN BY VDC (continued)

VDC name (Sorted by Filters Required)	*# of Filters Required*	ABF Quartile	*Filter Unit Sales*	Cost of Filters	Subsidy per Filter	Required Subsidy	Entrepreneur Gross Margin
Binauna	363	1	181	208,545	852	154,653	20,854
Holiya	346	3	173	198,646	1,006	173,838	19,865
RampurKhap	345	4	172	198,197	1,021	176,105	19,820
Sankarpur	317	3	159	182,207	925	146,684	18,221
Hakui	316	2	158	181,797	910	143,872	18,180
Mahendrakot	311	1	156	178,755	899	139,854	17,876
Suganikash	308	4	154	176,988	1,032	158,899	17,699
Arnamalalpur	307	4	154	176,568	1,033	158,780	17,657
Pahalmanpur	295	1	148	169,772	876	129,443	16,977
Achalgadh	293	4	147	168,368	1,042	152,659	16,837
Raghunathpur	290	3	145	166,446	992	143,707	16,645
Musauli	281	4	140	161,308	1,033	144,969	16,131
Swathi	268	1	134	153,725	914	122,201	15,373
NepalgunjN.P.	265	1	132	152,163	888	117,511	15,216
Saraswor	258	3	129	148,106	957	123,282	14,811
Bishrampur	247	3	123	141,873	977	120,647	14,187
Ratanpur	247	1	123	141,705	776	95,708	14,171
RamoliBairiya	245	2	122	140,530	944	115,484	14,053

VDC name (Sorted by Filters Required)	*# of Filters Required*	ABF Quartile	*Filter Unit Sales*	Cost of Filters	Subsidy per Filter	Required Subsidy	Entrepreneur Gross Margin
Balara	243	3	121	139,541	1,015	123,217	13,954
Rampurwa	242	2	121	139,107	894	108,157	13,911
Bhajani	234	2	117	134,218	927	108,235	13,422
Sonaul	229	4	114	131,433	1,045	119,452	13,143
Daijee	218	2	109	125,473	956	104,369	12,547
Basantpur	217	3	109	124,851	970	105,398	12,485
Inarwa	217	4	108	124,552	1,030	111,615	12,455
Jahada	201	1	101	115,663	836	84,152	11,566
Somani	200	2	100	114,842	844	84,370	11,484
Barainiya	180	4	90	103,322	1,032	92,749	10,332
Bariyarpur	179	2	89	102,783	935	83,591	10,278
Purainiya	177	4	89	101,859	1,021	90,533	10,186
Jhatiyahi	177	4	88	101,658	1,045	92,422	10,166
Dubiya	175	2	87	100,438	897	78,413	10,044
Samanpur	166	3	83	95,221	998	82,672	9,522
Thunhiya	165	3	83	94,935	953	78,703	9,494
Balubari	159	1	80	91,597	952	75,870	9,160

SUBSIDY & ENTREPRENEUR MARGIN BY VDC (continued)

VDC name (Sorted by Filters Required)	*# of Filters Required*	ABF Quartile	*Filter Unit Sales*	Cost of Filters	Subsidy per Filter	Required Subsidy	Entrepreneur Gross Margin
Bahuari	158	2	79	90,860	881	69,663	9,086
Sarawal	158	2	79	90,644	915	72,146	9,064
Baniniya	156	4	78	89,643	1,052	82,038	8,964
Radhopur	154	4	77	88,762	1,047	80,893	8,876
KalaiyaN.P.	147	2	73	84,428	918	67,422	8,443
Bishunpur	146	4	73	83,897	1,008	73,601	8,390
Sukrauli	142	2	71	81,807	938	66,762	8,181
Titihiriya	138	1	69	79,194	845	58,210	7,919

VDC name (Sorted by Filters Required)	*# of Filters Required*	ABF Quartile	*Filter Unit Sales*	Cost of Filters	Subsidy per Filter	Required Subsidy	Entrepreneur Gross Margin
NarkatiyaGuthi	132	2	66	75,827	885	58,401	7,583
Lokaha	129	3	64	73,948	988	63,551	7,395
Langadi	123	3	62	70,824	999	61,549	7,082
LaxmipurBelbichawa	118	2	59	67,681	897	52,805	6,768
Bagahi	116	3	58	66,419	1,000	57,772	6,642
ThuloKhairatawa	116	2	58	66,408	842	48,680	6,641
Santpur(Matiaun)	115	1	58	66,135	837	48,158	6,614
GamhariyaBirta	115	2	57	66,031	955	54,849	6,603
Lakhanpur	114	4	57	65,233	1,030	58,479	6,523
Narayanpur	113	2	56	64,647	947	53,251	6,465
Mathiya	111	2	55	63,657	940	52,048	6,366
ShivaWorga	98	3	49	56,178	963	47,078	5,618
Raghunathpur	95	4	47	54,350	1,026	48,526	5,435
Jhalari	94	1	47	53,837	886	41,484	5,384
Dudharakchhe	93	1	47	53,482	917	42,662	5,348
Udayapur	91	3	46	52,330	916	41,704	5,233
Hariharpur	88	4	44	50,385	1,024	44,881	5,039
Chanai	85	2	42	48,701	901	38,160	4,870
ParsauniBirta	84	3	42	48,461	940	39,656	4,846
Parasan	79	2	40	45,601	940	37,310	4,560
Judibela	77	1	38	44,074	886	33,984	4,407
Batara	76	4	38	43,445	1,021	38,606	4,344
Basbitti	74	4	37	42,791	1,030	38,363	4,279
DharmaNagar	72	3	36	41,281	957	34,384	4,128
Deudakala	65	2	32	37,116	950	30,672	3,712
Banjariya	64	3	32	36,513	981	31,170	3,651
Bagahi	63	3	32	36,394	977	30,938	3,639
HadiryaPaltuwa	63	4	32	36,244	1,031	32,528	3,624

SUBSIDY & ENTREPRENEUR MARGIN BY VDC (continued)

VDC name	*# of Filters Required*	ABF Quartile	*Filter Unit Sales*	Cost of Filters	Subsidy / Filter	Required Subsidy	Entrepreneur Margin
Motisar	62	2	31	35,732	874	27,170	3,573
Bishrampur	58	3	29	33,285	944	27,345	3,328
Chhipagada	54	1	27	30,929	851	22,901	3,093
Sorhawa	51	2	26	29,528	933	23,962	2,953
Ajigara	50	4	25	29,008	1,003	25,319	2,901
Alau	50	3	25	28,761	939	23,493	2,876
Debahi	48	3	24	27,865	993	24,088	2,787
BeriyaBirta	42	4	21	23,995	1,027	21,436	2,400
Budhi	40	2	20	22,831	934	18,561	2,283
BageshwariTirtrona	37	4	18	20,998	1,022	18,664	2,100
Rajpur	34	4	17	19,353	1,014	17,080	1,935
Basantpur	33	3	17	18,969	941	15,530	1,897
GuthiSuryapura	32	2	16	18,152	872	13,771	1,815
DayaNagar	31	1	15	17,560	915	13,978	1,756
Barakulpur	29	2	14	16,619	892	12,903	1,662
Basantapatti	29	3	14	16,477	1,007	14,437	1,648
Harduona	28	3	14	15,909	957	13,246	1,591
Matiarwa	25	4	13	14,609	1,008	12,810	1,461
Gajedi	24	1	12	14,065	904	11,061	1,406
Khesarhiya	23	3	11	13,077	999	11,371	1,308
Chhatawa	22	4	11	12,483	1,019	11,065	1,248
Jethrahiya	21	3	11	12,191	989	10,491	1,219
Parroha	21	1	11	12,108	899	9,476	1,211
Bairghat	20	1	10	11,693	886	9,010	1,169
Motipur	19	1	10	10,940	902	8,588	1,094
Janakitala	18	4	9	10,068	1,032	9,043	1,007
Jamuniya	17	1	9	9,988	864	7,509	999
Mithuawa	14	3	7	8,153	1,001	7,101	815
Malahi		3	7				

VDC name	*# of Filters Required*	ABF Quartile	*Filter Unit Sales*	Cost of Filters	Subsidy / Filter	Required Subsidy	Entrepreneur Margin
	14			7,812	977	6,642	781
RampurKhadauna	13	2	7	7,733	916	6,162	773
Parsohiya	13	2	7	7,674	851	5,681	767
HariharpurBirta	12	2	6	7,061	919	5,647	706
Jahadi	11	3	5	6,107	952	5,060	611
Sarmujawa	10	3	5	6,001	987	5,153	600
PaparpatiJabdi	10	4	5	5,922	963	4,963	592
PatharaBudharampur	10	3	5	5,725	982	4,892	572
Masihani	10	4	5	5,532	1,020	4,909	553
FatuhaMaheshpur	9	4	5	5,214	1,033	4,684	521
Harnaiya	8	1	4	4,567	836	3,322	457
Jayanagar	7	1	4	4,252	879	3,252	425
Sauraha	7	3	3	3,944	914	3,136	394

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