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The Application of a Cost Benefit Approach on Rural Water Supply Projects

A Minor Field Study of UNICEF's Water Supply Project in Udaipur in Rajahastan

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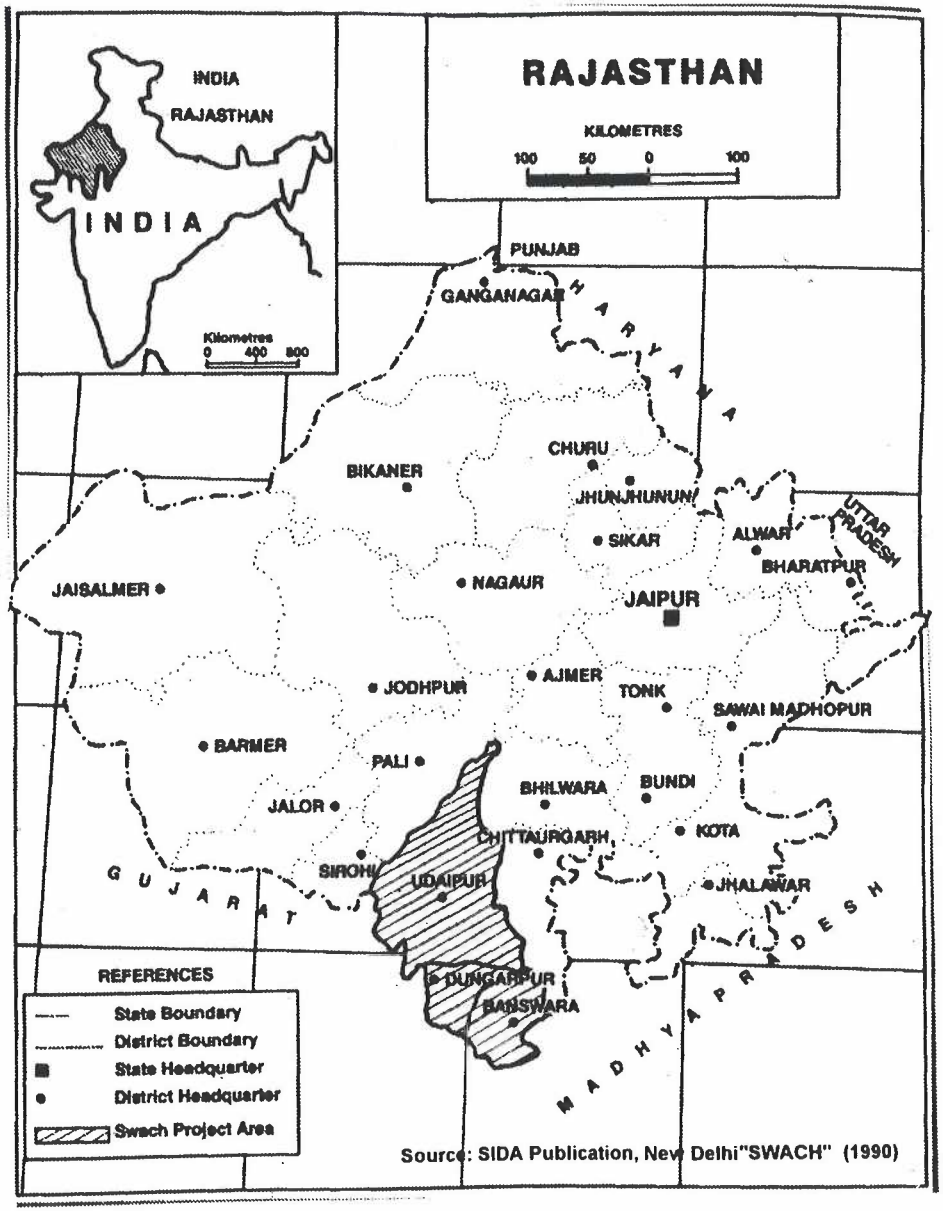
Glossary and Acronyms

a	Benefit surplus
AC	Average Cost
CBA	Cost-benefit Analysis
DTT	District Training Team
G	Investment cost
GOR	Government of Rajasthan
GW	Guinea Worm
HP	Handpump
i	Discount rate
IAS	Indian Administrative Services
IGEP	Integrated Guinea Worm Eradication Project
JAS	Jakt, Attack, Spaning (A new Swedish plane model)
LDC	Less Developed Countries
MC	Marginal Cost
MD	Marginal Damage
MPC	Marginal Private Cost
MR	Marginal Revenue
MSC	Marginal Social Cost
N	Life time of project
NGO	Non Governmental Organisation
NPV	Net Present Value
Panchyat Samiti	Block level local self government
PHED	Public Health Engineering Department
PV	Present Value
PV_A	Present Value of Ordinary Annuity
R	Scrap value
Rs	Rupees, the Indian currency
RWSP	Rural Water Supply Project
SER	Shadow Exchange Rate
SIDA	Swedish International Development Authority
SWACH	Sanitation, Water and Community Health
Swach	Hindi for "clean"
TAD	Village Contact Drive
VCT	Village Contact Team
WHO	World Health Organisation
X_b	External benefits
X_c	External costs



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However, none of the persons mentioned above can be held responsible for any inaccuracies the study may contain.

Abstract

The glorious theories of economics sometimes seem detached from reality, and how they can be applied to real world events may for many students remain a mystery. Therefore, my intention was to look at a specific project to see whether it functions satisfactorily, generates the expected benefits and with this information as a basis, calculate the social benefit in accordance with the cost-benefit method. My choice of a water project was easy to make, since water is the symbol of life and improvements in that area can be expected to give rise to great benefits and improve the socio-economic conditions. A Minor Field Study was conducted in Udaipur district in southern Rajasthan, where UNICEF in co-operation with the Indian government and with financial assistance from SIDA, have improved the rural communities access to safe water. In the study, rural women were interviewed about issues concerning water collection.

The field trip showed that the great majority of the households used the handpumps and that they on average spent 12,7 minutes per trip 4,4 times a'day. The pumps were repaired within 2 days on average for which the villagers in interior villages had to pay Rs 2-5. The women said that they benefited from the pumps by time savings, clean water and that they saved lives. Hence, the field trip showed that the project was successful in generating benefits. What now was left to do was to estimate the value of these benefits. I limited myself to look at time savings only.

The investment analysis proved the general idea that these kinds of projects give rise to high social benefits, and showed that time savings of less than 12 minutes per household a day is enough for the investment in a handpump to be economically viable. It further showed that even if the opportunity value of women's time is considered to be very low, Rs 0,3 in 1987-year prices, the NPV still becomes positive. Additional information that was given by the analysis was that even at high discount rates the NPV becomes positive. In short, the NPV calculation illustrated how gainful the investment in a handpump can be!

1. Introduction

1.1 Water Supply in Developing Countries

"All peoples, whatever their stage of development and their social and economic conditions have the right to have access to drinking water in quantities and of quality equal to their basic needs" (Mar del Plata 1977)[1]

Water availability is a prerequisite for sustenance and is indispensable for agricultural food production and for the development of most industries. In tropical areas the minimum consumption lies between 1,8 and 3 litres per day, with additional quantities being required to maintain good health.[2] The average water consumption per person and 24 h in the tropics is 25 litres.

According to WHO, 80% of all diseases in developing countries are in some way related to water and sanitation and therefore, not surprisingly, the issue of clean water has been given top priority in many countries. Over a million Asian children die every year from waterborne or water related diseases.[3] Worst affected are children under five. These deaths could be avoided if all the people had access to clean water and sanitation facilities. Fresh water, a renewable resource in theory is not readily available every where. Surface waters are often contaminated with disease carriers and are seldom available in sufficient quantities during the dry season.

There was an increasing awareness in the 1970s, of the importance of safe water supplies as a major contributor to improvements in public health. 1980-1990 was declared by UN to be the International Drinking Water Supply and Sanitation Decade, which spread further light on the water & sanitation problems. As a result many water and sanitation projects were initiated and much aid from various organisations and developed countries was channelled into those projects. For example, UNICEF hardly spent any money on water and sanitation programmes in India in 1970 but roughly $15 million in the middle of the Water & Sanitation decade and the government in India spent at that time approximately $650 million on water and sanitation.[4] The aim has been to develop low cost, well functioning technologies that suits the demands of the users.

[1] United Nation's Water Conference 1977 in Mar del Plata, Resolution (1977) p.66
[2] Hahn.R. .Andersson-Hahn.L and Reuterswärd.L. "Village Water Supply in India" (1981)
[3] UN Publication. Water series No.26, "Criteria for an Approaches to Water Quality Management in Developing Countries" (1991)
[4] UN Publication, "Water and Sanitation in UNICEF 1956-1986" (1987)

1.2 Motives Behind the Study.

The issue of clean water and its potential of enhancing economic development is a very interesting topic and deserves the attention it has been given in recent years. The quality and quantity of water available to the general population affect the development of the country in many ways.

1. First of all a Rural Water Supply Project (RWSP) can lead to substantial improvements in public health and thereby save expenses like hospitalisation costs, medicines, cost of transportation to hospitals and loss of production due to lost days and weeks because of illness. Improved health also lead to improved capabilities of absorbing knowledge, which is vital in the development process of a country.

2. Secondly, a positive indirect effect is that the standards of nutrition can also be substantially improved when the state of health becomes better, since illnesses reduce the body's ability to absorb food, burn calories and drain nutrients in vomiting and diarrhoea.[5] The standard of nutrition is also positively affected by the lower effort needed to collect drinking water, after a RWSP is implemented. Studies in Nepal have shown that remarkable savings of calories can follow from RWSPs.[6]

3. Thirdly, time is released. The spare time may lead to increased attendance in school, better preparation of meals and create economic spin-offs. The time saved has an economic value, assuming that the workforce is gainfully employed. In chapter five, the results from the field study will give an idea about how village women use the extra time and how much the extra time can be said to be worth in rupees.

In short, RWSP is a worthwhile area of concern if one is interested in development issues, and in order to try to quantify the gain to society, a Cost-benefit approach can be adopted.

1.3 Objective of the Study

Several hundred million dollars have been invested in water supply projects initiated by the Indian Government or by aid organisations in co-operation with the government. Therefore it is very exciting to see how well one of these projects has succeeded and what the gain to the rural Indian community is. It is also very interesting to try to

[5] "...it is the sheer frequency of illness in the world's poor countries which is the single most important cause of malnutrition" (U.Jonsson) Source. UNICEF Publication, "The Progress of Nations 1994" (1994) p.7
[6] K.J Nath has presented results from research undertaken in Nepal, where he studied the time and energy saved by women following the provision of easy access to water supply. The average household savings were 3 hours and the average daily savings of calories, 350 k. calories. "Planning for Health & Socio-economic benefits from Water and Environment Sanitation programmes."

quantify the benefits in monetary terms, since this kind of investment with a soft input is generally not accompanied with figures of benefit surpluses etc. I choose to look at a project in southern Rajasthan, where UNICEF in co-operation with the Indian government and with supplementary funds from the Swedish development agency SIDA, has reduced the burden of water collection and incidence of water related diseases by providing handpumps and health education.

The objectives of the study are to:

A) Investigate if the handpumps SWACH[7] has invested in are functioning satisfactorily in some selected villages, and hence, generate benefits there.
B) First, estimate the benefit of time savings to society, through a Cost-benefit approach and make a simplified investment analysis of a handpump. Secondly present potential health benefits of RWSP.

To be able to account for A, a field trip was conducted where the efficiency of water provision, accessibility & availability of water and efficiency of repair & maintenance in some selected villages in Udaipur district, was looked at. With these findings as a basis, the gains to society, item B can be elaborated and estimated by making a simplified NPV calculation of the investment in a handpump.

1.4 Demarcation

First of all I had to restrict the study to one of the major benefits that arise from water supply projects, namely time savings. To try to grapple with both health benefits and time savings would be too burdensome. One reason why I choose to focus on time savings is that the health effects of a RWSP are very difficult to identify and quantify since the status of public health is affected by a variety of factors and hence require some knowledge about epidemiology. Another reason was that I find that the time benefits often play second fiddle to the health benefits in evaluation studies, even though a focus on time savings can give a good indication of the social gain. There is also a positive correlation between time savings and improved health as mentioned before.

Another restriction was that of the size of the sample. As the study was conducted at a very busy time of the year, I tried not to take up too much of the women's time and hence interviewed about 8 women in every village. However, by forming the questionnaire carefully I felt that the results seemed to be valid for the hamlet as a whole.[8]

It would also have been interesting to visit a couple of villages where SWACH has not worked. That information would however, be of no significance to the study since the

[7] Sanitation Water and Community Health, the name of the water project in question.
[8] See Appendix

objective of the case study was to see whether the pumps SWACH had invested in were working well or were frequently out of order.
I do not claim to provide a statistically accurate survey, but instead this is a case study where the findings from some selected villages are presented. Based on these findings, a Cost-benefit approach is adopted and hence, the analysis gives an indication of the economic viability of the investment in a handpump under those circumstances. By making a sensitivity analysis where the parameters vary, the investment analysis can however be applied on other villages as well.

1.5. Methodology

1.5.1 Selection of Villages:

The Project Manager and Block Supervisor of SWACH selected the sample of 8 villages. The selection of villages was done on the basis of their geographic location, where villages from different geographic regions and of varying degree of remoteness were selected. They also tried to put together a sample that would be representative of the total composition of villages concerning income etc. Since interior villages greatly differ from those near the national highway, I had a desire to see both and not only out of convenience choose the most accessible ones. The variation between villages, of answers concerning women's meetings, possibility to earn extra money and time spent on queuing etc. give an indication that the sample contains villages of different categories and not only the most successful ones. However, the representativeness of the sample cannot be guaranteed, but I find it likely that the sample gives a good indication of the situation in the villages. A combination of qualitative and quantitative research techniques were used.

1.5.2 Issues of Interest

The qualitative research techniques, such as interviews of village women, interview of Block Supervisor and on site inspection (of handpump platforms, drainage etc.), were carried out as below:

Main focus on:

Issues:	Research technique:
1.Efficiency of water provision?	Villagers were asked questions about time spent on water collection and about queues.

	On site inspection of water delivery rate
2. Accessibility and availability of water?	Village women were asked about distance to source, no. of families using the same HP (to see whether there exist unequal access to pumps), no. of breakdowns /year etc. On site inspection, location of pump, surroundings etc.
3. Efficiency of repair & maintenance?	Villagers were asked questions about frequency of breakdowns, length of down time. Notation of no. of HPs out of order

Briefly looked at:

4.Condition of HP platform and surroundings?	On site inspection. Use of waste water? Is the platform clean and intact? Are cattle washed and given water near the pump? Etc
5.Responsibility for the maintenance of HP's?	Attempt to reveal indirectly, through various questions, the effort made by villagers to keep the pumps running. On site inspection of HP platforms and surroundings.
6.General awareness of water & diseases?	Only briefly looked at. Questions about why they use HP water if so, storage and how they take water from storage vessel. Inspection of storage of water in houses. On site inspection.

1.5.3 Procedure of Information Collection:

In each village, a sample of 6-8 women from different households answered questions from the questionnaire. In order to get women from different income groups and of dissimilar social status, the intention was to go and randomly pick households in different parts of the village, since families of similar social status and income, tend to live close together. Hence, I found it likely that the families standing lowest on the scale would live together in the outer ends of the village. However, after the first day it became clear that it was not practicable to go around and ask questions at their houses, since they felt uncomfortable and suspicious when asked at their home. Instead, one woman went to collect the other women and the interview was conducted at one house, centrally located in the village, usually the SWACH health worker's house. Therefore, it is not likely that women who are not socially accepted in the village are included in the sample, since they probably were not asked to attend. The caste of women interviewed was, however, noted so major errors concerning representativeness of sample, could be detected.

To be able to communicate with the women, I needed to have a person with me, who knew the villagers and had their respect, otherwise I could not be sure they would want to answer any of my questions. I also needed to have someone with me, who was good at both the local language and English. I was very lucky to get great support from the SWACH office in Udaipur and one of Block Supervisors and her daughter came with me on the visits of the villages.

Literature concerning water and health, Cost-benefit Analysis and evaluation methodology is gathered mainly from the University Libraries in Lund and from UNICEF's headquarter in Copenhagen. That literature provides the base for chapter 2 and 5 of the essay. Chapter 3 will be based on documents from UNICEF in New Delhi and Jaipur, and from SWACH office in Udaipur. In chapter 4 the material gathered from the field research is presented.

1.6 Outline of the Study

In chapter 1, the motives behind the study, the objective and methodology are presented. The purpose is to show why Water Supply is an interesting topic and how I have approached it. In chapter 2, the theory of Cost-benefit Analysis is described which serve as a basis for chapter 5 and 6. In chapter 3, information is given about the project that has been investigated, SWACH to give the reader insight into its objectives and shaping. In chapter 4,the result from the field trip in Udaipur is presented. Here I provide material that is the core of the analysis in 5.2 and chapter 6. In section 5.1, water related diseases and potential health benefits are elaborated to stress what impact RWSPs can have on health and to account for not quantifying these in the Net Present Value Analysis. In 5.2 time benefits and the valuation of time is discussed. Chapter 6 is where the major revision of results is done and a NPV investment analysis is conducted in accordance with the Cost-benefit method. Facts like downtime etc., collected at the

field trip is incorporated in the analysis. Finally, a short conclusion is made in chapter 7 where the major findings are summarised.

2. Theoretical Framework

2.1 Theory of Cost-Benefit Analysis

The main objective of a CBA is to estimate and evaluate the net benefits associated with a number of investment projects to facilitate a decision of whether they should be undertaken or not, and if investable funds are limited, which project will be given priority. The CBA analyst seeks to determine whether the net benefit to society outweighs the cost of the project. The techniques of project evaluation used by private firms only take into account private monetary costs and benefits whereas the span of a CBA is much wider. A CBA takes into account externalities and private non-monetary costs and benefits as well, to maximise social welfare. *What is social welfare then, and how can it be measured?*

The value judgements of social welfare are frequently based on the Potential Pareto Improvement Criterion (PPI). The idea of PPI is that social welfare is improved, and hence the project should be undertaken, if and only if the gainers from the project could fully compensate the losers from the project without themselves becoming net losers.[9] A CBA works as a guide to decision making by approximating social costs and benefits involved in certain projects, and is ultimately a way to select the socially most preferred option. Its relevance and ability to forecast has often been questioned and criticised. Anyway, a CBA is vital since it slows down the process of ratifying and implementing projects and a second thought is given, which improve the quality of investments since it can reduce the rate of subjective decisions.

There are several steps in the procedure of performing a CBA. First of all the objective of the project must be clearly defined, where the decision maker has to state what the project aims to maximise, so that the project which contains most of the specific gains can be identified. Then all costs and benefits are evaluated, including all monetary and non-monetary costs and benefits and externalities, and the life time of the project is determined. After that the magnitude of losses and gains is quantified and a monetary value is assigned to each cost and benefit. A common measurement must be used if the advantages and disadvantages are to be added up, but assigning a monetary value to benefits like improved health is arduous and there is a risk of incorrect estimations. The fourth step in the CBA procedure is to find out the likelihood of costs and benefits to occur. If there i.e. is a 70% risk of a cost of $100 occurring, it will be valued at $70 and so on. Then the timing of outlays and revenues has to be taken into consideration in the analysis. For example, $200 of benefits received today is regarded as more desirable than the same amount in ten years. Future gains and losses are reduced in value by discounting. The choice of discount rate is sometimes a political issue, but also reflects

[9] The compensation principle by Kaldor & Hicks.
Johansson Per-Olov " An Introduction to Modern Welfare Economics" (1991) p.22

the scarcity of capital. Finally some normative judgements of the distribution of negative and positive benefits is desirable.[10]

A CBA can take the form of either an ex ante estimation of a project or an ex post evaluation. When the CBA is used as an appraisal, the intention is to provide a sufficient information basis on which well thought out decisions can be made. As an evaluation the main purpose is to improve the quality of future development project by providing feedback. Did everything go as planned? Were the net social benefits as high as estimated? A cost-effectiveness study answers the question, would a less costly water project in combination with a sanitation programme maybe have given better yield?

2.1.1 Identifying Costs and Benefits.

Once the objective of the project has been clearly defined, the next major problem is to identify all costs and benefits concerned without double counting. Much of the criticism against CBA concernsthe arduous task of estimating the social costs and benefits involved such as improved health and the problem of incorrect analysis due to double counting.

The general benefits of a rural water supply project are health improvements and time savings. Often the RWSP creates important so-called spin-offs, which are activities initiated or increased by the new water supply. Spin off activities include a diversity of economic activities like growing vegetables in the gardens, increased home production of e.g. baskets, pots and hand loom, diversification of rural industries using water and effects on conditions on live stock.

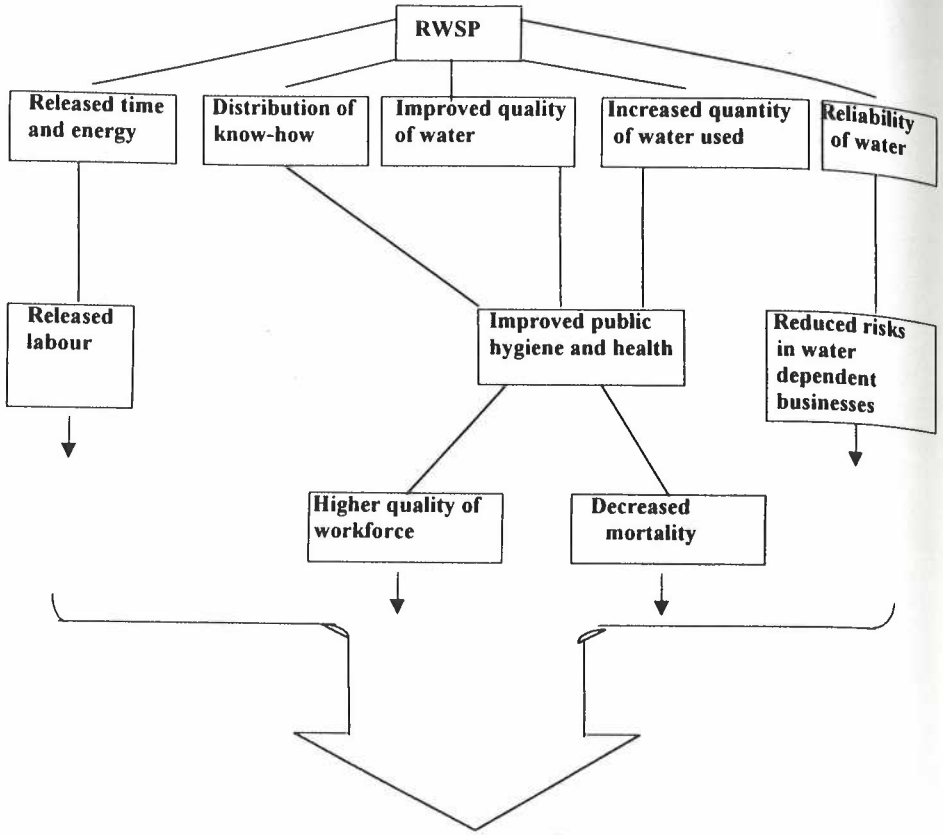
In most developing countries a significant part of the workforce is under utilised. Then a water supply project that absorbs part of the excess labour is beneficial since it increases social welfare and productivity. At the same time labour is released since time spent on collecting water is reduced. In a situation where full employment exists, the released labour can increase the production remarkably. When the unemployment is severe, the released labour might not be absorbed in the production process, but the spare time can be spent on other activities with a high social yield. Examples are increased attendance of children at school, better nutrition since the distance to source is reduced and more time is allocated on preparations of meals. There is a chance of substantial improvements in the workforce since the people employed in a well designed RWSP have to attend courses and are taught how to operate and maintain the new water source. Most of the RWSP that have failed to operate efficiently and finally ceased to exist have not put enough emphasis on management issues

Another important aspect is that changes of social and economic pattern due to RWSP often result in changes in attitudes and values of people involved, which facilitate future development. Since it is mainly women who collect water, they have since the middle of 1980 been given the primary responsibility for operation and maintenance of RWSP.

[10] A great amount of Cost-benefit literature is used for this chapter. I will throughout the chapter hardly refer to any literature in particular as the theory is conventional and hence, the authors of the different books more or less provide the same cornerstones, only in different words. See Reference list. The most useful ones are however, Mattson B (1988), Irvin.G (1978), Mishan.E.J (1972) and Jönsson.B (1981)

Hence, they sometimes have to learn quite advanced techniques which ameliorate their self-esteem when they see that they can cope, and their social position in society can be improved. Another advantage of a water supply project is that the water source becomes more reliable and smooths out seasonal fluctuation with the result of reducing the risk in business dependent on water.

Fig.2.1 Model of potential benefits of a RWSP[11]



More high value crops, higher yields, higher productivity of workforce. New livestock activities, improved animal production, lower animal mortality, higher milk yields. Lower family health costs, increased well being and attendance at school. Improved family planning.

[11] Eklund & Herrman "The application of Cost Benefit Analysis on Rural Water Supply Project"(1991) p.45 give a good description of potential benefits.

[12] The first order benefits arise thanks to released time and energy, distribution of know-how and other effects mentioned in the first row of the figure. Released labour, reduced risks in water dependent business and improved public hygiene and health are first order benefits. For example improved public health, which contain two elements, give rise to both higher productivity and improved family planning among other second order benefits.

The achievement of the possible gains associated with the project depends on the proximity to the new source and the cost charged. *What is the cost and of risk of such a project?*

The social cost of the project is the forgone value of alternative project, i.e. the opportunity cost.[13] However, if the project is financed entirely by external funds in the form of pure aid, the opportunity cost to the country concerned depends on whether the grant is tied to the country or will, in the absence of the project, be allocated in another LDC. In the former the opportunity cost is calculated as usual and the cost of capital etc. is estimated for different proposals. In the latter case, the social cost for the host country is zeros. However, most development projects are financed partly by the country in question and partly by the aid organisation

The simplest method to calculate the opportunity cost of a project, is based on existing market prices and wages of different resources. The market price, however, is not always an accurate measure of the true cost to society. There are several factors like under employment and unemployment, monopolies taxes etc., which can make market prices inappropriate as measures of the marginal social value of goods and services. When the social cost of i.e. employing labour for the project diverge from the market price due to under employment the need for shadow prices arises. In a CBA the cost of the good or service is set in accordance with the opportunity cost, the good/service is shadow priced.

The cost of the RWSP consists of both pure financial costs and economic costs. The financial costs are for example costs for: planning and design, investigation of area concerned, the development of a source, materials required and machines, drilling equipment, pumping equipment etc or treatment facilities, distribution network, cost of labour used for construction, operation and maintenance and costs for spare parts, fuel etc. The specific cost of a RWSP naturally depends on the grade of sophistication. There are a lot of costs to take into consideration when performing a CBA, but those mentioned above are quite easy to count and the costs are usually not the reason for miscalculations of net benefits. The spare parts needed and the cost of maintenance can sometimes be higher than expected and hence reduce the net benefits of the project. External costs or unmarketed goods are additional economic costs, which are not included in a financial analysis, but are real costs since they use resources, which could be productively utilised in other activities.

As mentioned before, there are many positive effects of a RWSP, but there is also a risk involved. If the villagers used to fetch water from an open source, they then became resistant to the bacteriological content. If the new source i.e. a hand pump breaks down and is not repaired at once, the villagers may not be able to go back to using the traditional source, since they are no longer resistant.

[13] Mishan E.J "Elements of Cost Benefit Analysis and Economic Theory" 1972
Lesourne "Cost- benefit Analysis and Economic Theory" 1975

2.1.2 Quantifying the Costs and Benefits of a RWSP.

The health effects of a RWSP are very difficult to identify and quantify since the status of public health is affected by a variety of factors. For example, cholera and other waterborne diseases can be transmitted by contaminated food as well as by drinking water. Therefore the social benefits arising from the water supply project may be over- or under estimated. In economic theory, people are assumed to act rationally and pay according to their preferences. In the case of water supply it is not definite that the individual acts rationally since the situation is too complex as the health effects are difficult to identify (information problem) and put a monetary value on. Willingness to pay can however, be a useful measure of social value if the individual is informed of the relevant aspects of the project.[14]

Another problem is that of *ability*, if asked what he/she is willing to pay, he has his limited budget in mind and will name a price according to that. If he had a larger income he would be willing to pay a higher price for the same amount of water. Therefore, in the case of water, willingness to pay does not reflect the social value of the project. The benefits must however be given some approximate number to make a CBA possible. Since willingness to pay for improved health is difficult to estimate, methods of indirect estimating the value of health can be useful. The four most common methods of indirect measurement are based on:[15]

* Averted treatment costs
* Growth of production
* Political decisions
* The insurance principle

If certain medical care costs can be prevented thanks to the water supply project initiated, resources will be saved and can be used to enhance social and economic development. The advantage of this method of valuing averted treatment costs, is that the resources saved have a market price which can be used for appraisal. The problem with this method is that the averted costs can be hard to value since most ill people in LCDs are nursed at home.

The second method used is based on the assumption of full employment and that the individuals are gainfully employed. Prolonged life and higher rate of presence at work would then increase production factors and production would rise accordingly. The method equates social welfare with the size of the gross domestic product. The wages are assumed to be set in accordance to the individual contributions to production. The value of better health can therefore be calculated as the discounted value of the increase in income generated by the improvement in health.[16] There are problems with this method, like which discount rate should be used, do the wages reflect the individuals contribution to production and how homework is to be evaluated. These problems are however not impossible to overcome. The discount rate is actually often a political issue, and the problem of choosing it arises no matter which method chosen. The wages

[14] Sassone & Schaffer "Cost Benefit Analysis" (1978)
[15] Jönsson B. "Cost-Benefit Analysis in Public Health and Medical Care" (1981)
The four indirect methods of valuing health improvements are described in this source with start on page 21.
[16] a.a

are simply assumed to be set in accordance to productivity and the work at home is priced at a minimum wage. Despite the assumptions made, the method can be quite useful since it sets a minimum value on health and life and is easy to use.

The idea behind the third method is that, by studying political decisions, the value of health can be revealed implicitly as the investment and projects undertaken aiming at maximising a specific goal, are designed in accord with the value that is set upon human life and health. For example, safety regulations and social services. The method works better in theory than practice as the politicians often are subject to lobbying and, sometimes are corrupted. Therefore a consistent thread running through political decisions might be difficult to find.

The fourth method, the insurance principle, seeks to answer the question, what are the members of society willing to pay to reduce the risk of ill health and death? In most LCDs there do not exist a well functioning insurance market. Hence it is not possible to buy insurance, at a reasonable price, that will guarantee you treatment free of charge if you catch the disease. But, the individuals can insure themselves in other ways by purchasing water filters, boiling the water etc. So the conclusion is that the self insurance principle can contribute to put a value on health, if the individuals are fully informed about the relationship between dirty water and diseases, otherwise they would naturally not know how to insure themselves against bad health and hence would not spend enough money on self insurance activities.

Another way of approaching the problem of quantifying benefits of RWSPs, is to concentrate on time savings instead, since the health effects are so difficult to evaluate. A formula of the estimated collection time per cubic meter is outlined below.[17]

The collection time (T) is given by the equation:

$$T = (2D / 1000\,S + q / 60 + V / 60\,Qd)\,[1000 / V]$$

T = collection time (hours / m^3)
D = one way travel distance (meters)
S = walking speed (km / hour)
q = queue time (minutes / trip)
V = volume carried (litres / trip)
Qd = water delivery rate at the source (litres / minute)
m^3 = 1000 litres

An example of how to estimate the collection time T, is given below.
In village X where the water supply situation is extremely bad, the women have to go 5 km in the dry season to collect water from the traditional source. The average walking speed is assumed to be 2 km an hour. The women carry 15 litres each trip since it is hilly and (of other respects) arduous to walk through the terrain. They are assumed to queue 2 minutes, but often spend more time at the well, which has an important social role to play as a meeting point for women. The water delivery rate from the traditional source, is in this example is assumed to be 5 litres per minute.

[17] Eklund & Herrman "The application of Cost Benefit Analysis on Rural Water Supply Project" (1991) Appendix

Then the collection time is:

$T = (2 \times 5000 / 1000 \times 2 + 2 / 60 + 15 / 60 \times 5) \; [1000 / V]$
$T = (5 + 0{,}03 + 0{,}05) \; [1000 / 15]$
$T = 5{,}08 \times 66{,}7$
$T = 338{,}7 \text{ h} / \text{m}^3 \Longrightarrow 0{,}339 \text{ h} / \text{l}$

A family is assumed to collect an average of 50 l a day, but in this case the people would probably bath at the source and only carry home water for drinking and cooking purposes. When many hours have to be spent, the quantity of water used for hygienic purposes usually decrease. In villages where the water source is far away, the households, that can afford to, often invest in donkeys to carry the water or pay haulers.

Assume that a RWSP is undertaken and handpumps are installed. The distance to walk to the nearest communal water point is now on average 250 meters. The water delivery rate and the walking speed are assumed to be the same as before. The queuing time has increased to 20 minutes, and the volume carried per trip is 20 litres since it is possible to carry a heavier load if the walking distance is reduced and the way walked is better.

The collection time is then:

$T = (2 \times 250 / 1000 \times 2 + 20 / 60 + 20 / 60 \times 5) \; 1000 / V$
$T = (0{,}25 + 0{,}333 + 0{,}0667) \times 50$
$T = 32{,}5 \text{ h} / \text{m}^3 \Longrightarrow 0{,}0325 \text{ h} / \text{l}$

The hours spent on collecting the daily family consumption is then 1,625[18] hours out of which 0,83 hours is spent on queuing. The family consumption will probably increase and more water will be consumed, and hence more time spent. The estimated time spent on collecting water varies greatly depending on how many litres the woman is assumed to carry. If she in the example above instead had been assumed to carry 15 litres only, ceteris paribus, she would instead have spent 2,11 hours on collecting water. As follow from the example, the total amount of hours saved by a RWSP greatly vary with the parameters and hence the net benefits. If there are not enough handpumps to supply the village efficiently, the queue time might become intolerably large and the traditional source is used as a complement.

When performing an ex post CBA, the way of proceeding is much the same as when performing an ex ante CBA. In an ex post CBA, the benefits realised are evaluated how much time is actually saved? How many minutes do they have to queue etc. The difficulty with an ex post CBA is that the project, when evaluating its efficiency and net social benefits, has to be compared with an the alternative course of action, which naturally is difficult to investigate.

[18] In India they punctuate differently, what is meant here is about one and a half hour. In this report, the comma is set after integers.

The conclusion of this elaboration of time savings is that the time saved and hence the benefits, greatly depends on:

1. * The season
2. * Distance to source
3. * Litres carried per trip
4. * Queue time

The quantity needed is assumed to be quite fixed, even though the amount is adjusted when too much effort has to be made or if the effort needed is substantially reduced.
The information on timesaving can be obtained either by using a control area or through a time series study. To be able to put a monetary value on time saved, the opportunity cost of women's time must be determined.

3. SWACH

3.1 Background to SWACH

3.1.1Rajasthan

Rajasthan is situated in the Northwest of India. The state has a population of 44005990, with a sex ratio of 913 compared to the national average of 929.[19] Rajasthan's per capita income at current prices in 1989-90 was Rs 3595 (Us $ 115) which was below the national average.[20] The female literacy rate is approximately 21%. About 40% of the land is desert or belongs to the semi arid category.[21] The water table is getting lower each year due to scanty rain and irrigation.

3.1.2 Summary of SWACH

The acronym SWACH stands for Sanitation, Water and Community Health. It is a most suitable name, since it sounds exactly like a word in Hindi, which means "clean". The first Plan of Action in 1986, described the project as an integrated Guinea Worm Control, Rural Water Supply, Health Education and Environmental Sanitation Project (IGEP)[22] The projects area of concern was the two southernmost districts of Rajasthan, Banswara and Dungarpur, which both were severely affected by Guinea Worm (GW). Southern Rajasthan accounted 1984 for a majority of the 15 210 known cases a year in Rajasthan, the most affected state in India.[23]

The project's objectives were to improve the supply of safe drinking water by installing handpumps, especially in areas with scarcity of drinkable water, converting stepwells and by improving the operation and maintenance of handpumps and wells. At the same time continuous health education programmes and improvements of domestic and environmental sanitation began to reduce the incidence of GW and other water related diseases. The strategies for attaining the objectives were built upon involvement of communities, active participation of women and an integration of separate organisations to build up a base of knowledge and an understanding of all elements of operations.

[19] UNICEF Publication. "Project Clean: The SWACH Experience in Rajasthan" (1994) p. 1-2
Sex ratio = no. of women per 1000 men.
[20] a.a p.2
[21] a.a p.3
[22] SIDA: SWACH Evaluation Rajasthan: India Final Report (1994) p.i
[23] UNICEF Publication. "Project Clean: The SWACH Experience in Rajasthan" (1994) p.5

The funding of SWACH was 60% from UNICEF and 40% from Government of Rajasthan (GOR).[24] The Swedish International Development Agency (SIDA) funded UNICEF's share as supplementary funds and GOR got its funding from the Tribal Area Development Department. SWACH was given flexibility to carry over unspent funds into the next financial year, which enhanced economical use of financial means. Between 1986-90, the project was budgeted at Rs[25] 120 million[26]. In 1988, SWACH extended to include Udaipur and Rajsamand district, and now the project covered an area of 23800 square km with a population of 4800 000 people.[27] The four districts have a high concentration of Scheduled Tribe. A majority of the people is involved in agricultural business and cattling.

The fund for 1987-92 was Rs 180 million.[28] The major investment cost was that of providing safe water by drilling boreholes, installing handpumps, converting stepwells etc, which counted for 70-80 % of project costs.

3.2 Social Marketing of the SWACH Message

3.2.1 The Objectives of SWACH

- To improve the quality of life and socio-economic conditions in the rural areas of Rajsamand, Udaipur, Dungarpur & Banswara, with special concern for women and children.
- To reduce the incidence of GW, diarrhoea and other water related diseases.
- To teach and encourage the villagers good health practices.
- To establish a functioning community participation and self-reliance role in the planning, implementation and maintenance of drinking water supply.

The major means of achieving these targets were, as mentioned before, by securing safe water supply by providing handpumps and converting stepwells, and through health education.

Many water supply projects have failed because of inadequate operation, maintenance and monitoring. It is important when a breakdown occurs that there is a well functioning system of reporting the damage, mechanical competence in the neighbourhood and availability of cheap spare parts.

[24] SIDA: SWACH Evaluation Rajasthan: India Final Report (1994) p.ii
[25] Rs = rupees. the Indian currency. 1 US Dollar is approximately 35 rupees. (Nov. 1996)
[26] SIDA: SWACH Evaluation Rajasthan: India Final Report p. 2
[27] a.a p.2
[28] a.a p.ii

3.2.2 The Village Contact Drive (VCD)

To establish a close contact with the villagers, campaigns run by teams of five persons, who promoted awareness of water and sanitation and the worm, were initiated. The members of the village contact teams were local men and women who were selected and trained by SWACH. The recruits needed information about what SWACH wanted to bring about and effective means of doing it, that is knowledge and communication skills. SWACH trained and utilised District Training Teams (DTT) for this purpose. The DTT consisted of school teachers, health department workers, SWACH workers, members of NGOs among others. Before each drive, there was a week long training of DTTs, where they learned about the lifecycle of the Guinea worm, prevention methods, basic information about health, safe water and sanitation and maintenance of handpumps. SWACH was given valuable help from NGOs, who helped organising training programmes. After the training, the trainers were divided into groups of 3-4 members and each group was assigned to a Panchyat Samititi to train 30-40 recruits for the VCTs. The recruits were trained for 4 days and learned about SWACH messages, how to collect relevant data from villages and how to communicate. The VCD proved to be a successful strategy to reach a large number of people in a short period of time. In the forth drive for example, 300 VCT visited 3117 villages in all 18 Panchyat Samitis of Udaipur and Rajsamand.

SWACHs messages were spread in a variety of ways, through messages of the local language, painted on walls, through songs & puppet shows, plays and poems.

3.2.3 Social Animators and Scouts

In each community (every 3-4 village) a person, preferably a woman, was trained as a social animator, who would work as an agent of change & development in her community and provide a link between the project and the community. The animators were selected on basis on their interest in the work, their ability to convey the messages and initiate discussions and their acceptability in the villages. Residents of villages infested with G.W, were SWACHs main target group for health messages about how to prevent the spread of the disease, sound personal and family hygiene, environmental sanitation and care and maintenance of handpumps. An animator visited each of her villages about 6 times a month. SWACH also supported local NGOs to run 3-day awareness camps, where village women were informed and encouraged to improve health conditions in their homes and communities.

A report system of G.W cases was established, in which village contact drives, animators and Health Department searchers provided information about cases. To improve the information flow, SWACH started recruiting young men from villages with a high incidence of G.W. These men - the scouts, were trained to detect and report patients at an early stage and then bring them to SWACH medical camps. The scouts visited the villagers in their homes weekly to identify new patients and check out the old. To support and motivate the scouts, coordinaters who were selected from NGOs and VCD, were employed.

SWACH ran special campaigns at the peak season of the G.W, April to June, to inform the villagers about transmission and treatment of the disease. Those who were infected by the parasite, were treated at special SWACH medical camps, where ayurved practitioners, who had gone through training in extracting G.W, surgically removed the worm if possible. At the medical camps the patients were informed about how to prevent the disease and were given filters to filter their water with. The patients were asked which sources they had used and these wells were after that treated with temephos by the District Health Department. Step wells in Guinea worm infected villages, were converted to draw wells to prevent people from stepping into the source and contaminating the water.

3.2.4 Project Organisation

The SWACH project was put under the Tribal Area Development Department (TAD). The Commissioner who headed TAD was made the ex-officio chairperson of SWACH. This institutional location was meant to give greater autonomy, flexibility and ensure authority. A separate organisation was created to give it greater freedom of operation, with an Indian Administrative Services (IAS) officer as its director. SIDA/UNICEF financial assistance ended from 1 January 1996, and SWACH is continuing as a NGO with government support and TAD assistance in water and sanitation issues.

3.2.5 Hardware

The conversion of stepwells started in mid-October 1986 after the first village contact drive had been conducted and the water level in the wells had receded after the monsoon. The conversion of stepwells was given high priority since it would mean that the transmission of GW would be cut off. The project did not have the resources needed to convert all stepwells and therefore priorities had to be made. The wells for conversion were identified by VCT who chose those wells that were used by a number of people for drinking water purpose and were potential sources for the disease. The estimated expenditure for the work per converted well was Rs 5500 (Us $176) in 1986-87 and Rs 6000 (Us $192) in 1987-88.[29] By the end of June 1988, however, the actual average annual cost per well was as low as Rs 3954 (Us $127)[30] The number of converted stepwells up to June 1985 in Udaipur district was 4993 and the number of handpumps installed was around 3607.[31]

When HPs had been drilled before, there had been two major problems associated with official intervention in this area. One, selection of previous sites had not always been based on maximum accessibility. Two, there had been no effective system for maintenance and repair. Now, the sites were chosen by the villagers and careful hydrogeological investigations were undertaken to improve the rate of success in drilling. In 1987, the cost per handpump was around Rs 16500.

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[29] UNICEF Publication, "Project Clean: The SWACH Experience in Rajasthan" (1994) p.36
[30] a.a p.36
[31] See appendix

In 1990, a survey of approximately 25600 HP's showed that in SWACH district, about 19% of the handpumps were out of order but reparable, compared to 42 % in non-SWACH districts. In 1995 approximately 23900 pumps were surveyed and of them 25% were out of order but reparable, in comparison with 41% in non-SWACH districts.[32] Since April 1993, the Panchyat Raj has managed the handpump maintenance programme, and employs the mechanics. Each handpump mechanic has the responsibility for 30-40 handpumps. Major replacements like those of pipes, rods and handle bearing are normally done during the HP maintenance campaign, which usually is once a year during the summer. (March to June) Animators and scouts have been trained in preventive maintenance, which has improved the functioning of the pumps.

In Udaipur district, 60 female handpump mechanics have been trained and out of them approximately 11 are currently working.[33]

3.2.6 Women's Empowerment

One of the expected benefits arising from a RWSP, if women are involved in the operation and maintenance, is improved knowledge and capacities, which hopefully can lead to an improved social position.

A number of SWACH functionaries at village level, because of the great experience and training they have acquired in the project, have become elected as local representatives. Of the 76 functionaries from Udaipur district which now hold key position in the local councils, are 66% women. However, one has to keep in mind, that the people employed by SWACH do generally have better education than the average population and hence, are more likely to reach higher positions.

[32]UNICEF Publication. "SWACH Project Rajasthan – India Final Progress Report" (1996) Annex H
[33] UNICEF Publication. "SWACH Project Rajasthan – India Final Progress Report" (1996) p.29

4. Field Work

4.1General Findings

The fieldwork for data collection was conducted during the 6 - 19th November 1996. The co-workers were a female Block Supervisor who has worked for SWACH a long time and knows the villagers and is held in their esteem. Her daughter, who is a student at Udaipur University, was chosen as interpreter. My travelling partner and the driver contributed to the high spirits and joined the discussions.

The 8 selected villages were:[34]

Madri (hamlet, Salvi)	Block, Jhadol
Piplia (hamlet, Medala)	Block, Kherwara
Makarjapa (hamlet, Nichala and Moodra)	Block, Kherwara
Sodala (hamlet Mangri and Sadak)	Block, Dhariyawad
Kadiya (hamlet, Akriya ka bhilwara)	Block, Kherwara
Sisharma (hamlet, "Bor Vali Givadi" and Bhilwara)	Block, Girwa
Nooli (hamlet, Boriya, Dootata)	-
Kholri	Block, Salumber

Community survey of selected villages, Udaipur district.

The main objective of the survey was to ascertain the efficiency of water provision, how much time the villagers spend on collecting water and how long the downtime in general is. The intention was also, if possible, to try to reveal the willingness to pay for water.

4.1.1 Background profile of the respondents

The villages visited had a high concentration of tribal women of which the majorities were doing agricultural work for a living. The majority of the women interviewed, 84 % were illiterate, out of which some could write their signature. The mean age of the sample was 32,4 years. The distribution of age is illustrated in the table below.

[34] Some of the names might be misspelt, since the names written by the interpreter, differ from those on the village profile I received from SWACH Office in Udaipur, hence some of the hamlets names are probably not spelt correctly.

Table.4.1. Distribution of Age (N = 51)

Age	Number	Percent
Up to 20 yrs	7	12%
21-30	21	41%
31-35	6	12%
36-40	5	10%
41-45	4	7,5%
46-50	5	10%
51+	4	7,5%

Mean age = 32,4 yrs

Table.4.2 Background Profile of the Respondents (N = 51)

		Education			
Age	Nil	Signature	2-4 yrs	5yrs	5+
Up to 20	2	2			2
21-25	7		1		1
26-30	9			2	
31-40	9	2		1	
41-50	8			1	
51+	4				
Sum	39	4	1	4	3
Percentage	76%	8%	2%	8%	6%

4.1.2. Down time

The pumps seem to be efficiently run and maintained. In villages where there lives a SWACH worker, the pumps are usually repaired the same day if the problem is of minor character. In general, if the village is close to the national highway or other roads of good standard, the repair is completed on the same day. In villages in more remote areas, the repair is usually carried out within 3 days. In almost every village visited, there was at least one pump out of order because of major breakdowns. The out of order proportion is hard to determine from such a small sample, though. In the interior villages it is naturally difficult and costly to repair the pumps if special equipment is needed, because the standard of the roads is low or there might not even be a road that lead all the way. In some of the villages of the study, there were only small paths the last 250 metres to the village/hamlet.

There exists a communication problem in some interior villages, and the villagers find it difficult to get in touch with the mechanic employed by the Panchyat and hence, the repair takes up to 15 days, or they hire a private mechanic instead to get quicker service.

Table. 4.3 General Downtime for Minor Problems (N = 50)

Downtime	Number
Repair same day	19
1-3 days	13
4-14 days	3
15 days - 1 month	1
1 month + - 2 months	1
Does not know, the pump has not broken in 1-2 yrs	13

Mean time = 2 days

4.1.3 Water

Almost all the respondents use solely handpump water for drinking purpose, only a few use other sources. Some people in Bhilwara and Salvi said that they use converted wells during the summer, because the handpumps dry up. The villagers proved to be very choosy about the taste of the water. In one village, Kholri, with 1700 habitants, they had 8 functioning pumps out of 9, but only one was used for drinking water collection. The reason was that the other pumps had hard water. The villagers were upset about the long queues. When asked about what time the queues were worse, they answered at sunrise and sunset. Some women went to collect water before sunrise and in the afternoon, to avoid the worst queues. The most of the women however, seemed to go at the time they preferred instead of trying to reduce the queues by spreading out the visits.

In general, the taste is found to be an important determinant of which handpump is used. If the taste of the closest pump is not good enough, the women choose to travel further and spend more time queuing. In most villages where SWACH has worked, the habitants seem to limit their choice between handpumps, and choose to collect from the closest handpump with best water, but do not use wells. In one hamlet though, Mangri of Sodala Village, where there have been no cases of Guinea worm, some women use well water because they prefer the taste of it. However, almost all respondents were aware of the fact that handpump water is a safer source and better for health, and therefore use it even if there are wells closer to their house. The villagers were asked the question, which source, they use for drinking water collection, and if they answered HP, which almost all did, they were asked, why? Some of the replies were:

The water is pure clean and we save time.
Well water is dirty, but handpump water comes from earth so it is good, and it saves time.
Well water causes so many diseases.
We save time.
It is near our house, its water is good and safe and we save time.
Sometimes before, people fell into the stepwell. We save lives and time.

It is good for our health since its water is clean.
Stepwell water is dirty because it is an open source, HP water is covered and clean.

4.1.4 Efficiency of Water Provision

Rural water supply projects have resulted in, as mentioned before, both time being saved and health status improved. The average time spent on water collection per trip was 12,7 minutes.

Table.4.4 Time Spent on Collecting Water (N=50)

Time taken	Number
01-10	29
11-20	11
21-30	7
31-50	2
Other	1

Mean time = 12,7 minutes

This information is based on the informants' recollections. It would of course have been more reliable to study actual behaviour, but because of the fact that most water collection is conducted before and at sunrise and at sunset, that kind of study would have required that we had stayed in the villages over night. It would be too much to ask for, and instead some control measures to test the reliability of informants recall was used instead.

To see whether the estimated time spending gives a good indicator, all women were asked later in the interview, how far away the pump was from their house. The distance multiplied with two plus the time spent at the site, should be the same as their estimation of collection time. Some women were asked to point out where their house and the pump were, and then I could see if their estimate seemed to be true. The women were also asked how many times per day they collected water and by multiplying this with the time spent each time, the approximate time spent per day was found. In order to prove if this was reasonable, they were also asked to rank the activities that took up most of their time per day. Hence I could see how much time that was spent on this in relation to other tasks. Water collection was usually ranked as the fourth most time consuming activity per day. Hence, I found that the average time of 12,7 minutes seem to give a good indicator of the average time spent per water collection trip in the villages surveyed. In the sample, the average number of times of water collection was 4,4 times per day.

Table.4.5 Average Number of Water Collection Times per Day

No. of times/day	Number (N = 50)
1-2	3
2-3	2
3-4	25
5-6	14
7-8	4
8+	2

Mean = 4,4 times per day

If 12,7 minutes is spent per trip 4,4 times a' day, the women spend on average 55 minutes per day on water collection, or a bit more depending on how much time they spend on socialising at the site. The water delivery rate was very satisfying in all the pumps tested, around 23 seconds for 10 litres. The pumps run smooth and easy, at least at that time of the year.

In the case study, most of the villagers said that they had saved time thanks to the handpumps. This extra time was used to do more agricultural work, for labour work in nearby villages, better preparation of meals and for childcare. When imputing a value on time savings, the use of extra time is of interest. Is the extra time spent on labour work, agricultural production, leisure or housework etc? The greatest obstacle to productive use of time is the remoteness of some villages.

4.1.5 Payment per Household.

In the more interior villages it is common to pay 2-5 rupees, and sometimes as much as 10 rupees per household for the handpump mechanic to repair the pumps. In villages close to the national highway, they usually do not pay anything. In those villages where a SWACH worker lived they did not pay him/her anything. Villagers, who could have the pump repaired for free by the handpump mechanic employed by the panchyat, preferred to hire a private mechanic in those areas where the mechanic had many pumps to take care of, to get quicker service. They paid Rs 1-3 per household in order to get quicker service, which indicate that their willingness to pay for handpump water is at least that sum. The handpump mechanic is employed and paid by the panchyat, and hence, the villagers do not have to pay him. However, it seems to be a common procedure that the villagers in interior areas are asked to pay. Whether this arises from too low salaries, pure opportunism or a combination of both, is an interesting question.

4.1.6 Activities for the Village Women

In all villages except one, meetings were held for the village women. In these meetings, they discussed family planning, good agricultural methods, money saving, immunisation, care of pregnant women & children, nutrition, seasonal diseases and sanitation. In those villages were meetings were held, which many women joined, the overall impression of cleanliness, healthiness of their children etc., was much better.

In Akriya ka bhilwara hamlet, SWACH used to hold meetings, but there are no meetings any longer. This hamlet is very poor and the small children there were very dusty and dirty with tangled hair, so it was a pity to hear that there were no meetings held.

In Sadak and Mangri hamlet of Sodala village, there are meetings held by SWACH, but the majority of the women interviewed said that they never attended. The hamlet is relatively well off but the small children in this village did not look very healthy and there were a lot of flies flying around everywhere, which indicate that the sanitation and garbage disposal may not be satisfactory.

In Sadak and Mangri, most of the people interviewed were of the caste, Patel. They were well off, but had not absorbed the messages very well. The majority of the sample did not use container with handle when taking out water from storage vessel and some of the women used converted wells because they preferred the taste of it.

In Salvi, there are monthly meetings held, but only 20-25 women are allowed to attend, because they do not want to have too big groups. As a result, the majority of the sample did not attend the meetings, but many of the women wanted to, and would have attended if they were allowed to.

4.2 A more Detailed Description of the Findings from Two Villages

4.2.1 Nichala and Moodra

In Nichala and Moodra hamlet, there are 45 respective 55 households. These hamlets belong to Makarjapa village of Kherwara Block. The houses are scattered and the village women have to walk quite far, 10-20 min walk to get to the handpumps. In Nichala the population is 210. There are 3 HPs, out of which 2 were working. The one, which didn't work, had been out of order for a month. In Moodra the population is 210 and there are 2HPs, but one is one year out of order (since drilling?)The other pump is new, 1 year and has not broken yet. For minor problems, the pumps are usually repaired the same day. The handpump mechanic comes from another village and he is employed by the Panchyat. The village women pay the mechanic between Rs 2-5 per household.

The women say that there are long queues, particularly at sunrise and sometimes before sunrise, with 15-25 women in the queue. A few women go earlier to avoid the worse queues. It takes about one minute to fill up the vessels, so it takes each woman at least 2 minutes at the pump. This means that the time spent on queuing in the morning is about 40 minutes. So, the women spent quite a lot of time everyday on collecting water, because of the queues and because the houses are scattered.

Some women used to spend about 2 hours per day before on water collection and some as much as 6 hours depending on if there were wells close to their house. In Makarjapa there are 10 wells, 10 converted wells and 3 stepwells. Hence, it is impossible to calculate the average time saving without asking every single household, since it naturally depends on how close they lived to the traditional sources. The estimated timesavings seem to be quite small, less than an hour per day and household, when the queue time is included. Some households seem to spend more or less the same time as before the handpumps, or even a little bit more. Of the women interviewed and of the other women who joined the discussions, they all did use handpumps for drinking water purpose. That this was true could further be indicated by the number of households that used the same pump as the woman interviewed. One question was, if they had answered that they use HP water for drinking water purpose, do you use the same handpump most of the time? If yes, how many families use the same pump as you? In Nichala, one of the pumps was used by 17-22 and the other by around 30 families, which is about the number of households in the hamlet. I looked at the caste composition of those who stated the lower number of families used the same handpump as they. The sample was however too small to be able to draw a conclusion about whether they had a more favourable access because of caste. It did not seem to be because of that reason however, but of instead of the location.

The women interviewed use a ladle with handle to take out water from storage vessel. They generally use converted wells for washing and bathing. There are meetings for the women in which they discuss family planning, seasonal diseases, immunisation, care of pregnant women and new-borns and money saving. The meetings are held by SWACH.

The pumps seem to be kept well, clean platform, useful use of wastewater and good drainage condition and surroundings.

Some of the women said that they could work as paid agricultural labour if they had more time left over, whereas others said that everything was too far away and that they had no skills.

4.2.2 Bor Vali Givadi and Bhilwara

There are 35 households in Bhor Vali Givadi and 35 in Bhilwara. The population is 200 respective 185. The hamlets belong to Sisharma village of Girwa block. In Sisharma the population is 4100 with 800 households. There are 9 HPs and 7 converted wells. There is also water pipelines with individual connections. There are 2 handpumps in Bhor Vali Givadi and 1 in Bhilwara.

The hamlets are situated near a big road of very good standard. The buses stop 6 times a 'day.

All women used handpump water for drinking purpose and when asked how many families that used the same pump, the answers indicate that more or less all households use handpump water. However, one woman said that they used converted wells in the summer. They all used handpump water for washing and bathing. The houses are close to each other, and the women only have to walk 2-5 minutes to get to the HP. Most women spend 1-10 minutes on water collection each time. They do not generally have to queue very much, there are usually only 2-3 women in the queue. Most people collect at sunrise, but some go before and, hence, the queues are reduced. Quite a lot of women in this village seem to get help from their husband with water collection. Half the sample mentioned their husband as one of them in the family who collected water, but the women said that they collected the water themselves most of the time. Anyway, this was a great difference to other villages where the husbands rarely collected water.

One of the handpumps is new and they therefore have no problem with breakdowns. The pump in Bhilwara works well too and only breaks 2-3 times a' year. There lives a female mechanic, who is employed by the panchyat, in the hamlet. Her area of responsibility is another village though, but she sometimes repairs the pumps anyway. When the pumps break down, she sometimes repairs them, but usually the mechanic (man) employed by the panchyat do it. The repair is usually quick, the same day. The villagers do not pay the mechanic anything. Before SWACH trained the female mechanic, the repair took 5-6 days, so even if she is not repairing the pumps most of the time, her sheer presence might have speeded up the work by the male mechanic. The villagers said that occasionally, if the handpump mechanic is not available, (he has to take care of many pumps) they hire a private mechanic instead and then pay him 1 rupees / household.

The houses we visited were clean and tidy. The water was stored in metal vessels and some had earthen vessels. All storage vessels were covered with a lid and placed in a nisch in the wall. The majority of the women took out water from the storage vessel with a container with a handle, but quite a few used one without. One woman, despite that she knew it is better to use one with handle, had not bought one. She said that next time we came to visit, she would have one with handle...SWACH has distributed a large number of ladles with handle and those who have been given one seem to use it. However, it is a bit difficult sometimes to make the villagers actively use the information they have acquired and as in this case, purchase a relatively cheap item that can have affects on their health.

In the houses we visited, their babies slept in baskets covered with scarves, hanging from the ceiling that meant that their babies were safe from flies and mosquitoes.

There are monthly meetings held, in which they discuss family planning, how to cook nutritious food, immunisation, sanitation and the importance of education for the children. When asked about what they talked about on the meetings, all the women in the sample mentioned that they were motivated to send their children to school and then they mentioned sanitation etc. The message of importance of education seems to play a big part on the meetings. In none of the other villages surveyed, was this mentioned as part of the meetings. There is a school close by and probably that is the reason to why

the villagers are particularly encouraged in this village.[35] A majority of the women interviewed went to the meetings, but some said that they never attended because of lack of time.

The women said that they had saved time thanks to the handpumps, but the magnitude of it is a bit unclear. Half the sample said that they used to spend 4-5 hours a' day, whereas the other half said around two hours. Since the village is not particularly scattered, it is unlikely that it should differ so much for the same household sizes. However, even if the estimated numbers is not correct, it is still interesting, because it reflect the perceived burden. If a person found the task of carrying home water very burdensome, they may recall it as taking long time. If one is really interested in finding out the time spent before the project, localisation of the wells and calculation of the average walking distance plus an estimate of seasonal sources (puddles, rainwater collection etc) give more reliable data. However, that would be far beyond the scope of this study.

The women in these hamlets had good opportunities to earn some extra money by working as paid agricultural labour, or by doing other paid labour work. All the women in the sample said that they could earn extra money if they had more time over, except for one woman who said that her husband did not allow her to work somewhere else.

[35] The school is by the way supported by Swedish aid and has been so for a long time.

5. The Major Benefits Arising from Rural Water Supply Projects

5.1 Health Benefits

5.1.1 Water Related Diseases.

A water related disease is one that is in some way related to water in the environment or to impurities within water. Water related diseases may be divided into those caused by a biological agent of disease (a pathogen) and those caused by some chemical substance in water. The former is also called water-related infections and includes some of the greatest causes of disease, which may have a deadly outcome like diarrheal disease and malaria. The latter include diseases such as fluorosis, which is linked to high fluoride levels in the drinking water. The depletion of groundwater leads to an increased concentration of salts in the water. Stiffening of limbs in some form is the main physical disability caused by fluorosis. It is also known to cause damage on teeth, kidney, the heart and the nervous system and can harm the foetus. Fluorosis is irreversible and can not be cured once it has affected the body. However, the chemistry related disease are of minor importance compared to those caused by biological agents. The water related infections have four transmission routes.

Table 5.1 The Four Routes and Preventive Strategies for Water Related Infection Transmission. [36]

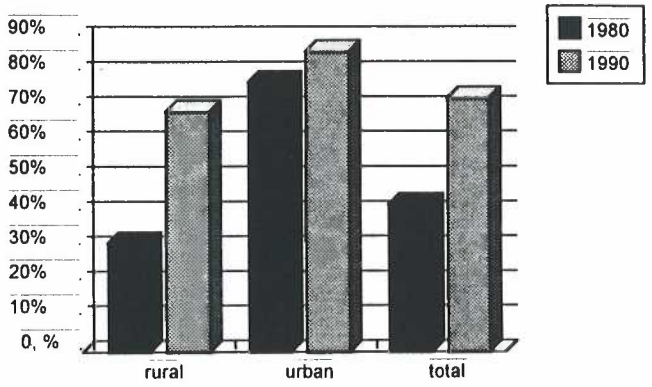
Transmission route:	Preventive strategy:
1. *Water-borne*	Improve quality of drinking water. Prevent causal use of other un-improved sources.
2. *Water-washed*	Increase water quantity used. Improve accessibility and reliability of domestic water supply. Improve hygiene.
3. *Water-based*	Decrease need for contact with infected water. Control snail population. Reduce contamination of surface water by excreta.
4. *Water related insect-vector.*	Improve surface water management. Destroy breeding sites of insects. Decrease need to visit breeding sites. Use mosquito netting.

[36] P.G Bourne "Water and Sanitation" (1984) chap 2. and
Hahn.R, .Andersson–Hahn.L and Reuterswärd.L. "Village Water Supply in India" (1981)

1.Truly water borne transmission occurs when the pathogen is in water that is drunk by a person or a animal who may become infected. Potentially water borne diseases are cholera and typhoid but also include a variety of other diseases such as infectious hepatitis, diarrhea, salmonellosis and dysentery.[37]

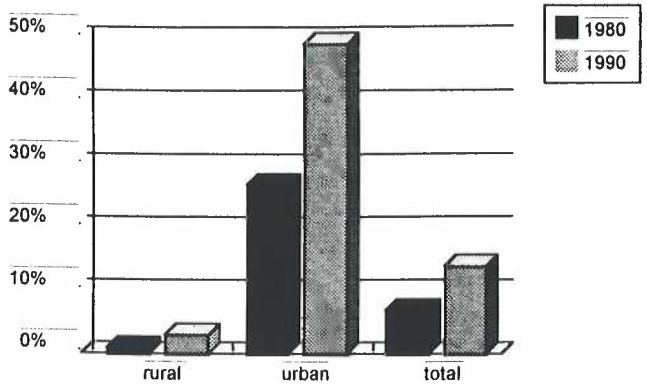
All water borne diseases can also be transmitted by any route that permits faecal material to pass into the mouth. Thus cholera can also be spread for instance with contaminated food. Therefore it is important that the country parallel with the water supply programmes have widespread sanitation programmes and health education.
Today 73 % of the total population in India have access to safe water, compared to 42% ten years earlier. Only 14% of the total population have access to sanitation[38]

Diagram 5.2 Access to Safe Drinking Water in India.



[37] For facts about symptoms and treatment, see Appendix.
[38] World Development Report 1994. A World Bank Publication.

Diagram 5.3 Access to Sanitation in India.



There are many infections that may be significantly reduced through improvements in domestic and personal hygiene. These improvements in hygiene often depend on the availability of water, on quantity rather than its quality.

2. A water washed disease may be formally defined as one whose transmission will be reduced through an increase in volume of water used for hygienic purposes no matter the quality of the water. There are three main types of water washed diseases:

First there are infections of the intestinal tract such as diarrheal diseases. Especially young children up to five are vulnerable to these infections, which include cholera, bacillary dysentery and other diseases mentioned under water borne diseases. These diseases are faecal-oral in their transmission route and are therefore either water borne or water washed. Diarrhoea is a leading cause of death among children under five in Rajasthan and is estimated to kill about 85 000 children every year.[39]

The second type of water washed infection is that of skin or eyes. Eye infections such as trachoma are common in LDCs and may lead to blindness. Other common infections are fungal infections of the skin. However these diseases mentioned are not faecal-oral and can not be water borne. The solution is therefore increased quantity of water for improved hygiene.

The third type of water washed infections is carried by lice or mites and can never be water borne. Improved personal hygiene reduces the probability of infestation of the body and clothes with these.

[39] SIDA: SWACH Evaluation Rajasthan: India Final Report (1994) p.60

3 In the Water based route, the pathogen depends on an intermediate aquatic host such as a water snail, or cyclop, to complete its life cycle.[40] Example, Guinea worm.

The Guinea worm disease is transmitted to humans when they drink contaminated water that contains infected water fleas, which act as an intermediate host for Dracunculus. The larvae of the parasite are released into the stomach when the cyclops are killed by gastric juices. When freed into the body, the larvae mate. After mating, the male worm dies, whereas the female worm always survives. The incubation time is 10-12 months, and it is not until after this period that symptoms occur. The female worm grows to about one metre long and migrate to a position under the skin, usually in the legs, where it cause an ulcer. When the ulcer is in contact with water, the worm ejects thousands of larvae into the water. If the worm is not extracted, it will continue to eject larvae for some time. Each female worm contains on estimate 1,4-3 million larvae.[41] The larvae seeks an intermediate aquatic host, a cyclop, which become infected with the larvae. The contaminated water is later on consumed and the cycle starts again.

The Guinea worm is transmitted entirely by drinking water. Contaminated water is most often found in open surface sources such as stagnant ponds or step wells, and since no effective immunity system develops, people may be infected year after year. The disease is a serious impediment to economic development as it has both social and economic affects. A lot of infected people are prevented from working because they are crippled by emerging worms and school attendance is also disrupted during the peak period. The traditional method of extracting the parasite, is a method of rolling the worm on a stick, and takes from one to three months. It is a painful process and bacterial infections are common. The worm can, however, be removed by surgical extraction, which is painless and quick. A patient is generally aware of the worm 10 days before it emerges and it can therefore be surgically removed before breaking through the skin, hence reducing chances of transmission.

4. Finally, the fourth transmission route - the insect vector route is via insects that either breed in or bite near water. Malaria and yellow fever are examples of diseases that are transmitted by insects that bite near water. Sometimes the development of water supply creates pools or puddles that extend into the dry season and prolong the period of malaria transmission. Therefore it is important to design and build proper water supply system so that the provision does not result in spreading diseases due to insect growth in places soaked with water. The handpumps should have a solid platform and a well functioning drainage system. When considering the human contribution to economic development the quality of the workforce is of significance, the level of education and their status of health. Everything is interrelated and an investment in one area lead to improvements in others. As mentioned before a high percentage of diseases are related to water of unsatisfactory quality, and therefore the government has an important role to play in providing safe water and thereby improving the public health and enhancing economic development.

[40] See Appendix, lifecycle and possible interventions.
[41] Bourne.P.G p.95

5.1.2 Eradication of the Guinea Worm

Studies have shown[42] that if there is only one worm, and it is extracted before larvae release, the average number of working days lost/ patient is 3,1 and average number of days disabled is 9.5.[43] If the worm is extracted after larvae release, the number of work days lost is instead 12.5 on average, and days disabled 22.4. If the treatment is partial extraction, the average no. of working days lost is instead 16.1 and the average number of disabled, 47.4. If inflammation prevents extraction, the working days lost increase by two days. When the treatment method is only to clean and dress the ulcer, the average number of working days lost is 27.4 and days of disability, 45.8 !

Before the SWACH project, patients were treated for abscess and ulceration after the worm had started to emerge, and it was generally preferred among traditional practitioners, to let the worm come out spontaneously. That method is painful, time consuming and there is a risk of toxic reactions and infections. The numbers of working days lost is almost 10 times more than in the case when the worm is surgically removed before larvae release. The method of spontaneous eruption is still the method preferred the world over, even though it obviously has great disadvantages for the patient. Ayurvedic[44] practitioners in Southern Rajasthan have, during the last two decades developed the method of surgically removing the worm before eruption, and SWACH adopted this method as it gives highest relief to patients and prevent transmission. The method was perfected and modernised by SWACH medical teams, who had modern aseptic techniques and used simple surgical instruments. After the success of the SWACH project other countries such as Africa have adopted the method

In the table below the number of GW cases in some of the villages survey, is presented.

Table 5.4 Guinea Worm Cases in some of the Villages Surveyed[45]

	Madri	Piplia	Makarjapa	Sodala	Kohlri
1985	0	0	0	0	0
1986	0	15	1	0	35
1987	2	21	5	0	9
1988	4	9	2	0	11
1989	1	5	0	0	7
1990	0	2	0	0	0
1991	1	-	-	-	-

[42] In 1990 a study team observed the procedure as applied to more than 800 patients. Out of these, 161 patients had only one worm in their body, and were taken as the basis for investing the effects of surgical intervention. Symptoms, days of illness and work loss were recorded.
"Project Clean. The SWACH Experience in Rajasthan" (1994) p.32

[43] a.a p.8. The following numbers about days lost come from the same source.

[44] Ayurveda = ancient medical science, which provides medication distilled from natural sources.

[49] Source of information: SWACH Headquarters in Udaipur.
The numbers for the first years are probably not correct, since in the pre SWACH period, lack of information or interest resulted in under reporting. The figures are probably higher for the first years.

In Jhadol block, SWACH treated 697 GW patients in 1988 and the number went down to 238 cases in 1990. In Kherwara block the number was 255 and 3 respectively. In Dhariawad block 107 GW cases were treated in 1988 and 58 cases two years later. In Salumber the number was 301 to only 135 two years later. In total in the Udaipur district, there were 2633 cases of Guinea worm 1988 and the number decreased to 1203 in 1990. Five years later, there were 0 cases in Udaipur - a remarkable achievement!

The SWACH project has as the numbers tell you, been very successful in eradicating the dreaded Guinea Worm. Some critics mean however, that the extensive stress on Guinea Worm eradication has meant a loss of opportunities for tackling other urgent health problems, particularly other waterborne diseases.[46] However, one thing the critics should not forget is that the remarkable achievement in eradicating the GW has led to the villagers winning respect and now they are open to make other changes and listen to advice. If SWACH instead had tried to accomplish improvements in all areas, this would probably led to mediocre results. SWACH would in that case not have appeared so trustworthy and further improvements could have been difficult to accomplish.

The value of GW eradication could easily be estimated by the "Growth of production method", discussed in chapter 2.2.2. As mentioned before, however, I concentrate mainly on time savings. I have therefore in this chapter given a quite detailed description of potential health benefits to compensate for that.

[46] SIDA: SWACH Evaluation Rajasthan: India Final Report (1994) p.60-63

5.2 Time benefits and the Valuation of Saved Time

The value to society of reduced water collection time can be estimated by looking at the alternative use of time and the value of its alternative utilisation. The higher value to society arising from time savings, can be in the form of increased economic output as well as the value of time reallocated to housework with better childcare and preparation of meals and increased attendance at school, as a result. Benefits like less injuries and higher utility arising from less time spent on the burdensome task also have a value, which however is not quantified in this analysis, but is included in the component external benefit.

5.2.1 Time Savings Reallocated to Agricultural Work.

In the study, a majority of the women said that they used the extra time for agricultural work. The study was conducted at the busiest period and hence, the thing that preoccupied their minds was their fields. In the driest periods, when the greatest relative time savings arise, the agriculture do not however, demand as much labour. At different seasonal periods, the spared time is allocated in higher extent to some activities. One way to put a monetary value on the time spent on agriculture, is to look at the productivity per person and hour and the prices of the output on the local market. Naturally this means that a significant deal of information is required, which complicates the analysis. Instead the opportunity value of time spent on this activity can be used for valuation of time benefits. *What other possible incomes do the rural women loose because of their choice to work on their own fields?*

5.2.2 Time Savings Reallocated to Labour Work

In the study, some women said that they used the extra time, and would if they got more spare time, to work as paid labour in nearby villages. Some women whose family did not have their own land, worked as paid agricultural labour or did paid housework. The value of this work is the wage earned, approximately Rs 5 per hour for unskilled labour, if one assume that the person's wage is equal to his contribution to production.

5.2.3 Time Savings Reallocated to Housework

The economic value of housework is nearly impossible to estimate directly. What is the value of better preparation of meals, sounder cleaning of the house and more careful childcare? One way could be to impute a value on housework by looking at its opportunity cost. If women prefer to work at home doing household chores, even if there is demand for agricultural labour, they must value the housework at least as high as the marginal product of extra labour input on their field, or the wage they can earn

working somewhere else. However, if the individual who can earn an extra Rs 5/hour by working overtime, have a marginal tax of say 60 %, the net wage becomes 5*(1-0,6) = Rs 2. It is more appropriate to look at the net wage when determining the value of housework or leisure on the marginal. The low-income rural women do hardly pay any taxes, however. In theory, women choose to work on the fields when the marginal revenue of that exceeds the marginal productivity of housework. However, their husbands might not allow them to work somewhere else, and their field might not need extra labour. The labour market is not perfect either, with seasonal peak periods of demand, regional imperfections etc. Despite the problems apparent, the housework needs to be valued and there are at least two ways of doing so. One), by tracing the opportunity cost i.e. what individuals could have earned, two) by looking at the cost of a maid to do the household chores.[47]

Table. 5.5 Valuation of Alternative Use of Time.

	Base for valuation	Comments
Subsistence Production	a)Price of products on local market	Applied only if the relationship between labour input and crop output is known, and a market price exists.
	b)Opportunity value of time spent on agriculture	Other incomes fore-gone because of this activity.
Housework	a)Opportunity cost of time	Other incomes fore-gone, e.g Rs 5/hour
	b)Replacement cost of housewife	Cost to hire an employee to do the housework

[47] Eklund & Herrman "The application of Cost Benefit Analysis on Rural Water Supply Project"(1991) p.131

5.2.4 Problems identified

First the problem of seasonality arises, where the labour market experiences peak periods of demand. The women in the study generally spend about 55 minutes a day all year on collection. Most of them use HP water only, but some have to use other sources in the dry period when the HP dries up. The relative time savings differ however, but an average of the whole year can be used. The problem is to estimate the value of this time when no flow of money will reflect the benefit to society. One way of solving this problem is to frankly assume that the time these poor women spend on different activities is productive and hence, benefits society. In the sample 60% of the women used the extra time to do more agricultural work or some as labour work. The marginal productivity can be assumed to be of a value of at least Rs 5per hour, since that is what they could have earned elsewhere. By shadow pricing the value of these time savings by, say 60%, the probability that not all women can get work somewhere else or choose to /get commanded to do household work, is considered. In that case the time saving with a possible opportunity cost of Rs 5 is valued at Rs 3.

The household work give great external benefits to society and imputing a value of Rs5/hour would probably not over estimate the true benefit to society. However, not all household chores give rise to high benefits to the rest of society, but instead result in higher personal utility. On the other side, the society consists of individuals and their sum of welfare is the welfare of society. By assigning a value of Rs 5 irrespective of whether this time is spent on housework or agriculture, the element of higher utility is given a value in the calculation. As mentioned before, this utility can be traced by looking at the net wage which in this case would be Rs 5 *(1- marginal tax) In the sensitivity analysis the estimated value of women's time is varied to see the effect on NPV.

Another problem is that, if only a few minutes per day is saved, this time may not be spent productively and hence it is sometimes argued that small time savings do not have any value.[48] The argument for that is that it is easier to make change of ones life if the time saving is coherent instead of scattered to a few minutes here and there. But that is a static way of looking at the problem and as Mattson points out, improvements in different areas can lead to a substantial amount of time being saved in total. I will therefore not discriminate small time savings, both because these add up and because even small time savings increase utility.[49]

[48] Mattson.B "Lönsamhet från samhällets synpunkt" (1979) p. 96

[49] Small time savings can have higher marginal utility than big, since if there was a lot of spare time, the time saved might not be valued as high on the marginal.

6. Net Present Value Investment Analysis

6.1 Components of the Model

The Net Present Value (NPV) is the difference between the present value of the net benefits (income minus operating expenditures) and the amount of project investments. A high NPV of a project indicate that the project is economically feasible, the higher the NPV the more economically viable it is. The difference in NPV would indicate which is the least cost solution. This method will be used for the analysis of the investment in a handpump.

6.1.1 The Discount Rate

A positive rate of discount means that the benefits or costs are assigned a lower value in the future than today. The higher the rate of discount, the lower the value of consumption in the future. The discount rate include three components, *compensation for postponed consumption, lost purchasing power and risk.* The social discount rate include these three and two other components, namely *society's time preference and the public expenditures opportunity cost.* If the discounted costs exceed the discounted benefits, the project lowers the welfare in society and the project should not be undertaken.

According to Mattson and other economists, the discount rate can not be calculated from the particulars of a single project. Instead it should be settled by central authorities and applied to investment analysis of similar projects.[50] I do not however, have any information about which discount rate is used for the SWACH project, or for other projects of similar character in India.

Generally, a lower rate of discount is used for public projects than for private. With a low rate of discount, less profitable projects also show a positive NPV, and therefore projects with a soft output, who generally have less strict requirements on profitability, often chose a low discount rate. But on the otherhand, in developing countries, poor people have a strong preference for immediate consumption and hence, a higher discount rate that reflects the diminishing value of future consumption should be used. So, these two forces work in the opposite directions. For private projects, the Fisher method is often used to calculate the real discount rate.

[50] Mattson.B "Cost-benefit kalkyler" (1988) p.56
"...diskonteringsräntan inte går att beräkna från de data som gäller ett enskilt projekt. Diskonteringsräntan bör fastställas centralt och gälla generellt för lönsamhetsbedömning av likartade projekt."

The ***Fisher method*** [51]:

$(1+r_q) = (1+r) \times (1+q)$
q = inflation rate
r_q = nominal discount rate at inflation q
r = real discount rate

Assumptions:
8,7% inflation in India[52]
16,3% nominal interest rates of banks. (lending rate)[53]

$0,163 = r + 0,087 + (r \times 0,087)$

$r \approx 7\%$

Hence, for a private project, a real discount rate of at least 7% should be used. However, since the preference of immediate consumption is very high, I will use a constant discount rate of 10%. I will do a sensitivity analysis, in which the discount rate varies, to see the different results of various discount rates. I will not argue in favour of one specific discount rate, but simply show how the NPV is affected by the choice of discount rate.

6.1.2 Shadow Prices

The need for shadow prices arises when the market price either does not reflect the true cost or benefit to society, or when there are no market prices. There are seven distortions that call for adjustment by shadow pricing, namely:[54]

1. Indirect- or income taxes
2. Uncorrected externalities
3. Quantity control
4. Controlled prices
5. Tariffs and trade control
6. Oligopoly
7. Imperfect information, transaction costs and missing markets

There are a number of adjustment actions which stem from the distortions mentioned above.[55] The first action suggested is that the value of all traded goods should be based on their border prices. For traded goods, the social opportunity cost is the foregone

[51] Yard.S "Kalkyler för investeringar och verksamheter " (1991) p.65-67
[52] World Development Report (1994) p.184
[53] a.a
[54] Mac Arthur John.D's article "Shadow pricing without tears: how to estimate acceptable ERRs with minimal data" p.115 Published in "Cost-benefit Analysis and Project Appraisal in developing countries" (1996) edited by C Kirkpatric and J Weiss
The distortions and the adjustment actions identified comes initially from a Dreze and Stern (1994)
[55] a.a p. 117

value of trade and the border price represents the value at which the goods can be bought and sold on the international market.

Secondly, all transfer payments like the value of direct taxes, subsidies and excess profits, should be removed from the prices of the items.[56] In a situation with full employment however, there is no need to value the labour cost at the net wage, but instead the cost is the gross wage + payroll fringe costs.[57] The reason for that is, in a situation with full employment, the labour absorbed by the project could be gainfully employed somewhere else contributing, to the production at a value equal to their marginal productivity. The company would hire labour up to the point where the gross wage + payroll fringe costs equal the marginal productivity. The same way of thinking applies to the problem of indirect taxes like value added tax. If the supplier increase its production by the same amount as the project require, then the social opportunity cost is the marginal production cost and the value added tax should not be included. If the project's consumption of inputs instead result in shortage of inputs available to other companies, the opportunity cost is MC + value added tax.[58]

Thirdly, the discontinuity between international and domestic values caused by taxes on international trade is adjusted. The foreign exchange is valued upwards through the use of a SER greater than unity, which is discussed further below in 6.2.1.

The next adjustment is to value non-traded inputs at their long-term marginal cost of supply. Generally the need of additional supply of nontraded goods are met by additional domestic supply.[59]If the needs of the project instead are met through diversion of inputs from another user, then the market price should be used.

The fifth adjustment is to make allowance for the fact that wages of some kinds of labour may be higher than the market price, especially for formal unskilled workers. Some workers are able to secure wages that are fixed at higher rates than the market-clearing price.[60]

The next step suggested by the author is to calculate the border- or market value of the goods and services used or produced by the project in question with the shadow pricing requirements taken into account. This however, I feel is done simultaneously through the other steps.

Finally the value of the potential consumer surplus is estimated, in which all externalities are taken into account.

[56] a.a
[57] Mattson Bengt "Lönsamhet från samhällets synpunkt" (1979) p. 73-75 With social payment, I mean costs like national insurance costs etc. which the employer has to pay when hiring labour.
[58] a.a p.76
[59] Mac Arthur John.D's article "Shadow pricing without tears: how to estimate acceptable ERRs with minimal data" Published in "Cost-benefit Analysis and Project Appraisal in developing countries" (1996) edited by C Kirkpatric and J Weiss p.116
[60] a.a p.117

6.1.3 Shadow Pricing the Exchange Rate

In Developing countries, the domestic currency is commonly over-valued, or synonymously, the foreign exchange is undervalued. Hence, the use of foreign exchange is more expensive than what the official rate shows, and therefore in CBA, a shadow price should be used. According to Irving.G, there are two arguments to why the official exchange rate in many developing countries cannot be taken as accurately reflecting the true value of foreign exchange. One is that protective policies (tariffs, quotas, restrictions etc.) distort the domestic price structure and hence, resources are not allocated efficiently between domestic production and trade. The second argument is that foreign exchange is indispensable for investment and its scarcity "limits the extent to which the desired rate of capital accumulation can be realised."[61]

The Shadow Exchange Rate (SER) can be estimated by taking the domestic border price ratio of traded commodities weighted by the share of each good in the country's marginal trade bill.[62] The net benefit of the project can either be expressed in terms of domestic consumption, which then is taken as numeraire , or in terms of foreign exchange, with foreign exchange as the numeraire.

6.2 A Simplified NPV of an Investment in a Handpump

The net present value calculation of investment in a handpump will here be conducted below. As mentioned before in chapter 2, investment in safe drinking water supply give rise to a great amount of benefits. I will however ignore all these, but time savings. All other benefits or costs are included in X_b and X_c.

$$NPV = G + a \times PV_A(12\ yrs, 10\%) + R \times PV + X_b - X_c$$

G = Investment costs
a = Benefit surplus (value of time savings minus current costs)
R = Scrap value
N = Lifetime of project
i = Discount rate
X_b = External benefits
X_c = External costs
PV_A = Present Value of Ordinary Annuity, $(1-(1+i)^{-N}) / i$
PV = Present Value, $(1+i)^{-N}$

[61] Irvin George "Modern Cost-benefit Methods" (1978) p. 76
[62] a.a p 76

Table 6.1 Costs for Drilling and Installation of Handpump in 1987 yrs Prices[63]

Economic life time.	Assumed to be 12 yrs
Discount rate.	Assumed to be 10%
Scrap value.	Assumed to be 0
Hydreological mapping.	Rs 250 / HP
Diesel consumed by compressor, carrier and support truck.	Rs 2215 / HP
Oils and lubricants for compressor, carrier and support truck.	Rs 424 / HP
Hammers, bits, grinding wheels on drilling rods.	Rs 1551 / HP
Camp equipment.	Rs 82 / HP
Labour	Rs 2310 / HP
Repairs and replacement.	Rs 778 / HP
Sundries.	Rs 108 / HP
Direct charges of carrier trucks, excluding diesel and oil.	Rs 937 / HP
Direct charges of support trucks, excluding diesel and oil.	Rs 1563 / HP
H.P with connecting rods.	Rs 2196 / HP
Riser pipes.	Rs 1500 / HP
Casing pipes.	Rs 1411 / HP
Cost of installation of H.P's	Rs 1202 / HP
	Σ = Rs **16 527** / HP[64]

The wage for unskilled labour is estimated to be approximately Rs 5/ hour in 1996 year prices. This has to be converted to 1987-year prices. If the wage is assumed to be constant in real terms, an adjustment for the inflation can be made and then it can be expressed in 1987-year prices. The inflation is around 8% for the period in question.

$Rs\ 5 \times 1{,}08^{-9} = Rs\ 2{,}50$

Hence, Rs 2,50/hour can be used for the valuation of the time savings arising from the project. If Rs 2,50 is used, then all time savings are valued the same irrespective of what the extra time is used for and hence, the analysis can be said to include the higher utility arising from doing less burdensome tasks (e.g. housework) compared to water collection. If a more careful approach is adopted and housework is not valued as high as for example agricultural work, the number must be shadow priced. Here a shadow price of 60% is used, which makes the time saved worth Rs 1,50.

[63] Plan of Action (Udaipur Project) 1987/88 - 1991/92, p. 21
SWACH Document No. P-2 The figures used here are revised however, estimated out of lumpsum cost and a given number of handpumps.

[64] The estimated cost of one handpump in 1987 year prices is here Rs.16 527. I have generally made the assumption that the costs over the years have changed at the same rate as the inflation. To test whether this is true, I looked at some figures I had for the cost at the end of 1994, beginning of 1995 which was Rs.30 590. If the assumption is close to reality $16\ 527 * 1.08^8$ should be the same or close to the cost of one handpump in 94-95. If I make this calculation, $16\ 527 * 1.08^8 = 29\ 800$ which is close to 30 590.

If the handpump is assumed to break down 2-3 times a' year with an average downtime of two days, 5 days a' year are lost because of breakdowns and time savings arise 360 days a' year. The number of households using the pump is assumed to be 25 and each household is assumed to save a) 0,5 hour / day b) 1 hour / day
If the cost of maintenance is ignored for the moment and the scrap value is assumed to be zero, then the NPV in 1987 year prices, is:

a) $-16\,527 + PV_A\,(12yrs, 10\%) \times Rs\ 1{,}50 \times 0{,}5 \times 25 \times 360 = Rs\ 29\,465 + X_b - X_c$

b) $NPV = Rs\ 75\,458 + X_b - X_c$

If a value of Rs 2,50/hour is used instead, then the NPV is:

a) $-16527 + PV_A\,(12\ yrs, 10\%) \times Rs\ 2{,}50 \times 0{,}5 \times 25 \times 360 = Rs\ 60\,127 + X_b - X_c$

b) $NPV = Rs\ 136\,781 + X_b - X_c$

6.3 Sensitivity Analysis

In the sensitivity analysis different variables are varied one at the time, ceteris paribus. In the following analysis, the NPV is expressed in 1987 year prices. The scrap value is assumed to be zero, which is not the case in reality however. It is less costly to replace old models of handpumps than drilling and installing at a new site, hence the scrap value is not zero. But the scrap value of a handpump has a very little impact on the NPV and can therefore for the sake of simplicity be ignored. However, if one wishes to include it in the analysis, the scrap value R is multiplied with $(1+i)^{-N}$

The number of households using the pump is assumed to be 25, which seem to be the average in the village surveyed, where all pumps are used. In some villages where the taste of water greatly varied between the pumps, 100 households or more could use the pump with the preferred taste. However, it is recommended that there is one pump per 100 people, which would be a little less than 20 households per pump.

The yearly cost of maintenance and repair is for the moment not included. If the maintenance cost mainly consists of the handpump mechanic labour cost, the cost is shadow priced by a factor that reflects the cost to society when factors like under-employment and unemployment has been considered. The cost of repair is naturally not the same every year during the projects life time. In the study, many villagers who had had a pump for two years reported that there had been no breakdowns during that period. After a couple of years they generally break down 2-3 times a' year if they function well. When the pump gets a bit older they might break once a month. So the benefits are higher the first years when the repair and maintenance cost is lower and the pump is rarely out of order. In the sensitivity analysis, by varying the days the handpump generate benefits per year, one can see how a change in the estimated days

effects the NPV. In a more sophisticated analysis, the benefits and costs are not assumed to be constant over the years, but are exactly determined for each year.

In the simplified version of the NPV calculation, the functioning days per year is assumed to be the same during the projects lifetime. In the sensitivity analysis no. One, 360 days per year is used as the standard, based on the information collected at the field study, where the average rate of breakdown was 2-3 times a' year and the average down time 2 days. For the first two years the pump might function 365 days a' year, but after some years the number of functioning days is probably less. Another problem is that the handpumps sometimes dry up in the summer, and it is more likely that the pump is used only about 300-320 days a' year. When asked if they had any problems with the availability of the water, the women rarely stated this as a problem and usually did not mentioned it, but then someone in the sample would say that she used converted wells in the summer because the handpump dried up. Because of this communication problem, it is difficult to see how big a problem it is in general. However, by varying the days of function in the sensitivity analysis the effect on the NPV can be studied. In the sensitivity analysis no. two, 320 days are used as the standard and the value of time savings is Rs 2,5 to illustrate the effects on NPV arising from the assumptions made. Sensitivity Analysis One show that it is enough that the pump function a little more than 60 days, ceteris paribus, for the NPV to show a positive value. If the pump only was used around 60 days per year, the total benefit would, however be quite low compared to the other alternatives, since the health benefit would be negligible.

In the sample, time saving was reported as one of the benefits of the handpumps. The time savings greatly vary between villages though, depending on whether the houses are situated close to each other or are scattered in the village in question. It also varies within regions where there are high concentrations of traditional water sources in some areas, whereas traditional water sources are scarce relatively close by.

One hour per household and day or more is not an unlikely number of the achieved time savings thanks to the project. In many areas, as much as 3 hours per household and day may have been saved. In the sensitivity analysis, the time saving is varied to see how this effects the NPV. If the value of each hour saved is assumed to be Rs 1,5 , the constant discount rate to be 10 % and the number of benefit generating days to be 360 days per year, Sensitivity Analysis One shows that if only 0,1 hour (6 minutes)of time saving per day and household is achieved, the NPV will be negative. Around 6-12 minutes per household and functioning day is required for the NPV to show a positive value. If time saving was the only benefit arising from the project, there would in that case have been no investment in handpumps in hamlets were the time saving was estimated to be less than 6-12 minutes per day and household. However, the benefit that is generally considered to be the most important one, is the health benefit. One have to keep in mind though, that it is more likely that the health benefits will be achieved if the villagers save time at the same time since they in that case will be more prone to use the new improved source.

If each family save 1 hour per day 360 days a year and the discount rate is 10 % but the value of each hour saved is worth only Rs 0,2 , the NPV becomes negative. Hence, in the analysis in 1987 year prices, the estimated value of one hour saved had to be more than Rs 0,2 for the project to be undertaken, ceteris paribus.

The discount rate is varied in the analysis and ceteris paribus, to show a negative NPV, the discount rate need to be very high. In short, the project is worthwhile undertaking even at high discount rates.

Sensitivity Analysis 1
Net Present Value Calculations

Rs	Time savings	Days	Disc. rate	NSF	NPV (Rs)
3,5	1,0	360	0,1	6,8137	**198104,3**
2,5	1,0	360	0,1	6,8137	**136781,1**
1,5	1,0	360	0,1	6,8137	**75457,8**
1,0	1,0	360	0,1	6,8137	**44796,2**
0,5	1,0	360	0,1	6,8137	**14134,6**
0,2	1,0	360	0,1	6,8137	**-4262,4**
1,5	**3,5**	360	0,1	6,8137	**305419,9**
1,5	**2,5**	360	0,1	6,8137	**213435,1**
1,5	**1,5**	360	0,1	6,8137	**121450,3**
1,5	**0,5**	360	0,1	6,8137	**29465,4**
1,5	**0,2**	360	0,1	6,8137	**1870,0**
1,5	**0,1**	360	0,1	6,8137	**-7328,5**
1,5	1,0	**350**	0,1	6,8137	**72902,7**
1,5	1,0	**340**	0,1	6,8137	**70347,6**
1,5	1,0	**330**	0,1	6,8137	**67792,4**
1,5	1,0	**320**	0,1	6,8137	**65237,3**
1,5	1,0	**310**	0,1	6,8137	**62682,2**
1,5	1,0	**60**	0,1	6,8137	**-1196,2**
1,5	1,0	360	**0,11**	6,4924	**71119,8**
1,5	1,0	360	**0,13**	5,9176	**63361,2**
1,5	1,0	360	**0,15**	5,4206	**56651,4**
1,5	1,0	360	**0,17**	4,9884	**50816,2**
1,5	1,0	360	**0,19**	4,6105	**45714,8**
1,5	1,0	360	**0,25**	3,7251	**33762,1**

Sensitivity Analysis 2
Net Present Value Calculations

Rs	Time savings	Days	Disc. rate	NSF	NPV (Rs)
3,5	1,0	320	0,1	6,8137	**174256,4**
2,5	1,0	320	0,1	6,8137	**119746,8**
1,5	1,0	320	0,1	6,8137	**65237,3**
1,0	1,0	320	0,1	6,8137	**37982,5**
0,5	1,0	320	0,1	6,8137	**10727,8**
0,2	1,0	320	0,1	6,8137	**-5625,1**
2,5	**3,5**	320	0,1	6,8137	**460431,4**
2,5	**2,5**	320	0,1	6,8137	**324157,6**
2,5	**1,5**	320	0,1	6,8137	**187883,8**
2,5	**0,5**	320	0,1	6,8137	**51609,9**
2,5	**0,2**	320	0,1	6,8137	**10727,8**
2,5	**0,1**	320	0,1	6,8137	**-2899,6**
2,5	1,0	**350**	0,1	6,8137	**132522,5**
2,5	1,0	**340**	0,1	6,8137	**128264,0**
2,5	1,0	**330**	0,1	6,8137	**124005,4**
2,5	1,0	**320**	0,1	6,8137	**119746,8**
2,5	1,0	**310**	0,1	6,8137	**115488,3**
2,5	1,0	**30**	0,1	6,8137	**-3751,3**
2,5	1,0	320	**0,11**	6,4924	**113320,1**
2,5	1,0	320	**0,13**	5,9176	**101825,9**
2,5	1,0	320	**0,15**	5,4206	**91885,4**
2,5	1,0	320	**0,17**	4,9884	**83240,7**
2,5	1,0	320	**0,19**	4,6105	**75683,1**
2,5	1,0	320	**0,25**	3,7251	**57975,4**

6.4 Factors to Consider in the NPV Analysis

- Cost of maintenance and repair
- Distribution of benefits over the year
- Scrap value
- Other costs
- Shadow pricing

6.4.1 Cost of Maintenance and Repair

The state government spent in 1987 about Rs 200 per pump every year, out of which Rs 135 was for the salary of the mechanic and Rs 65 for the purchase of certain spare parts. In addition the PHED carried out an intensive repair campaign twice a'year under which major repair was undertaken. On average the cost of such a repair was Rs 100 per pump. Thus the state government spent about Rs 300 on average per handpump and year in 1987.[65] In the NPV analysis, the cost of maintenance and repair is deducted from the benefit surplus, a. The cost of Rs 300 is assumed to be constant over the years and hence the number is adjusted for the inflation for each year if expressed in current terms. If the NPV is expressed in constant terms, the maintenance cost need no adjustment. In current numbers 1996, the cost of maintenance and repair would be around Rs 600 per handpump and year. The analysis can further be complicated by shadow pricing the labour cost by a conversion factor, which reflect the situation on the labour market. If the spare parts are imported or exportable, the foreign exchange lost should be included in the social cost of maintenance and repair. Since foreign exchange is valuable, a significant loss in foreign exchange would lower the NPV and the investment would become less profitable.

6.4.2 Distribution of the Benefits Over the Years

For the first years the pump might not break down at all and, hence, generate benefits 365 days per year, if the pump is assumed to withstand the drought. Over the years the pump break down more frequently and the number of benefit generating days decrease. From year 3 to 6 it might break down 2-3 times a'year if it is functioning well. If the average downtime is assumed to be 2 days as reported in the study, the pump generates benefits 360 days. When the pump gets older it might break down once a month or more. In that case, its functioning days per year would be 341 or less. In the NPV the distribution of benefits is of importance to delineate, since benefits in the immediate future are valued higher, which is indicated by the positive discount rate. Hence, in a sophisticated NPV analysis, the estimated number each year should be used instead of an average over the years.

[65] Plan of Action (Udaipur Project) 1987/88 - 1991/92, p. 6
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6.4.3 The Scrap Value

When making a NPV calculation, the scrap value, R is multiplied with $(1+i)^{-N}$ if expressed at the prices at the end of the project. For a handpump, the scrap value is positive and can be of significance since the pump can be modified and parts be replaced. However, the lifetime chosen for the project in this analysis is quite long and it is expected that less costly modifications will be conducted during the time period in question. Anyway, if there is any value left after 12 years, this should be included in the analysis. I have however, no information about the scrap value so I can not give an exact value, merely note the fact that if the ground water level has not been significantly lowered, the salinity not increased and the pump not totally out of fashion, the scrap value is positive.

6.4.4 Other Costs

The cost of land is not included in the analysis since no cost is presented in the documents. If the land used is small it can be priced at the market price, whereas if it is large the alternative net product is used as the basis for valuation. Other costs that should be included in a cost-benefit analysis are all external cost (and benefits). In the simplified analysis, these are not estimated but only notified.

6.4.5 Shadow Pricing

India has during the 1980-ties pursued a strict import substitution program in oil. In the middle of that decade, the oil imported accounted for one third of the domestic oil consumption compared to three quarters ten years earlier. The import substitution in oil was achieved not only by expanding domestic supply but also by restraining domestic consumption. Domestic oil prices are kept substantially above cif prices. When taking this fact into consideration, there are two factors that need to be considered when shadow pricing. First, in the cost for the diesel, Rs 2215, there are substantial taxes included. Second, valuable foreign exchange could be earned if the oil was exported. If there had not been high taxes included in the price, the conversion factor (CV) would be well above unity if expressed at domestic prices. Since oil is a resource for which the "production" can not easily be increased when the demand rise, the use of it for the project divert it from other users. The correct way of proceeding is to remove the taxes and is multiply the remaining value with the SER. However, the taxes are set to spare foreign exchange and hence, it seems as if it has already been priced according to its value as an import substitute. In that case it can remain untouched at the value of Rs 2215 and Rs 424 respectively.

The other inputs are adjusted accordingly, with taxes removed when there is spare capacity and further adjusted down if there exist unemployment etc. and adjusted upwards when they alternatively been exported. For example, the conversion factor for the labour cost is close to unity if the labour is skilled and scarce, whereas if excess is

absorbed, the social cost is much lower. The handpump with connecting rods should be priced accordingly to the foreign exchange it could earn if it was instead exported.

7. Conclusions

A) First of all in the beginning of my work, I was curious to know whether the pumps that the project have invested in, were actually functioning satisfactorily and generating the expected benefits. The field trip showed that the majority of the villagers in the villages surveyed use handpump water for drinking purposes and that the pumps in general function well with quick repair in case of breakdown. There seems however to be at least one pump out of order, because of major breakdown, in every village. Another problem was that in some hamlets, the pumps dry up in the summer. How widespread a problem this is I cannot tell from my survey.

Another interesting finding of the field trip was that the villagers often pay the handpump mechanic who is employed and paid by the panchyat. In some cases they hired and paid a private mechanic Rs 1-3 voluntarily in order to get quick service and in villages located a bit aside often are asked to pay Rs 2-5 to the mechanic employed by the panchyat. If the pumps are assumed to break down 2-3 times a year and 25 households share one pump the handpump mechanic who repair the pumps in interior areas is hence earning at least about Rs 219 per pump a year by charging the villagers a repair fee. Probably the amount is higher since it seems to be the procedure that all the households in the hamlet are asked to pay. The villagers find it in order to pay the mechanic, but they would not want to pay the government since they think it is their responsibility to provide and maintain the pumps. However, it seems as if they have started to take responsibility for the pumps, since they even hire private mechanics.

My suggestion is that in order to save money on public expenditure the salaries to handpump mechanics or other staff that work on repair an maintenance of future public projects, should be set at a minimum and the mechanic should be encouraged to charge the villagers a repair fee of about Rs 2 or 3 per household. Since the villagers seem to have a bit of an unclear idea about what the state is and where it gets the money from it is easier to make them pay to a person of flesh and blood, than to a fund of repair and maintenance. Some control measures like a one day survey of selected villages could be used to ensure that the villagers are not over-charged by the mechanic. The reason why the state pays and trains the mechanic, is to ensure that the pumps work properly and this should of course still be the priority.

B) The second objective of the study was to try to quantify the gains to society, by a cost-benefit approach in which the NPV was calculated. With the information from the field study as a basis, I could start to estimate how the benefits arising from the pumps could be valued from a social economic perspective. The analysis show that even if there are only small time savings per household and day, less than 6-12 minutes in total, the NPV becomes positive. It further showed that even if the opportunity value of women's time is considered to be very low, a little less than Rs 0,3 in 1987-year prices, the NPV still becomes positive. Additional information that was given by the analysis was that at even at very high discount rates, the NPV still becomes positive. I feel that a simplified NPV can give a good idea about the social gain of the project whereas a

sophisticated NPV may be less cost-effective. A NPV of approximately Rs 128 000 + $X_b - X_c$, expressed in 1987-year prices, is a likely value of the benefit of an investment in a handpump in the rural areas of Udaipur. My final conclusion is that the NPV calculation has successfully illustrated how gainful the investment in a handpump can be and the usefulness of the theories of benefit calculations, shadow pricing of costs etc in quantifying an appraising projects is proved.

Appendix

In appendix, there is complementary information to some chapters. This information is either explanatory in character or serves to give a deeper insight to the facts behind a matter.

Chapter 3 SWACH's Investment in Hardware

Table 3.1 Number of Stepwells Converted up to June 1995

Period	Udaipur	Banswara/Dungarpur	Total
1986-87	0	1912	1912
1987-88	1063	957	2020
1988-89	1636	163	1799
1989-90	725	133	858
1990-91	535	374	909
1991-92	423	325	748
1992-93	611	324	935
1993-94	-	-	223
1994-95	-	-	91
Total	4993	4188	9495

Table 3.2 Number of Handpumps installed up to June 1995

Period	Udaipur	Banswara/Dungarpur	Total
1986-87	0	587	587
1987-88	36	1065	1101
1988-89	516	851	1367
1989-90	600	1036	1636
1990-91	1391	430	1821
1991-92	932	230	1162
1992-93	132	64	196
1993-94	-	-	362
1994-95	-	-	428
Sum	3607	4263	8660

Chapter 4. Field Study Questionnaires

Name of village:_____.
No. Of households:_____.
Population:_____.
No. Of HPs:_____.
Other sources available:_____.

Data / respondent:
Name:_____.
Age:_____.
Caste:_____.
Family size:_____.
Education:_____.

1. Do you face any problems with the availability of drinking water from the handpump?

❑Yes ❑ No

1b. If yes, type of problem:

❑ Scarcity during dry season.
❑ Overcrowding at handpump site.
❑ Handpump too far away.
❑ Repeated HP breakdowns.
❑ Arguments / fight over water.
❑ Other,_____.

2. Source used for drinking water collection:

❑ Handpump.
❑ Stepwell, other open.
❑ Other, such as._____.

2b. Storage of water?:

❑ Earthern.
❑ Metal.
❑ Plastic.

2c. How do you take water from the storage vessel?:

❑ Tap attached to vessel.
❑ Pour out.
❑ Ladle / container with handle.
❑ Container without handle.
❑ Other, _____.

3.Source used for washing & bathing:

❑ Handpump.
❑ Stepwell, other open.
❑ Other, such as._____.

3b. If other source than HP is used for drinking water collection, reason to that:

❑ HP does not work.
❑ Water tastes bad.
❑ No access.
❑ Too long queues.
❑ Too hard work using the pump.
❑ Other, _____.

3. Time spent on collecting water each time (approximately)

❑ 01-10 min
❑ 11-20 min
❑ 21-30 min
❑ 31-50 min
❑ Other, _____.

4. How many times do you (household) collect water every day?:

❑ 1-2
❑ 3-4
❑ 5-6
❑ 7-8
❑ Other, _____.

5. At what time do you usually collect water (if more than once a day, mark all alternatives):

❑ Before sunrise
❑ At sunrise
❑ Midday
❑ Afternoon
❑ Sunset
❑ After sunset

6. Do you think there often is a long queue?:

❑Yes ❑ No

If yes, how many women in the queue?

_____.

7b.
If yes, at what time is the queue worse? (Ranking 1 worse, 2 second worse and so on).:
- ❑ Before sunrise
- ❑ At sunrise
- ❑ Midday
- ❑ Afternoon
- ❑ Sunset
- ❑ After sunset

8. Do you use the same HP most of the time to collect drinking water?:
❑Yes ❑ No

8b. If yes, how many families use the same HP as you do?:
- ❑ 1-4
- ❑ 5-10
- ❑ 11-16
- ❑ 17-22
- ❑ 22 +
- ❑ (Exact no _____)

8c. Approximately how far away from your house is the HP?
_____.

9.Is there a HP that is not used very much?:
❑Yes ❑ No

9b. If, yes reason (mark all alt.):
- ❑ Does not work.
- ❑ Access prohibited.
- ❑ Too little water comes out.
- ❑ Water tastes bad.
- ❑ Other, _____.

10. If the HP breaks down, how long is the downtime in general?:
- ❑ Repair same day.
- ❑ 1-3.
- ❑ 4-14.
- ❑ 15-27.
- ❑ 1-2 month.
- ❑ Other, _____.

11. Who repairs the pumps?:
_____.
_____.
_____.

12. Do you have to pay for the repair?:
❑Yes ❑ No

12b. If yes how much?:
_____.

13. How often do the HP/HPs break down?:
- ❑ Once a year.
- ❑ 2-3 times / year.
- ❑ 4 +.
- ❑ Other, _____.

14. Who collects the water in your household? (If more then one person, ranking 1,2,3...):
- ❑ The woman herself.
- ❑ Daughters – 13.
- ❑ Daughters 13 +-
- ❑ Sons – 13.
- ❑ Sons 13 +.
- ❑ Husband.
- ❑ Mother-in-law.
- ❑ Water hauler

14b. If water hauler is used, how much do you pay for that?:
_____.

15. Have you benefited from the HPs?
❑Yes ❑ No

15b. If yes, how?
_____.

15c. If time saving, what do you use the extra time for?:
- ❑ Gardening.
- ❑ Agriculture work.
- ❑ Longer sleep.
- ❑ Preparation of meals.
- ❑ Child care.
- ❑ Handicraft, handloom.
- ❑ Leisure time.
- ❑ Other, _____.

15d. How much time did you spend on collecting water before HPs?:
_____.

16. If you had some extra hours to spend, would you have a possibility to earn some extra money?
❑Yes ❑ No

16b. If yes, how?:

- ❑ Paid agr. Labour
- ❑ Work in nearest village.
- ❑ Handicraft, handloom.
- ❑ Poultry, livestock.
- ❑ Other, _____.

16c. If no, why not?:

- ❑ Everything is too far away.
- ❑ Have no skills.
- ❑ No money to invest.
- ❑ My husband will not allow me.
- ❑ Have no idea of what I could do.
- ❑ Other, _____.

17. Do you have any special activities for women in your village?:

❑Yes ❑ No

17b. If yes, what kind?:(Do you attend?)

_____.
_____.
_____.
_____.

18. How does your day look like? Rank the activities that take up your day.:

- ❑ Fuel & fodder collecting.
- ❑ Water collecting
- ❑ Preparation of meals.
- ❑ Working on fields.
- ❑ Washing.
- ❑ Childcare.
- ❑ Cleaning the house.
- ❑ Other, _____.

ON SITE INSPECTION

Handpump No._____.
Location_____.
_____.

1. Water delivery rate (after monsoon)

10 litres, time_____.
Effort:

- ❑ Smooth & easy
- ❑ Satisfactory
- ❑ Hard work
- ❑ Very Hard work

2. Queue time

W	Characteristics	Arr.	Wat.	Pump Str.	App L.	Ready Dep-	Actua l dep	Dip hands
A								
B								
C								
D								
E								
F								
G								
H								
I								
J								
K								
L								
M								
N								

2b. Queue formation

- ❑ Fair
- ❑ Unfair
- ❑ Discriminatory

2c. Mode of collectors

- ❑ Jolly
- ❑ Neutral
- ❑ Irritated

CONDITION

3. Pump intact & well functioning

❑ Yes ❑ No

3b. If not, why?

_____.

_____.

4. Platform condition

❑ Good ❑ Bad

Remarks,_____.

_____.

_____.

5. Drainage condition

❑ Good ❑ Bad

Remarks. _____.

_____.

_____.

6. Pump surroundings

❑ Good ❑ Bad

Remarks. _____.

_____.

7. Points of notation

Yes	No	
❑	❑	Cattle washed near pump
❑	❑	People defecate near the pump
❑	❑	Cattle through exist
❑	❑	Washing platform exist
❑	❑	Wastewater is used usefully
❑	❑	Access is easy

DISTANCE TO SOURCE

Square km.....

No. of pumps.....

Traditional source.....

.....

Location.....

.....

.....

Sample / distance to HP:

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
N	

Other facts:.....

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ECONOMIC ACTIVITIES

Infrastructure

Road from village:
{ } Good { } Bad { } Non existent

Public transport to and from:

Train	Bus	
{ }	{ }	4 + a' day
{ }	{ }	2 - 3 times a' day
{ }	{ }	Once a' day
{ }	{ }	Two to three times a' week
{ }	{ }	Less than 2 times a week
{ }		Other,.....
	{ }	Other,.....

Electricity
{ } 10-25%
{ } 26-50%
{ } 51-75%
{ } 76-100%
{ } None existent
{ } Other,.....

Notation on economic activities present in the village

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Chapter 5. Water Related Diseases

Cholera: Cholera is caused by the bacterium Vibrio cholerae and the toxin that it produces. The disease is accompanied by severe diarrhoea and vomiting, which might result in loss of body fluids equal to the persons body weight, within the course of one to two days. If lost fluids are not replaced, the patient dehydrates and develop sunken eyes, dry mouth, cold extremities and depressed blood pressure. Children may also suffer fever. If fluid is not provided, the patient develops shock and dies. The treatment of the person is to replace fluids and electrolytes and by prescribing antibiotics such as tetracycline which shorten the duration and severity of the illness.

Hepatitis: Hepatitis is an inflammation of the liver, usually caused by viral invasion. Infections of any of the related hepatitis viruses often results in low grade fever, nausea, jaundice (discoloration of the skin and eyes) and abdominal pain. There is vaccine which is effective against most hepatitis viruses and have a long duration.

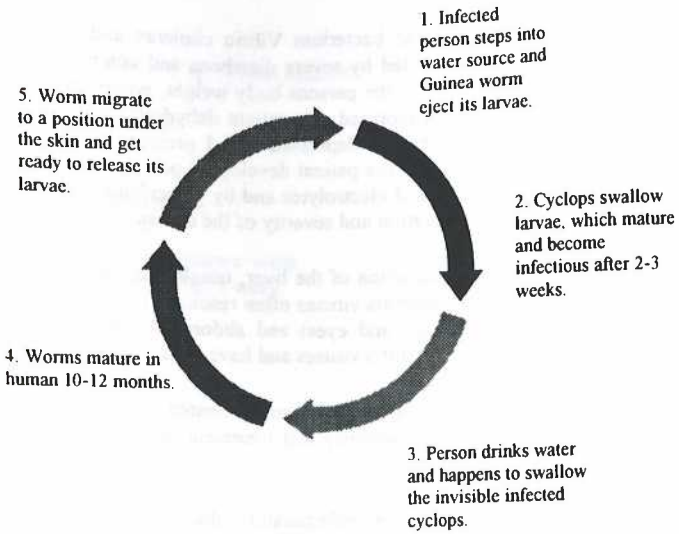
Salmonella: The disease is transmitted with contaminated food or water. There are 1400 serotypes and the symptoms, severity and treatment depends on which type the patient has caught.

Trachoma: Trachoma is a chronic inflammatory disease of the eye caused by Chlamydia trachomatis, a bacteria like micro-organism that grows within the tissue cells of the infected host. The cornea becomes inflamed and if the scarring is extensive, it can lead to corneal opacity and blindness.

Typhoid: Typhoid fever is caused by a specific serotype called Salmonella typhosa, which is endemic in many countries. Some of the symptoms of the illness are high fever, chills, headache, abdominal pain and a rash. The treatment requires specific antibodies.

Yellow Fever: Yellow fever is caused by a virus that is found in forest monkeys and which is transmitted to humans by mosquitos. The illness is accompanied by sudden onset of fever, chills, headache, photophobia (pain upon looking at light), backache, nausea and vomiting. The name of the disease has come out of the yellowish colour of the patient's eyes and skin. Yellow fever can cause heart failure and kidney derangement. The best way to prevent the disease is by immunisation.

Life cycle of Guinea worm



Possible Interventions.

1.

- Provision of new safe resources.
- Health education to prevent carriers of the disease stepping into water sources.
- Converting wells.

2.

- Temephos treatment of source to kill water cyclops.
- Planting fish in well to eat the cyclops.

3.

- Filtering of unsafe drinking water.
- Substituting wells for safer sources like handpumps.

4.

- No possible intervention.

5.

- 10 days before eruption, worm can be surgically removed.
- If the worm has already started to emerge, bandaging the limb to avoid larvae leakage and bacterial infection.
- Health education.

References

Publications Authorized by Organisations:

- **GOR & UNICEF**
  "Plan of Action 1986-1990"
  GOR and UNICEF Publication (1986)

- **Habitat (United Nations centre for Human Settlements)**
  "The Conservation of Drinking Water Supplies. Techniques for Low-income Settlements".
  UN Publication Nairobi (1989)

- **UNDP**
  "Gender Issues Sourcebook for Water and Sanitation Projects"
  UN Publication (1995)

- **UNICEF (United Nations Childrens Fund)**
  "The Progress of Nations"
  UNICEF Publication (1994)

- **UNICEF (United Nations Childrens Fund)**
  "Project Clean:The SWACH Experience in Rajasthan"
  UNICEF Publication (1994)

- **UNICEF (United Nations Childrens Fund)**
  "Water and Sanitation in UNICEF 1946-86".
  UNICEF Publication (1987)

- **SIDA**
  " A Note on SWACH: SIDA Annual Review April 1994"
  SIDA Publication (1994)

- **SIDA**
  "SIDA: SWACH Evaluation Rajasthan, India Final Report"
  Centre for Development Studies Swansea UK (1994)

- **SIDA**
  "SWACH Project Rajasthan – India, Final Progress Report July 1994 to December 1995
  UNICEF (1996)

- **UNITAR**
  "UN Development Aid: Criteria and Methods of Evaluation"
  UN Publication New York (1971)

- **United Nations**
  "Criteria for and Approaches to Water Quality Management in Developing Countries".
  Natural Resources Water Series No. 26.
  UN Publication New York (1991)

- **United Nations**
  "Systematic Monitoring and Evaluation of Integrated Development Programmes: A Source Book"
  UN Publication (1978)

- **United Nations**
  "Ground Water Quality and Monitoring in Asia and the Pacific".
  Water Resources Series No. 70.
  UN Publication (1991)

- **United Nations**
  "Guide to Practical Project Appraisal - Social Benefit Cost Analysis in Developing countries"
  UN Publication (1978)

- **United Nations**
  "Guidelines for Project Evaluation"
  UN Publication (1972)

- **United Nations**
  "Legal and Insitutional Factors affecting the Implementation of the International Drinking Water Supply and Sanitation Decade".
  National Resources Water Series No. 23 ,1989

- **United Nations**
  "Promotion of Women's Participation in Water Resources Development".
  Natural Resources Water Series No.25 (1990)

- **United Nations**
  "Report of the United Nations Water Conference".
  Mar del Plata (1977)

- **United Nations**
  "Report of the World Conference of the United Nations decade for Women's Equality, Development and Peace".
  Copenhagen (1990)

- **United Nations**
  "Water Quality Monitoring in the Asian and Pacific Region".
  Water Resources Series No. 67 (1990)

- **United Nations**
  "Water Resources Planning to meet Long Term Demand: Guidelines for Developing Countries".
  National Resources Water Series No. 21

- **World Bank**
  "World Development Report 1990, Poverty".

- **World Bank**
  "World Development Report 1993, Investing in Health".

- **World Bank**
  "World Development Report 1994, Infrastructure for Development".

- **World Health Organization**
  "Operation and Maintenace of Urban Water Supply and Sanitation Systems. A guide for managers" (1994)

- **World Health Organization**
  "Guidlines for Drinking-Water Quality"
  Second Edition Volume 1 Recomendations (1993)

- **World Health Organization**
  "Integrated Vector Control".
  Technical Report Series 688. (1983)

- **World Health Organization**
  "Models of Management Systems for the Operation and Maintenance of Rural Water Supply and Sanitation Systems"
  Published (1993)

- **World Health Organization**
  "Tools for the Assessment of Operation and Maintenance Status of Water Supplies"
  Published (1994)

- **World Health Organization**
  "WHO Expert Committee on Malaria".
  Technical Report Series 735 (1986)

- **Växjö Högskola**
  Eklund and Herrman
  "The Application of Cost Benefit Analysis of Rural Water Supply Projects".
  Ser. 1. Economy and politics 29 (1991)