# ENVIRONMENTAL IMPACT ASSESSMENT OF POTABLE WATER SUPPLY AND SANITATION IN RURAL AREAS OF DEVELOPING COUNTRIES

A THESIS SUBMITTED FOR DEGREE OF DOCTOR OF PHILOSOPHY(PhD)

by

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I sincerely thank my wife and children for their patience during undertaking of my research.

# DECLARATIONS

I declare that the study presented in this thesis is the result of my own investigation.

HASSAN NANABKHSH

Salford , November

1993

I declare that this work has under no circumstances been submitted in candidature for any other degree.

HASSAN NANBAKHSH

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1993

# ABSTRACT

The main objective of the present research was to assess the environmental impacts of the provision of potable water supplies and sanitation projects, both during the construction and operation phases. The research was related to rural areas of developing countries. Field research was undertaken in the rural areas of the Northwest and Central regions of Iran.

Data were obtained by observations and survey from the field, and a comprehensive questionnaire and literature review. Interviews were carried out by the author in households, particularly women, in four villages with a piped water supply and sanitation facilities, and four villages without such facilities, in the two different regions.

To assess the beneficial and negative impacts stemming from the projects, Environmental Impact Assessment (EIA) techniques were used. After the application of EIA through the use of checklist of impacts and the Leopold's matrix, results demonstrated that the implementation of water supply and sanitation projects can have several negative impacts on the natural environment, and positive beneficial impacts on the social and economic environment.

In relation to water supply and sanitation projects, the most effective EIA method was shown by this study to be the Leopold's matrix. It can identify both positive and negative impacts and the interaction between the project activities and environmental parameters. The most important recommendations that stem from this research are, that project planners and water engineers should employ EIA methods in planning water projects, particularly in the rural areas of developing countries.

# CHAPTER 1

## 1.O: GENERAL INTRODUCTION

## 1.1: Objectives of research

The present study seeks to investigate the major positive and negative impacts that may stem from providing a potable water supply and sanitation in the rural areas of developing countries, with particular reference to Iran. The overall objectives of the study have two main aspects, including:-

### I. General Objective:

- To study the environmental implications of a potable water supply and sanitation project in rural areas of developing countries.

### II. Specific Objectives:

- To study the occurrence of impacts of water supply and sanitation projects using case studies.
- To study the application of EIA to water supply and sanitation projects in the rural areas of Iran.
- To identify and assess the positive and negative impacts generated by such projects.
- To recommend environmental action to control and /or minimize the negative impacts, and maximize or enhance the positive impacts
- To suggest some requirement recommendations.

**1.2: Outlines of study**

In preparing this thesis, I have structured the text as follows:-

**Chapter 1.** deals with the general introduction, concerning objectives of the research, the importance of water supply and sanitation, the situation and dimensions of problems and the goals and objectives of improved water supply in rural areas of developing countries.

**Chapter 2:** addresses the concept and processes of Environmental Impact Assessment (EIA), the situation of EIA in developing countries including the Asia and Pacific Region and in Iran, and the application of EIA in water resources projects in developing countries.

**Chapter 3:** gives the types of water supply techniques used in rural areas of developing countries, the problems and limitations of water sources, the adverse environmental impacts of more usage of ground water, and methods of control.

**Chapter 4:** discusses the adverse environmental effects of pollution on water sources such as ground water, surface waters, and rain water with respect to protection and sanitary measures.

**Chapter 5:** presents the impacts of simple water treatment processes for rural communities and households and with respect to their environmental impacts.

**Chapter 6:** focuses on the wider implications of potable water supply and sanitation projects in rural areas. It examines the relation between water supply and sanitation on one hand, and their impacts on health, on the other. This chapter also considers the social and economic benefits that might be expected to result from investment in rural water supply projects.

**Chapter 7:** deals with my EIA base line study in my eight sample villages where four villages included two villages with water supply and sanitation facilities, and two without such facilities, in the Urmia areas North West of Iran. Similarly, four villages were sampled in the Yazd City, the Central desert area of Iran. Various aspects of the environment, health, and socio-economic status of the villages are described here. Data obtained by health centres, observations and field survey, and from questionnaires are described. This chapter also identifies a variety of impacts that may be produced by a water supply and sanitation project in the improved villages during operation, and in the unimproved villages during the construction and operation phase.

**Chapter 8:** Firstly, focuses on the EIA methodology, the selection of EIA methods, and the application of checklists and matrices for the assessment of impacts stemming from water supply and sanitation projects. Secondly, it comments on the most important positive and negative impacts identified, and the mitigation measures which may be used to reduced the adverse impacts.

**Chapter 9:** Lists conclusions and makes recommendations, which may be useful for the implementation of water supply and sanitation projects in the rural areas of Iran.

## 1.3:Definitions

The following definitions are related to water supply and sanitation projects in rural areas of developing countries.

**I. Adequate supply and safe water:** Farrar in 1974 noted that an adequate supply is one where people have "reasonable access to safe water". This phrase is clarified a little by saying reasonable access exists when a women does not have to spend a disproportionate part of the day in carrying water for her family's needs.

Safe water is treated surface water, or untreated but uncontaminated water, such as from boreholes, protected springs and sanitary wells. Other water of doubtful quality will be classified as unsafe (Dieterich,1974; Farrar, 1974).

Potable water or good water is sometimes described as "wholesome and palatable", a term which is defined by Fair, et al. in 1971, as water which is free from disease organisms, poisonous substances, and excessive amounts of mineral and organic matter. To be palatable, it must be significantly free from colour, turbidity, taste and odour and well aerated". Tebbutt in 1983 suggested that in addition, as far as possible, it should be suitable for other domestic uses such as washing clothes, and bathing.

**II. Sanitary measures:** The term "sanitation" has been defined by Saunders and Wardford (1976) and the United Nations in 1987. Sanitation is the provision of facilities for excreta and waste water collection and disposal. Pacey in 1980 reported that the term "sanitation" can cover water supply as well as excreta disposal. Otherwise, the word sanitation refers to all measures that protect health by the elimination of dirt and the infection dirt may carry. In this thesis, the term " sanitary measures" is used for the prevention of the pollution of potable water, or the protection of water sources such as springs and wells.

## 1.4: Importance of improved water supply and sanitation

Water is not only necessary for Man's survival on Earth but also is an essential component for the improvement of the quality of life of the people living in developing countries ( Biswas and Asce, 1980).

One of the most necessary constituents of the human environment is water. As Honari, noted in 1979, water exists in, on and over the Earth from about 10 km below the surface to about 5 km above it. Oceans, seas, lakes, and rivers cover seven tenths of the Globe's surface, only 0.635 % of the total amount of water is on land, and a still smaller percentage of water is available to Man.

The use of water by Man, plants, and animals is universal. Without water there can be no life. Every living thing demands water. Man can live nearly two months without food, but can live only three or four days without water (Shelat and Mansuri, 1971; Wright, 1956).

Man may use water for a variety of important purposes, among them irrigation, hydroelectric power generation, industrial manufacturing, waste disposal, recreation, and wildlife enhancement. The most significant use of all, particularly in the rural areas of developing countries is immediate and vital and is for drinking, cooking, washing, and sanitation (Biswas, 1981).

According to Tebbutt in 1973, since water is an essential need for maintaining life and settlements, and for the development of communities, its presence or absence in an area has a profound impact on its development and prosperity.

In the developments of rural communities water plays a vital role, hence, a reliable supply of water is an essential prerequisite for the establishment of a permanent settlement. Unfortunately, animal and human wastes from such a community may have considerable impact on that water (Tebbutt, 1983).

It is difficult to imagine any clean and sanitary environment without water. The progress of sanitation throughout the world has been closely associated with the availability of water. Generally, the larger the quantity and the better the quality of water, the more rapid and extensive has been the advance of public health ( Wagner and Laniox, 1959).

The provision of potable water supply and sanitation facilities in rural areas entails capital investment that is of permanent value. Investment in sanitation has a cumulative effect as more resources are allocated to it. In order, however, to obtain the best possible health benefits from the investment in sanitary facilities, there is a need to ensure that these facilities are properly and extensively used, and are also well maintained. These activities also require investment in health education, and possibly also in items such as drainage for used water (Cvjetanovic, 1979).

**1.5: The situation and dimensions of the problems**

The majority of people in developing countries live in the rural areas and depend on agriculture, or trades directly associated with it, for a living. Farrar, in 1974, pointed out that there is increasing concern about the water supplies available to this large proportion of Mankind for two main reasons:

**(a)** poor water supplies are considered a significant restraint on the economic development of rural populations, and

**(b)** inadequate supplies are the cause of much hardship, and in some instances, acute suffering from natural disasters, for instance the droughts of Botswana in the late 1960's and those of India and West Africa in 1972- 1973.

The provision of adequate water supplies to the millions of rural population who currently lack them is an enormous challenge to the international community. Many governments and agencies have found that progress in this field is by no means simple and depends on more than just the allocation of funds for the construction of systems ( Feachem et al. 1977).

The World Health Organization (WHO) is the United Nations agency which is directly concerned with community water supply and sanitation in developing countries. The

Twelfth World Health Assembly in 1959 initiated the WHO community water supply programme to provide ample, continuous and convenient supplies of safe water to all human populations" (Farrar, 1974).

According to Holdgate et al (1982) this concern was also expressed at the United Nations Conference on Human Settlements in 1976, and on Water in 1977.

The WHO in 1971 made an assessment of the water supply and sanitation situation in the rural areas of developing countries. The results of this assessment are summarized in Table 1.1. For example; in 1970, only 12% of people had access to safe water supplies. By 1980 that proportion had risen to only 25%. Rural people were even worse off for sanitary facilities. By 1980 only 15% had sanitary facilities.

These findings caused concern at the World Health Organization and as a result of the world wide interest in improving this situation, the United Nations Water Conference, was held in 1977 at Mar-Del-Plata,in Argentina. The year period from 1980 to the 1990 was named the United Nations International Drinking Water Supply and Sanitation Decade (I D W S S D), with the target of providing safe potable water to all by 1990 (Diamant, 1981).

The main aims of the Decade was to improve people's health. In the introduction to "Drinking Water and Sanitation", the World Health Organisation stated that:

"By increasing the quantity and quality of water it will help to reduce the incidence of many water related diseases among people most at risk. By improving sanitation facilities and hygiene it can greatly increase the health impact of water supplies. It was the health impact of water and sanitation that concerns WHO most closely and provide the links with its primary health programme" ( WHO, 1981).

The International Drinking Water Supply and Sanitation Decade ended in 1990. A survey was carried out by the WHO, and United Nations at the end of Decade and the results have summarized and illustrated in the Table 1.1 and diagram 1.1.

Table 1.1 Estimated service coverage for water supply and sanitation in rural areas of developing countries from 1970 to 1990

| Year and population | 1970 | | | | 1980 | | | | 1990 | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Population 1166 million | | | | Population 1438 million | | | | Population 2.67 billion | | | | |
| Facilities | Served | % | Unserved | % | Served | % | Unserved | % | Served | % | Unserved | % | % |
| Water supply | 140 | 12 | 1026 | 88 | 357 | 25 | 1081 | 75 | 1.68 | 63 | 0.99 | 37 | 100 |
| Sanitation | 134 | 11.5 | 1032 | 88.5 | 213 | 15 | 1225 | 85 | 1.31 | 49 | 1.36 | 51 | 100 |

Source: Taken and adapted from Farrar (1974) and WHO (1981)

# Situation of Rural water supply and Sanitation in developing countries

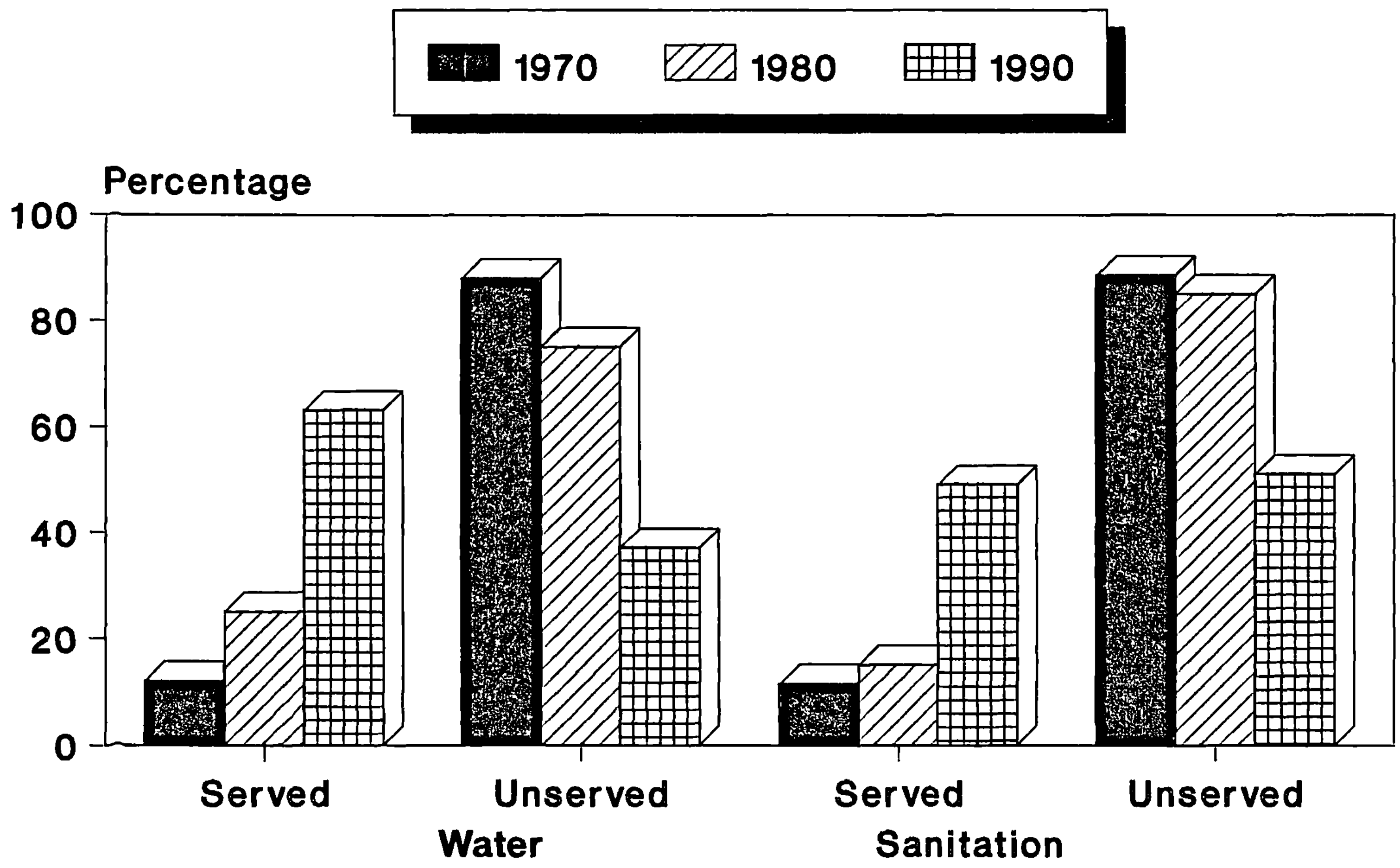



Figure 1.1

After 10 years of intensive global efforts, only 63% of rural people were served with potable water supplies. In the case of sanitation, 49% of the population were served with sanitation facilities.

According to Christmas and Rooy in 1991, at the beginning of the 1990's statistics revealed that 1.23 billion people in developing countries were without access to adequate and safe water supplies, and 1.74 billion without access to appropriate sanitation, that is 31 % without water, and 43% without sanitation. The consequences of this situation, in terms of human health and suffering, as well as social and economic cost, are staggering.

The results of the Decade showed that progress in the provision of a potable water supply and sanitation in developing countries had been made, but that there were still great problems in rural areas. These critical problems have been listed by Bulajich (1992); Hofkes et al:(1986); Elmendrof and Buckles (1980); Feachem, et al;( 1977): Glennie (1983); Christmas and Rooy (1991) and many others. They are:

1. Lack of sufficient resources
2. Lack of participation of rural people in the sanitation projects due to lack of financial resources.
3. Lack of trained professional and sub - professional personnel.

4. Lack of maintenance of water and sanitation facilities is a major problem, despite the appropriateness of technology. The problems related mainly to sustainable funding for obtaining spare parts.
5. Lack of information, the diversity of institutions involved in providing the basic infrastructure in rural areas and the choice of inappropriate technical design. Often the result is non-use, misuse, and breakdown in the system.
6. Lack of adaptation to and familiarity with local cultural preferences, lack of use of local available building materials, and lack of knowledge of local ground conditions for the low cost sanitation system.

In addition to the above problems, the major problem which at present many developing countries are facing, both in urban and rural regions, is increasing population. In 1992, Cairncross reported that rapid population growth in most developing countries means that ever larger populations must be provided with water supplies and sanitation facilities. This problem is especially the case in urban areas, where natural growth is aggravated by natural migration.

The lack of a healthy environment and the lack of safe drinking water in the 1990's were the cause of death of more than three million children. Two million of these deaths could have been prevented if adequate sanitation facilities and clean water had been available (Bulajich,1992).

According to Gupta (1988) the rapid spread of villages also results in widespread use of ground water, which unless properly monitored may lead to environmental degradation. Shallow groundwater sources in many rural areas of developing countries with inadequate sanitary systems are often polluted.

Falkenmark (1987) stated that as some problems were been solved, other more serious problems developed, mainly due to :- both over-and under-exploitation of the limited supplies available to human activities; to the mobility of water; and to population increases, all of which increase the stress on hydrologically limited water availability.

In conclusion, it seems that an improved potable water supply, and sanitation facilities, in developing countries may lead to improvement in rural peoples' health, and this in turn may lead to increased population. The consequences of these effects may have potentially adverse impact on the environment, and lack of potable water supply and sanitation facilities for all people. By using Environmental Impact Assessment (EIA) studies in developing countries in the planning and implementation of projects these major problems may be solved.

## 1.6: Goals and objectives of improved water supply

According to Pacey (1977) in the design of water supply projects for high income communities in the developed countries, the question of goals and objectives is not often discussed, as a high level provision of water services has come to be regarded as essential. For the vast majority of people who live in rural areas of developing countries, with grossly inadequate access to potable water, there is no possibility that available financial and human resources will give them the same level of water provision benefits as in developed countries. Because, as stated previously, in developing countries these resources are so limited, it is necessary to examine closely the goals of water supply in order to decide how available resources may be allocated in the most effective manner.

Feachem in 1990 pointed out that the resources concerned in providing an assured water supply are not only water itself, but also the financial and human resources needed to design, implement and maintain a water supply and sanitation programme.

Rural water supply programmes generally develop in response to public demand (Glennie, 1983). The allocation of resources must necessarily be based on some specific concept of goals and purposes of water supply development

(Feachem, 1990).

The WHO in 1983 reported that the ultimate objectives of allocating resources for water supply and sanitation investment are to improve the health, welfare, and economic status of the users of the facilities constructed. These objectives cannot be fully achieved unless the facilities are firstly, functioning in the correct way and secondly, utilized by the rural people.

According to Feachem (1990), as with any engineering endeavours, an improved piped water supply has several levels of goals, from the immediate and short term to the diffuse, complex and long term goals. Table 1.2 illustrates the most important and immediate of these goals.

Table 1.2 Goals and objectives for potable water supply investment in rural areas of developing countries

| Immediate objectives | <u>Further goals - stage.I</u><br><br>( These follow as consequences when the immediate objectives have been met) | <u>Further goals stage.II</u><br><br>(these follow from previous stages if complementary inputs are provided) | <u>Further goals Stage III:</u><br>(These are consequences of reaching the previous goals which follow if there are also inputs on many other fronts) |
|---|---|---|---|
| <u>Functional:</u><br><br>To improve the quality, quantity availability and reliability of the potable water supply<br><br><u>Other:</u> To carry out this improvement in a manner which:<br><br>(a) Secures the support of users;<br>(b) Conserves scarce resources( e.g. capital);<br>(c) Avoid adverse environmental consequences ( e.g. lowering water tables, encouraging mosquitoes) | <u>- Health:</u><br><br>To reduce incidence of water-borne and water based diseases<br><br><u>Energy / Time (Economic):</u><br><br>To save time and energy expended in fetching water<br><br><u>Social:</u><br><br>To arouse interest in the further health and economic benefits which may arise from the potable water supply<br><br><u>Economic:</u><br><br>To provide more water for livestock and garden irrigation and home industrial activity | <u>Health:</u><br>- To reduce incidence of water washed infections ( inputs required:<br>- Improved hygiene,<br>- Health education,<br>- Improved sanitation facilities)<br><br><u>Social / Technical:</u> To insure good long term maintenance of water supply and sanitation facilities( input required: training, clear allocation of responsibility, built - up of local maintenance organization)<br><br><u>Economic:</u> To use of time released to better agricultural output (input required: extension work, fertilizer supply, etc. | To active the greater well- being of the people through:<br><br>(a) social change- greater self reliance in the community, better organization, better deal of the poor, women, etc.<br><br>(b) Improved standard of living- health, nutrition, income, leisure |

Source: Pacey (1977)

The "immediate objectives" listed in the above table present the improvements of water supply and, in various combinations, will form the basis of the design criteria of a scheme.

Feachem (1990) noted that for a high grade water service in a prosperous community the immediate objectives have become established as to provide high quality ( i.e. clean and safe water ) water in abundant quantity, with continuous availability and total reliability. But these objectives, for the great majority of communities in the rural areas of developing countries, are unobtainable. Hence, some combination of improvements in quality, quantity, availability and reliability should be determined for the purpose of design.

According to Pacey (1977) in order to know what combination of improvements is most desirable in a particular case, it is essential to examine the potential benefits from a water supply, and then assess the degree to which different improvements will realize different levels of goals.

As Table 1.2 shows there are three main stages of goals. Stage 1 illustrates all benefits that are likely to be realized before stage II which will usually precede stage III. To get more benefits from improved piped water supply, some complementary inputs and improved standard of service are very essential and should be considered in stages II and III.

Jakobsen et al.(1971) pointed out that several impacts may result from an improved water supply and classified them into two main groups, (a) direct and (b) indirect impacts.

**(a) Direct impacts:**

These impacts are defined as those which result directly from improving water supplies and are largely independent of other inputs. They are clearly dependent on the water supply being used, but beyond that, no further changes are required from water consumers ( Farrar, 1974). These direct impacts will in turn generate what can be called "first order benefits" (Carruthers, 1973).

In Table 2.1, the most vital direct benefits are firstly related to time released and energy saving and secondly, to improvement in health. Glennie, (1983) suggested that, time released and energy saving are the main objectives from the villagers' point of view.

According to Pacey ( 1977) further possible improvements in health are obtainable as stage II goals, with a complementary input related to changes in hygiene practice. Such changes may occur automatically as soon as more water is available but in rural areas, more people need to be told about the importance of hygiene by means of health education inputs.

Farrar in 1974 reported that the "health impacts" may have social aspects, for example reduced suffering resulting from the improved health of users of the new water supply, and "economic" aspects, for instance because of their improved health water users have greater productive capacities. Similarly, "environmental impacts" will have social and economic components. In this thesis, the impacts of the improved water supply will be dealt with under these four main headings: "environmental", "social", "health" and "economic". Some of these impacts are positive and some negative.

**(b) Indirect impacts:**

An appropriate understanding of the primary benefits of water schemes is a precondition for obtaining the indirect or secondary impacts. Otherwise, indirect impacts only emerge when water supply improvements have been completed, and may not be fully realised (Farrar, 1974).

Time released and easy availability of water is the main input for the secondary, or indirect economic impacts such as increased livestock activity and possible irrigation of gardens leading to improved agricultural output.

The maintenance of water supply and sanitation facilities is another important stage II complementary goal which assures both the long term water supply but as it also needs the participation of rural people and lead to improved education and employment prospects.

Carruthers (1973) pointed out that the primary direct effects may lead to the following indirect benefits:

1. More crops
2. Higher crop yields
3. Lower production cost
4. More high value crops
5. Improved animal production
6. improved dairy technology and higher quality milk
7. Lower animal mortality
8. New livestock activities
9. More leisure
10. Increased sense of well-being through better health
11. long term improvement in family planning through reduction of infant mortality.
12. Lower family health costs.

Carruthers also stated that in order to achieve secondary benefits one or more of the following conditions must be considered:

(a) The availability of land

(b) The use of related labour

(c) The availability of credit

(d) The availability of health services

(e) The purchase of cattle

(f) The installation of complementary sanitary facilities

(g) Home economic and family welfare advice

## 1.7: Project activities

In order to identify and evaluate impacts associated with the provision of a potable water supply and sanitation project, it is first essential to establish a general list and description of project activities. The main activities are: (a) construction and (b) operation( including maintenance and project output ). These activities are defined by Maurice, et al; (1974) as including:-

**(a) Construction activities:** construction involves those activities which create physical structures and land alterations in accordance with the approved project design. For example; well drilling and the installation of taps.

**(b) Operation and maintenance activities:** After the project has been partially or completely built, it should be operated in accordance with approved design specifications and operating procedures to produce the specified project output. Maintenance activities should also be undertaken to ensure that the safety, stability, and environmental desirability of the project is maintained.

The project activities can have positive or negative impacts on the environment. The environment represents the project area divided into three very inter-related systems. These have been defined by Braun (1990) as including:

1. **Natural environment:** which represents all living beings interacting with the natural resources.

2. **Social environment:** in which people organise and interact with each other to develop their life and living style.

3. **Economic environment:** in which humans organise themselves to produce wealth and services for society to create economic activities.

Environmental Impact Assessment (EIA) was developed in order to identify and assess the most relevant positive and negative environmental impacts regarding the development of the project (Braun, 1990). It appears, however, that EIA techniques can be used to assess the impacts raised by the activities of a project.

The application of EIA even for small scale water supply and sanitation projects in rural areas of developing countries is very useful. EIA was carried out on the water use situation of 8 sample villages, four villages in the Northwest, and four villages in the Central part of Iran. EIA techniques were also used to assess the most important positive and negative impacts identified in each water project. All data were obtained through my own observations, from field survey; from questionnaires and a literature review.

The author used EIA to assess water supply and sanitation projects, to aid:-

1. The identification of the positive and negative impacts of water supply and sanitation projects.
2. The chances of obtaining satisfactory results from water supply projects.

# CHAPTER 2

# ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

## 2.1: Introduction

To assess the environmental impacts of potable water supply and sanitation in rural areas of developing countries, it is essential to be aware of the general aspects of EIA. The lack of environmental considerations and assessment in the development of water supply projects may result in severe effects on the natural environment and also on the socio - economic and health status of the community.

EIA is a process to ensure that the likely impacts of projects on the environment are completely understood and taken into consideration before development is allowed to proceed. Moreover, EIA is a method for the identification and prediction of impacts, and can influence decisions related to the approval and implementation of development activities, and the mitigation of adverse effects (Ahmad and Sammy, 1985; Biswas and Geping, 1987).

This chapter gives a brief description of the background, concepts, definitions and processes of EIA; their advantages and problems and the application of EIA in developing countries for water resource projects.

**2.2: Environmental background**

In ancient times, man lived by hunting and gathering and used fire for modifying some natural environments, and while, by domesticating animals and introducing agriculture, the effects of his action became widespread. The development of industry caused the rate of change to increase, as muscle power was replaced by energy released from fossil fuels. The vast increase in population and higher consumption during the last few decades has also led to human impact reaching an unprecedented intensity and effect throughout the world (Munn, 1979).

Human activities have changed the global environment in many ways. The effects are sometimes direct and obvious, but more often they are indirect, delayed or entirely unexpected. Pollutants are carried by the natural flow of water and wind from their points of origin, sometimes across international boundaries. For instance; people can become sick by drinking polluted river water drawn far from the source of the pollutants. Ground water may become contaminated by hazardous waste seeping from a long abandoned dumping place (World Resources, 1987).

From the 15th to the early 20th centuries, several commissions and committees were instituted in England which deplored the evils of air pollution, mainly from coal burning. William Blake (1752-1872) castigated England's "dark satanic mills". The expansion of the chemical industry in the 19th century led to the institution of the Alkali Inspectorate in the United Kingdom in 1863, and the first comprehensive control of air emissions from factories (United Nations, 1985).

Crises such as the 1952 London smog attracted world-wide attention, but long term exposure to reduced degrees of pollution may be a crucial threat to human health, and have effects on human behaviour before physical sickness can be realized (Munn, 1979).

The massive air pollution incidents that endangered the cities of London and Los Angles after World War II led to the setting up of air pollution control measures, and gave birth to the concept of comprehensive environmental pollution control (United Nations, 1985).

Increasing air pollution and solid waste management activities caused the concept of environmental protection to be developed in the late 1960's (Ludwing, 1979). Since the end of the 1960s environmental problems have increasingly been a subject of public debate and thus, conservation of natural resources has became a political topic. The response to this debate has reached far beyond the traditional conservation movement. Scientific arguments, political pressure, and growing environmental problems have made it necessary to create instruments to monitor environmental pollution (Wonner, 1986).

The first legislation for environmental impact studies was the National Environmental Policy Act(NEPA) of 1969 in the USA. It was signed in the early 1970s, and it gave significance to environmental issues and considerations (Canter, 1977). The aim of NEPA is to ensure that all practical means are used to control pollution, including national policy and improvement and coordination of Federal Plans. Its further aims are to achieve a balance between population and resource and to enhance the quality of renewable life (Canter, 1977, PADC, 1983, Ahmad and Sammy, 1985).

Many industrialised countries and a number of developing countries became much more aware of the rising problems of environmental damage at the end of 1960s. The evaluation of development projects concentrated basically upon economic value and did not sufficiently address environmental issues(Ahmad and Sammy, 1985; PADC, 1983). The incorporation of environmental factors in the decision-making process resulted in the formulation of particular policies that led to the introduction of a range of legislative tools for its fulfilment. Hence in the early 1970s a method of assessing environmental impact was laid down in law in the U.S.A.(Wonner, 1986; PADC, 1983). Thus the U.S.A was the first country in the world to accept legislation requiring environmental assessment on major projects (Ahmad and Sammy, 1985). Other industrialized countries, such as Canada, Australia, the Netherlands and Japan, accepted legislation in 1973, 1974, 1981 and 1984 respectively (Wathern, 1988).

Bilateral and multilateral *agencies have also been* interested in the potential of EIA. The Organization for Economic Co-operation and Development (OECD) accepted recommendations regarding EIA within its constituent states in 1979, and for development projects in 1985 ( UNEP, 198O).

The WHO became aware of the need to assess both the opportunities to improve the quality of life presented by development, and consequent adverse effects upon human health mediated through environmental change (Wathern, 1988).

## 2.3: EIA, The concept

The process of environmental impact assessment has undergone steady development. Thus, in the 1960s when EIA first started in the U.S.A as a part of the environmental movement, it was prepared as a separate document and not as part of the overall feasibility study of a scheme. Ideally, it is best to expand the feasibility report of a scheme to comprise a section on the environmental aspects, so as to result in a project plan which is environmentally sound as well as exact in its engineering aspects such as hydrological, structural, and hydraulic effects (Ludwing, 1984).

Early EIA methods resulted in costly, wasteful, parallel and repetitious reports. Many of the aspects that are covered in a feasibility study are also integral components of an EIA (United Nations, 1985). Figure 2.1 illustrates the history of environmental parameters in development planning in the United States.

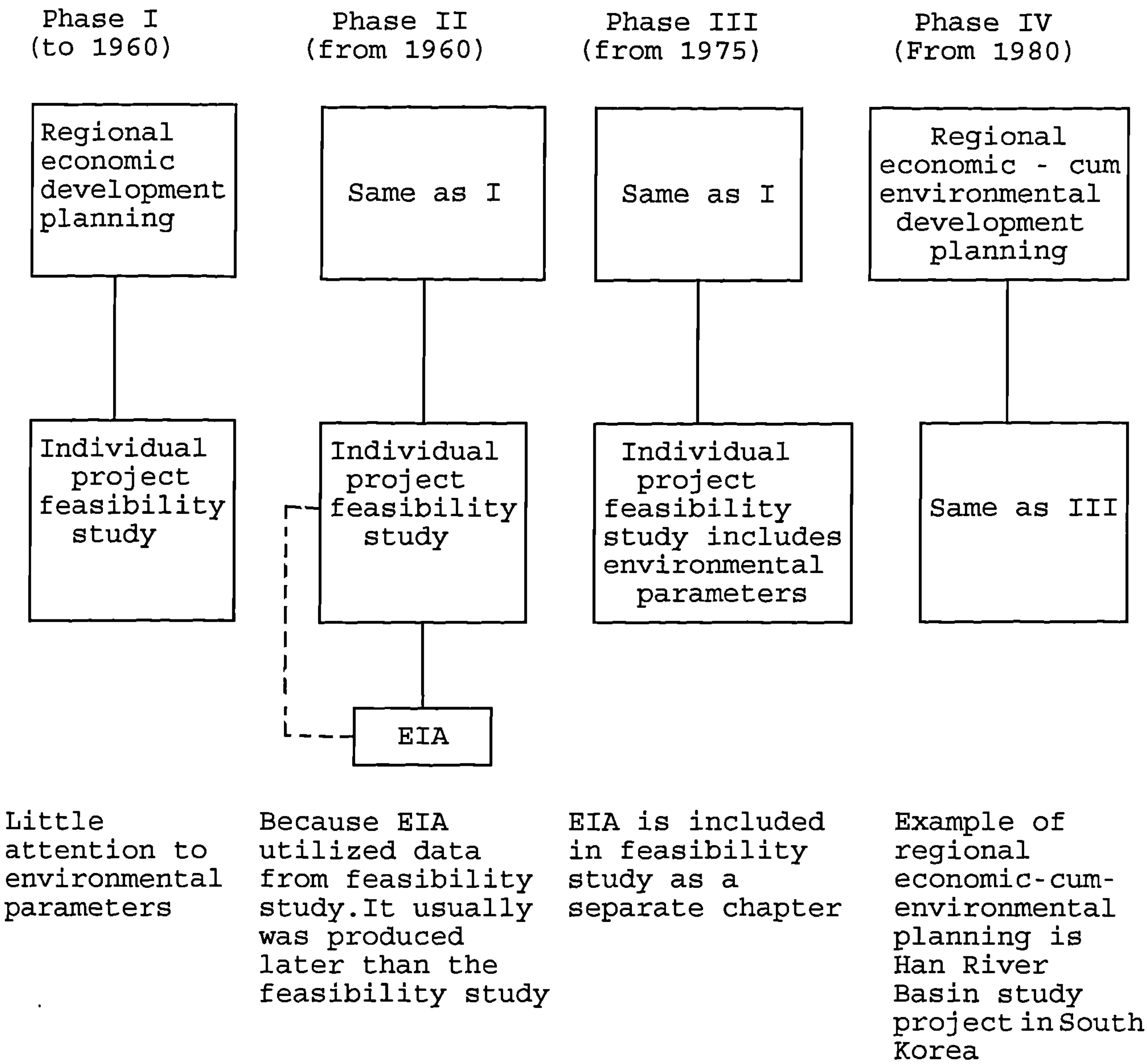



Fig 2.1: History of the use of environmental parameters in development planning in the United States. Source: United Nations, 1985

It can be seen that before the 1960s, very little attention was paid to the environmental effects of development projects. After the 1960 s, environmental assessment was increasingly combined with feasibility studies projects. After 1975 the trend changed, with a better understanding of the need to incorporate the EIA as a part of the feasibility study. Finally from the 1980s and onwards, there was a steady incremental acceptance of the concept of establishing regional economic-cum-environmental development planning(Evans, 1980).

To mitigate adverse environmental impacts, there is a need for methods which weigh environmental improvements against cost (PADC, 1983). In order to compare possibilities, it is necessary to take into account economic costs and benefits. The simplest approach to comparing possibilities across both economic and the environmental fronts is cost benefit analysis. In this case, the environmental impact must be converted into economic equivalents and listed as costs or benefits. A cost benefit analysis is then done for each possibility (Ahmad and Sammy, 1985).

Cost benefit analysis is a technique to assist managers in making decisions ( Mitchell, 1989). The objectives of CBA is to assess the relative economic merits of the outcomes of different options. The choice criterion used for judging the preferred outcome is the maximization of monetary benefits, without regard to who wins or loses. Clearly, value judgements are needed to assume that the monetary equivalents of welfare for different individuals can be gathered and compared and that any change in income distribution is still acceptable ( Ecksten,1976; Hufschmidt et al.' 1983).

According to Pearce in 1971, all public sector decision- making implicitly involves a balancing of costs against benefits. CBA is a quantitative approach to evaluate and rank projects on the basis of economic efficiency. The aim is to show how resources can be channelled into projects which will yield the greatest net benefit to society.

Quantitatively, the technique amounts to selecting the option yielding the largest net financial benefit. Evaluation of a project is based on a comparison of the resulting benefits to the condition without the project (Go, 1988).

CBA is a structured and systematic approach to estimate gains and costs between options. The framework for analysis is composed of five elements common to all problems. These are summarized by McKean (1968) as follows:

1) Objectives, or the benefits to be achieved
2) Alternatives
3) Costs, or the benefits that have to be foregone if one of the alternatives is to be adopted
4) Models, or the sets of relationship that help one trace out the impacts of each alternative on achievements (that is, benefits) and costs.
5) A criterion, involving both costs and benefits to

identify the preferred alternative.

McKean also stated that the quality of a CBA is dependent on how well the first two operational elements are conceived and elaborated.

Hundloe et al., in 1990, reported that CBA can be used in some stages of the EIA process with satisfactory results. The most important advantage of adopting CBA in an EIA is that it provides a consistent, objective framework, which facilities an optimized approach to the study of the environment.

Although, Cost Benefit Analysis has been well accepted in certain public planning activities such as water resource development, its application to environmental impact assessment has not become widespread. Part of the problem is the inherent difficulty of quantifying environmental and health impacts. In addition it can also be ascribed to the fact that the role of CBA is frequently misunderstood (Go, 1988). Furthermore, there are a variety of problems in applying CBA. Some of these problems will affect any decision - making, while others arise from technical difficulties (PADC, 1983).

Santos in 1992 reported that CBA may be used as an effective instrument alongside the other environmental and economic dimensions of a development project. However, the application of CBA in an EIA demands that impacts be converted into economic equivalents, and listed as costs and benefits. This is the main problem with CBA in EIA, as numerous impacts can not easily be reduced to cash equivalence.

As Lohani and Halim (1987) pointed out, CBA tries to assess effects in monetary terms and to express conditions in economic benefit cost form, which has not yet been found to be applicable to every kind of development project, and probably will not be suitable for rapid assessment in the future.

Generally, the aim of EIA is to discover the principal environmental, social and health effects of a proposed development. In other words, EIA attempts to identify and assess the physical, biological and socio - economic impacts which have adverse and beneficial effects, by accepting comparisons of option measures to attain a better balance of economic and environmental cost (PADC, 1983).

Sustainable development is a pattern of social and structural economic transformations, which optimises the existing social benefits, without endangering the potential for such benefits in the future (Goodland and Ledec, 1986). Support for sustainable development in developing countries is due, in part, to increasing concern over the often deleterious environmental, health, social, and economic consequences of inappropriate large - scale development projects. Two manifestations of this concern are Environmental Impact Assessment (EIA), and appropriate technology. Both share the objective of sustainable development as an ultimate goal (Goode and Johnstone, 1988).

## 2.4: Definition of EIA

According to Bisset and Tomlinson(1984) and PADC (1983), there is no comprehensive acceptable definition of EIA. Definitions are varied and the more commonly used are listed below:

1) EIA is "an activity designed to identify and predict the impact on the biogeophysical environment and on man's health and well being of:- legislative proposals; policies; programmes; projects and operational procedures; and to interpret and communicate information about the impacts" (Munn,1979 ).

Davies and Muller in 1983 argued for an extension of this definition to cover socio-economic effects to provide for a unified appraisal. Thus EIA is a process having the final objective of providing decision - makers with an indication of the likely total results of their actions.

2) EIA is "an assessment of all relevant environmental

and resulting social effects which would result from a project" (PADC, 1983).

3) EIA is "an assessment which establishes quantitative values for selected parameters which indicate the quality of the environment before, during and after preferred action" (Heer and Hagerty, 1977).

4) The last definition, given by Goode and Johnstone in 1988, is that EIA is "a procedure which provides the opportunity for identifying, mitigating or enhancing the potential environmental, health and social consequences of a proposed development activity and for generating alternative or additional options to that activity". It can also present information in a form that permits logical and rational decisions to be made, and thus provides a platform for the planning of the sustainable use of resources.

Previous definitions represent the different concepts of EIA. Some of them considered socio- economic impacts and well being which is the main target of EIA, wheras the third and the last definition concerned the total environment and protection of resources.

## 2.5 : EIA THE PROCESS

EIA has been viewed as being both a science and an art. EIA is also concerned with technical aspects of appraisal and the effects of EIA upon the decision-making process. In other words, some issues deal with technical matters such as impact identification and predica tion,and in this way, EIA works as a 'science'. Other activities deal with the management of a project and the context of polices, here EIA work as an 'art'. Generally, wherever it is used the overall EIA process contains the same type of operations. There may, however, be variations in detailed procedures related to the special needs of particular countries (Wathern, 1988 ). Most systems, in essence, conform to the structure shown in figure 2.2 which shows the various activities of the EIA process, and which include the phases from scoping to auditing. The proper identification and understanding of the various steps in this process are the basis for the choice of an appropriate method of assessment, a topic which will be dealt with in Chapter 8. Bisset (1989) and Ahmad and Sammy in 1985 reported that the main activities of the ideal type of EIA process in relation to the project planning cycle are as follows:

1. **Preliminary activities**: The first step is the decision that an EIA is necessary. Secondly, a description of the proposed action is made. Thirdly, all existing legislation relevant to the project must be identified.

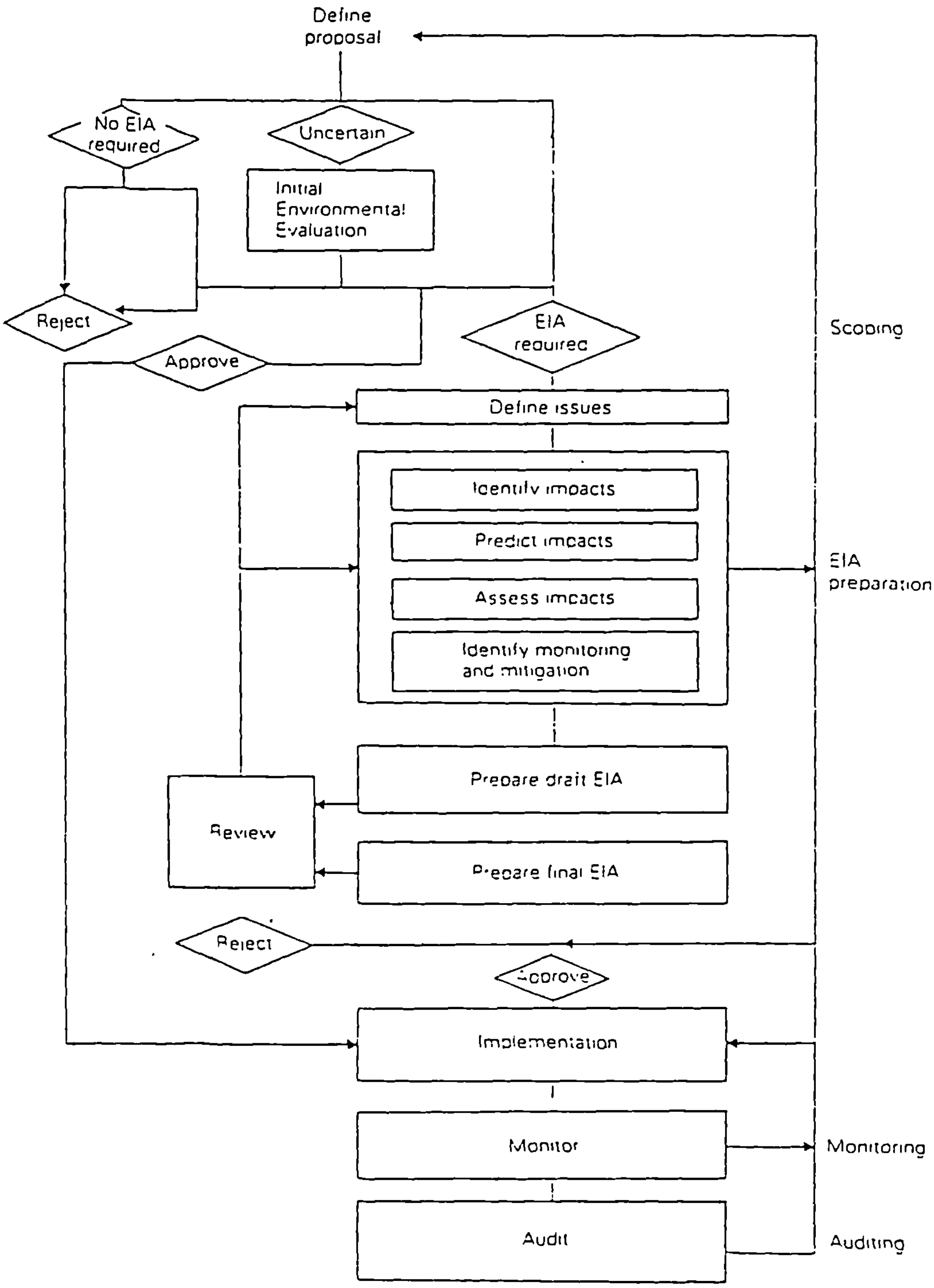



Fig 2.2 Flow diagram showing the main components of an EIA system

Source: Wathern, 1988

In addition, in the initial stages the availability and use of suitable assessment personnel must be checked, and where appropriate, individuals to undertake the work must be selected and the various aspects of the EIA allocated to appropriate specialists.

**2. Impact identification (scoping):** Generally, scoping involves two steps. Firstly, the listing of all possible impacts, and secondly, an examination of the list to select the most important impacts for detailed studies. To obtain the full list of relevant effects for a project it is often now best to refer to similar earlier assessments. Such information may be obtained from UNEP; referred system. National agencies concerned with environmental affairs may offer needed information.

**3-Baseline studies:** According to Wathern (1988), baseline studies are directed towards the collection of data on environmental and socio- economic factors for a proposed development project. This involves scientific and technical specialists who collect the information needed. Local people can help by presenting knowledge of their area. The baseline studies involve field work and a review of existing documents. Field sampling for new data collection for baseline studies consumes a large part of the overall cost of an EIA. There is a common problem as regards baseline studies encountered in EIA, which is that there are no well defined objectives for collecting data. Baseline studies concern all environmental aspects; but it is not always known why data are collected, and for what problem will be used (Wathern, 1988 ). Consequently, a great deal of time and resources may be wasted.

**4. Impact Evaluation:** According to Prusty in 1990, impact evaluation has two distinct interrelated operations. Firstly, it refers to the need to determine the importance of an impact. Secondly, the relative importance of impacts in comparison with other impacts of a different nature is sometimes considered as part of the impact interpretation. This is also termed an "evaluation". This process is generally considered at all stages of EIA but usually it occurs towards the end of EIA work, i.e. during preparation of an Environmental Impact Statement ( EIS ).

**5. Impact Monitoring and Mitigation Measures:** The identification of mitigating actions to prevent harmful impacts or reduce the intensity of these impacts is important (Bisset, 1987).

Bisset also stated that impact monitoring refers to the identification of impacts to be monitored during post-development periods. The major reason for this activity in the context of EIA there is monitoring to provide early warning of environmental damage so that measures to mitigate the unwanted impact may be taken, if possible to prevent or reduce the seriousness of the unwanted impact. Monitoring of this type can be used for another important purpose, namely, checking the accuracy of impact predictions made prior to a decision to authorize a project.

**6. Assessment (comparison of impacts ):** Assessing the environmental impact of each possible plan involves determining the likely impact upon the economy, the population and the environment during the implementation of a project. The consideration of options to the proposed project is one of the key aspects of EIA, in that, it provides a means by which project assumptions, goals and needs can be examined (Ahmad and Sammy , 1985 ). A comparison of the alternatives aims to assist decision-makers to select a choice which has a less adverse impact as well as added beneficial environmental , social and economic effects.

The identification of alternatives requires particular care, in that all possible alternatives should be given at least primary investigation. Impact assessment requires the exercise of professional judgment along with environmental standards or criteria and other scientific information (Canter, 1986).

**7. Decision - Making:** The decision makers should receive a working document ( the Environmental Impact Statement) to examine. They will then decide whether the proposed project can be accepted or whether additional information is needed. Generally "decision makers" are an agency or several government agencies who are not directly involved in EIA activities. They are dealing with a wide range of information which makes it difficult to arrive at an optimal decision (Ahmad and Sammy, 1985).

Decision makers may also suggest modifications to projects with regard to development and environmental protection. But they often choose a less costly alternative design. Finally, they must make a decision in a reasonable time to allow a developer to proceed with a project (Wathern , 1988 and PADC, 1983).

## 2.6: EIA in developing countries

Since the Stockholm Conference on the Human Environment in 1972, concern for the protection of the environment has spread through the world. Most developing countries began to focus their attention on environmental quality after 1972 ( Bisset and Tomlinson , 1984 ; United Nations, 1985 ). They often responded by establishing national agencies for the protection of the environment. Such agencies tended to be based on the format used in the United States. Environmental impact assessment accompanied the creation of such agencies. It was considered that it would provide a tool for the conservation of the environment in relation to the possible adverse effects of development projects (Bisset and Tomlinson, 1984 ).

Nevertheless, in 1983 PADC stated that the EIA process, in many developing countries is crude or even unknown. Developing countries, however, have an advantage, in that they can use the experience of the developed countries so as not to repeat their mistakes.

**I:Implementation of EIA in some developing countries**

Many developing countries have successfully used EIA procedures during the past decades, but some have only employed the procedure within the past ten years (Biswas and Geping,1987). Many have been concerned primarily with the techniques and tools used in the assessment exercise, but little attention has been paid to the whole EIA process. Some developing countries have made efforts to implement EIA. Such countries were usually Asian Pacific nations ( Bisset and Tomlinson,1984; Wathern, 1988). The pioneer countries were Thailand and the Philippines, which passed EIA laws in 1975. Other countries such as Indonesia are developing an EIA system as part of its industrial licensing process. Malaysia uses EIA for development projects more on an ad hoc basis (Volkmar and Hartje,1984).

Among the Latin America countries which have EIA procedures are Brazil, Uruguay, Colombia, Venezuela and Mexico. The first country to institute a formal EIA process was Colombia in 1974 (Wathern, 1988).

Most developing countries currently have institutions that have responsibilities for environmental policy ranging from the licensing of industrial plants to the managing of natural resources. The scope, size and political weight of these agencies varies considerably among the developing countries. The newly industrialized countries, and the countries with scientific infrastructures, such as India and the People's Republic of China, have already successfully introduced environmental management, to a large extent (Volkmar and Hartje, 1984).

Conversely, among the poorer nations of Africa the development of environmental institutions is severely restricted by the lack of financial resources and trained personnel. There is also a lack of data on the general environmental situation in Africa. However, a number of nations, including Botswana and the Sudan have, experience of the EIA process (Wathern,1988; Volkmar and Hartje,1984).

## II: EIA: its advantages

EIA is a mechanism which considers the potential environmental, social and economic and health impacts arising from the implementation of a development. It also aids the efficient application of human and natural resources which have proved valuable to both those developments and those responsible for their authorization (PADC,1983).

The implementation of EIA has significant advantages. According to Bisset and Tomlinson (1984) and PADC (1983 these advantages are as follows:

1. The need for baseline data for an EIA will encourage research centres and also stimulate training programs.

2. Mitigating measures identified during an EIA may be incorporated more economically at the design stage of a development than later.

3. EIA will arouse public awareness by improving understanding of environmental considerations.

4. EIA can be used not only to research and avoid adverse impacts, but also to increase the probability of benefits.

5. EIA can identify the areas most susceptible to adverse impacts and so guide site selection. It can also aid the identification of the most suitable site in terms of benefit maximization and the reduction of harmful impacts.

**III: EIA: its disadvantages**

In contrast to the advantages of EIA, there are various problems encountered in the implementation of an EIA. According to Bisset and Tomlinson, (1984) ; PADC( 1983) and Wathern (1988), several problems have occurred in countries such as Brazil, Ecuador, Kenya, Mexico, Rowanda, Somalia, Srilanka, Sudan and Tanzania. These are listed below:

1. A general lack of political awareness of the need for environmental assessment.

2. The introduction of EIA in many developing countries may be difficult because of inadequate skilled manpower.

3. A lack of any real understanding of EIA procedures. The multi disciplinary requirements of EIA can give rise to

additional personnel problems. These difficulties are probably greater in developing countries as there is often a lack of commitment to EIA among the various government agencies.

**4.** The government and decision makers in developing countries may not be aware of the deleterious effects of some forms of development on the environment.

The United Nations in 1985 stated that one of the reasons why EIA is expensive in developing countries is due to the limited technical and social data base upon which impact projections can be made. Problems of lesser importance are minor problems including:

a) lack of an institutional basis

b) Inadequate public participation

c) Lack of scientific data and information

d) Inadequate financial resources resulting in problems, which are listed below :-

i) Developing countries avoid bringing in foreign experts

ii) The expenditure of testing EIA may be too high

iii) In most developing countries there is no baseline data, so the preparation of an EIS may cause unacceptable delay of the development and so loss of income.

Consequently, due to these problems, the introduction of EIA in developing countries has often been delayed. Even so, with all these problems, some countries have tried to implement EIA systems in their planning process, and encouraged environmental consciousness amongst their communities.

## 2.7: The situation of EIA in the Asia and Pacific region

There is a significant and increasing awareness of environmental problems in Asia and the Pacific region. During the past decade most countries in this region have established institutional agencies to protect the environment by appointing relevant ministries or departments with environmental responsibilities. Moreover public awareness of environmental issues has been encouraged by the media, when environmental disasters are broadcast to the community in their homes, as in the case of the Bhopal and Chernobyl episodes.

As a result, throughout the region, there is also growing recognition that the incorporation of environmental considerations into project assessment may avoid costly economic misinvestment. For that reason, many countries have adopted the environmental impact planning tool for projects which may have potentially significant environmental impacts (UNEP, 1989).

In the Asian and Pacific region, the application of EIA as an environmental management and planning tool for the development projects is rising (United Nations, 1985).

Consequently, the EIA process is seen as a means not only of identifying potential impacts but also of enabling the integration of environment and development. The current status of EIA in this region is illustrated in Table 2.1 where three distinct, broad categories can be identified.

Table 2.1: status of EIA in the Asian and Pacific region

| Country | Status of EIA | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Australia | x | | |
| Bangladesh | | | x |
| China | | x | |
| Hongkong | | | x |
| India | | | x |
| Indonesia | | x | |
| Islamic republic of Iran | | x | |
| Japan | | | x |
| Republic of Korea | | x | |
| Malaysia | | x | |
| Maldives | | x | |
| Myanmar | | | x |
| Nepal | | | x |
| New Zealand | | x | |
| Pakistan | | x | |
| Papua New Guinea | x | | |
| Philippines | x | | |
| Srilanka | | x | |
| Thailand | x | | |

Source: United Nations: ( 1990 )

As Table 2.1 shows the status of EIA in the Asian and pacific region are as follows:-

**1)** Countries with specific legislation on EIA:

Philippines, Australia, Papua New Guinea and Thailand.

2) Countries having no specific legislation on EIA but having general legislation on environmental protection which empowers a government agency to require EIA for particular projects including:- Indonesia, China, Islamic Republic of Iran, New Zealand, Pakistan, Republic of Korea, Maldives, Malaysia and Srilanka.

3) Countries having no formal requirements for EIA, but which have informal procedures incorporating environmental consideration in the planning of specific types of projects, e.g., large - scale river basin development: India, Hong- Kong, Japan , Nepal, Mayamar and Bangladesh.

According to UNEP in 1989 the countries of the region, based either on explicit requirements or on an ad hoc basis, are trying to improve or upgrade their EIA systems. However, the EIA system and types of projects subject to it also vary from country to country due to the variety of legal systems, and the economic and social conditions of the different countries.

## 2.8: EIA in IRAN

### I: Introduction

In Iran there is no specific EIA legislation, and apart from its application to industrial developments the application of EIA in Iran has been very limited. However, the EIA Bureau was formed on the basis of the Environmental Protection and Environmental Act of 1974.

In this section, the dimensions of the environmental problems, available environmental information, the national environmental policy and EIA difficulties in Iran will be considered.

### II: Environmental problems in Iran

The Islamic Republic of Iran, as well as many other developing countries, is already facing many environmental problems. These problems have been caused by neglecting sound environmental protection and management.

The quality of air, water and soil is worsening in Iran because of an increasing population combined with industrialization. For instance, massive soil erosion occurs in the arid zones due to the increased mechanization and intensification of agriculture. As a result, the central and south - eastern parts of the country are now threatened with desertification (Khosravi, 1987).

Firouz (1974) stated that the majority of villages and fields are confined by moving sand; many of the ground and surface water sources have been polluted by agricultural and industrial development; too many people breathe polluted air in large cities which have been located in the industrial areas.

As there is no centralized data bank another problem is the collection and distribution of data by many different agencies . Khosravi (1987) pointed out that a great deal of time can be wasted searching for the agency that brought out a specific EIA publication. In addition there is lack of integration of environmental data between agencies to describe natural and representative landscapes, and in assigning values to the quality of such landscapes.

Khosravi (1987) also noted that in Iran various agencies or ministries are responsible for development projects and that each is responsible for planning the development of the project in their respective fields. They do not, however, usually give attention to environmental protection requirements in their plans. In a few cases problems of air and water contamination have received attention from such agencies.

**III: The Environmental Act and problems of EIA**

The Environmental Protection and Enhancement Act (EPEA) was passed in June 1974 (United Nations, 1985 ).

According to Khosravi in 1987, after the revolution in 1979, the constitution was altered and under section 50 of the new constitution, more emphasis was placed on National Environmental problems. The new law established the Environmental Department which besides being entrusted with control of certain areas as national parks, wildlife refuges, protected areas and monuments included:

1. Setting recommending standards and criteria for the control and prevention of water air and land contamination.
2. Conducting economic and scientific research and studies on environmental protection and enhancement.
3. Adopting measures associated with the enhancement of the environment.
4. Developing education programmes guiding the public in connection with the protection and enhancement of the environment.
5. Co - operating with foreign and international agencies in the field of environmental protection.

The Department of Environment is responsible for the implementation of this Act under section of 7 of the EPEA.

This department is authorized to coordinate activities relating to the project conflicting with the purpose of the EPEA. Figure 2.3 illustrates the organization of the environment department and EIA section in Iran.

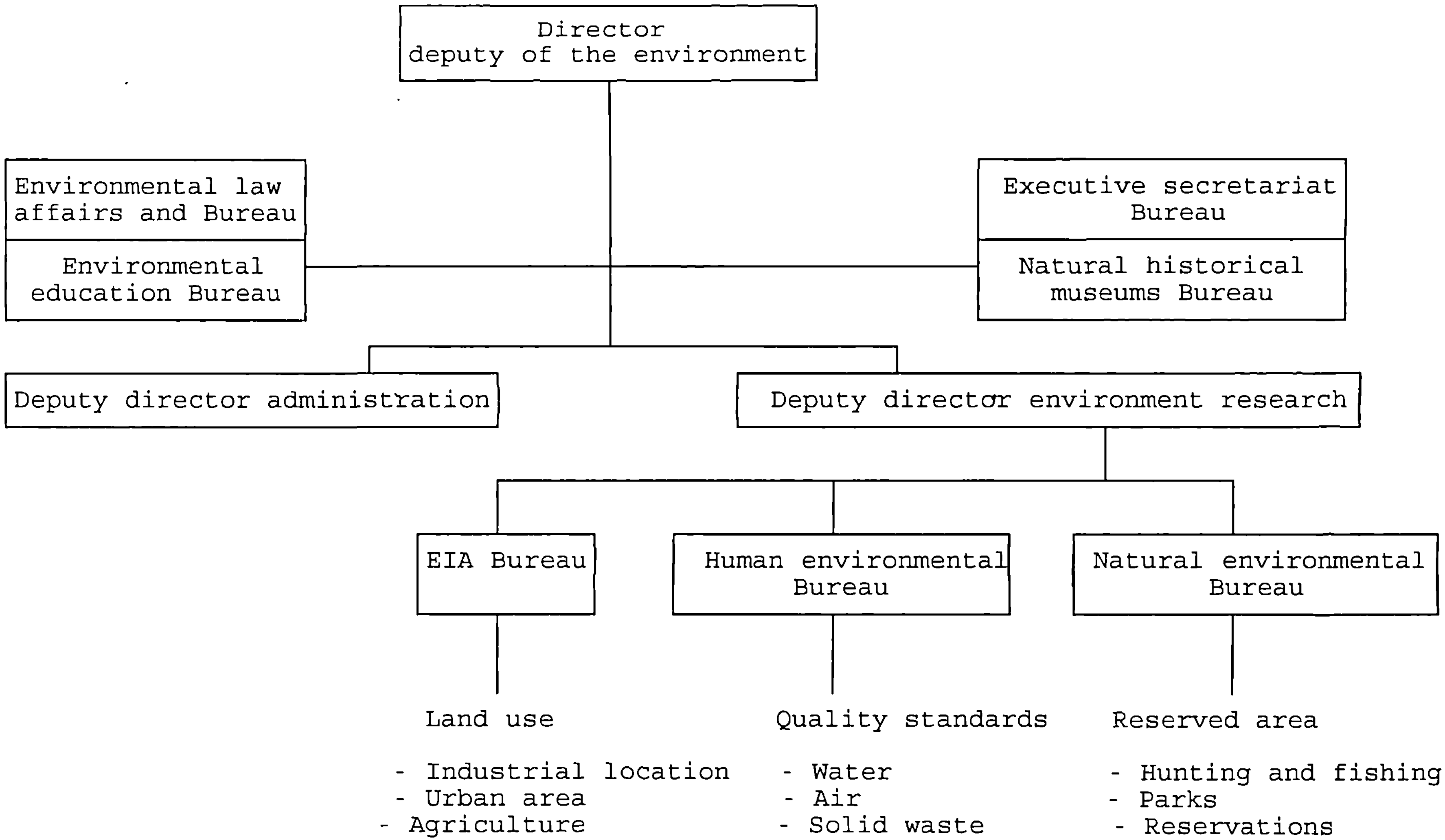



Figure 2.3 Organization of the main sectors of the Environment Department

Source: Khcsravi (1987)

As the figure 2.3 shows, an Environmental Impact Assessment ( EIA ) Bureau is a separate section under the Department of Environment, and it was established in 1986. Before that date it was a small unit in the Human Environment Division, with very limited activity such as site selection for development projects.

Several obstacles have to be overcome for an adequate implementation of EIA in Iran. Some of these are as follows;

1. Lack of financial resources to implement the EIA
2. Lack of technical experts
3. Lack of a satisfactory scientific data bank about the environment
4. The late incorporation of EIA in the implementation of a project
5. The lack of scientific knowledge among agencies
6. The diversity of different centres for decision making

In conclusion, it is essential to extend the application of EIA in the Department of Environment and to use it as a tool to solve the problems which arise from development projects. A project study should not only be made from the economic point of view but it should also give more attention to the EIA study in order to avoid negative environmental effects.

**IV: Tasks of EIA Bureau**

As I have already mentioned, under section 7 of the Environment Protection and Enhancement Act (EPEA) the Department has the authority to coordinate activities relating to a project which conflict with the aims of the Act. According to Khosravi (1987), at present the Department has under the EIA section created a special task force to assess a project with regard to potential damage to the environment. The task force is composed of specialists from various subordinate units of the Department whose aims is to make recommendations to development agencies, aimed at minimizing the environmental impacts of specific projects. The variety of cases to be considered by the task force include the following projects:-

1. Exploitation of mines
2. Highways
3. Large scale industries
4. Municipal service infrastructure
5. Agricultural industry

In 1987, Khosravi reported that most of the cases involve development within the boundaries of parks or reserves, under the direct jurisdiction of the Department. So far, the EIA section has not provided systematic procedures or guidelines for objective decision making. Figure 2.4 shows the process of the assessment of all projects. The EIA Bureau is, however, presently in the process of developing a shortened version of an Environmental Impact Statement (EIS) which developers would have to complete and submit to the Department, and this would allow a more detailed review of the projects.

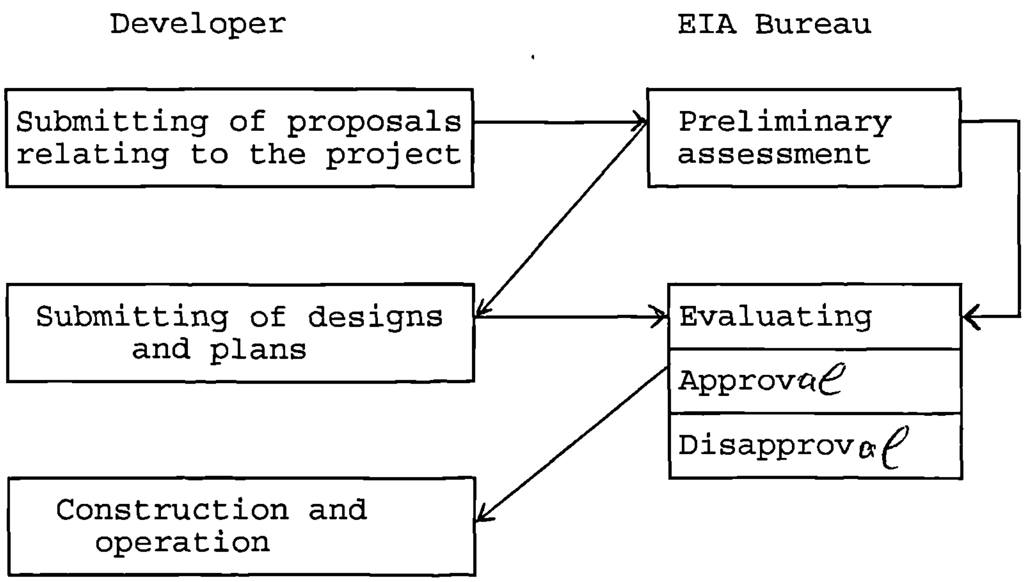



Figure 2.4 Stages of the process of assessment of all projects Source : Khosravi (1987)

To date, no EISs have been produced. Although projects are presently reviewed within the EIA Section, the process has not been standardized.

## 2.9: EIA and Water Resource Projects in developing countries

Since the dawn of civilisation Man has developed water projects in order to satisfy the ever increasing demands for easily available water. These have ranged from schemes for local needs to elaborate projects for large water demand. In most cases, projects were successful, but impacts on environment were ignored and caused changes which were not always advantageous. Such change was slow or rapid, predictable or unexpected, temporal or permanent, extensive or isolated, beneficial or disastrous (Singh, et al., 1985).

The community affected by such environmental effects had no choice but to accept the changes whatever they were, since the project was already completed and operational. Problems stemmed from the fact that during the planning and decision - making stages of the water resources project, the main effort was focused on the proper operational functioning of the project and its financial viability, while implications for other environmental areas were superficially considered or totally neglected (Singh, et al., 1985).

As stated earlier in this chapter, since 1972 and the Stockholm United Nations Conference, an increasing concern has been voiced particularly over the adverse environmental impact of water resource projects in general and on the creation of Man-made reservoirs by building small dams for irrigation and water supply in rural areas of developing countries(Pant, and Pant, 1985).

The creation of dams and reservoirs has significant environmental effects of a physical, biological, chemical, and socio and economic nature. As several reported case histories have shown (Hinnawi and Hashmi,1982; Pant and Pant,1985), these effects are not only beneficial but also deleterious. The identification of potential environmental impacts should be an early activity in the design of water projects. General knowledge about the type of impacts which could occur can be used in identifying potential environmental impacts for new projects (Canter, 1985).

Water resources projects are being developed throughout the developing countries and the main purpose of these projects is optimum utilization of available water supplies. Environmental Impact Assessment ( EIA ) of the water resource project activities is very significant in the context of providing high quality of water and increasing quantity of water.

As Ziyun in 1985 suggested, if we use *EIA for the* proposed water resources projects, we can estimate the future change of environment due to the project before hand, and we can then make a proper selection from the alternatives and can also propose mitigation measures in the planning, design, construction and operation of the project. Thus, EIA is an important tool helping to achieve efficient and effective water resources development and to avoid serious degradation of the environment.

Evidence shows that the application of EIA in a small scale water supply and sanitation project in the rural areas of developing countries is still limited, or is not employed. It is however, recommended as a tool to predict all the impacts arising from the activities of a project. Canter, in 1985, pointed out that in nearly all developing countries most, major water resource projects were built in recent years without adequate environmental impact assessment. Thus, it seems that, the most important function at present is to identify and monitor the overall impacts both adverse and beneficial.

Canter also stated that all water resources projects such as water supply, or dams and reservoirs, and dredging, can represent large scale engineering works or activities which cause significant impacts on chemical, physical, biological, cultural and socio-economic components of the environment. Environmental impact studies for such projects should be planned and conducted in a scientifically defensible manner. Canter, also concluded that the key components of environmental impact studies for water resources projects were as follows :

1. Identification of impacts
2. Conduct of baseline studies
3. Prediction of impacts on several environment factors
4. Assessment of predictable impacts
5. Conduct of trade - off analysis
6. Identification and evaluation of mitigation measures

Consequently, it seems that, in order to obtain more benefits and to minimize harmful effects on the environment, EIA should be used in all water resources projects. EIA studies for water resources projects can best be achieved through the application of technically sound approaches.

# CHAPTER 3

# Types of Water Sources and Water Supply Techniques in Rural Areas of Developing Countries

## 3.1: Introduction

The provision of a potable water supply in rural areas of developing countries may be affected by the water resources. According to Bastemeyer and Lee in 1992 the development of an adequate potable water supply depends on the existence of reliable water sources which can provide a yield of sufficient quality and quantity throughout the life of the water supply project.

The development of water supply and sanitation facilities is one of the most significant activities in rural areas of developing countries. It is, however, recognized that water supply projects although having many beneficial effects may also have adverse environmental impacts, either directly or indirectly, and on a short or long term basis. This chapter deals with:

- water occurrence and the hydrological cycle;
- choosing a suitable water source;
- the types of water sources and water supply techniques

which may be used in rural areas of developing countries, under three main headings:-

1- **Ground water sources :** Ground waters such as; springs, tube wells, boreholes and qanat waters may be used as a potable water supply are described. The development, benefits and limitations of ground water and adverse environmental impacts which may arise from over pumping of them are considered.

2- **Surface water sources:** Surface water sources including; streams, rivers, canals, village ponds, lakes and small earth dams are described. The method of the provision of potable water supply from these sources and the resulting environmental impacts will be discussed.

3- **rain water sources**: Rain water harvesting which is used a potable water supply many rural areas. The roof and ground water catchment and storage tank are considered.

The environmental effects of even small scale water projects in rural areas may be significant. EIA as a process may be used to predict the problems of the use of water sources and to identify the adverse consequences of water supply projects during their planning, construction and implementation in rural areas. In this chapter, only the environmental effects of water supply are discussed, the socio-economic and health effects will be considered in chapter 6.

## 3.2: Water occurrence and the hydrology cycle

According to Hofkes,et al;(1986); Ehler and Steel (1959);Fair et al·(1971); and Lvovich (1973), the water on earth, whether as water vapour in the atmosphere, as ground water in the subsurface ground strata and as surface water in rivers, streams, lakes, seas, and oceans is for the most part in a state of continuous recycling movement. This state is called the hydrological cycle.

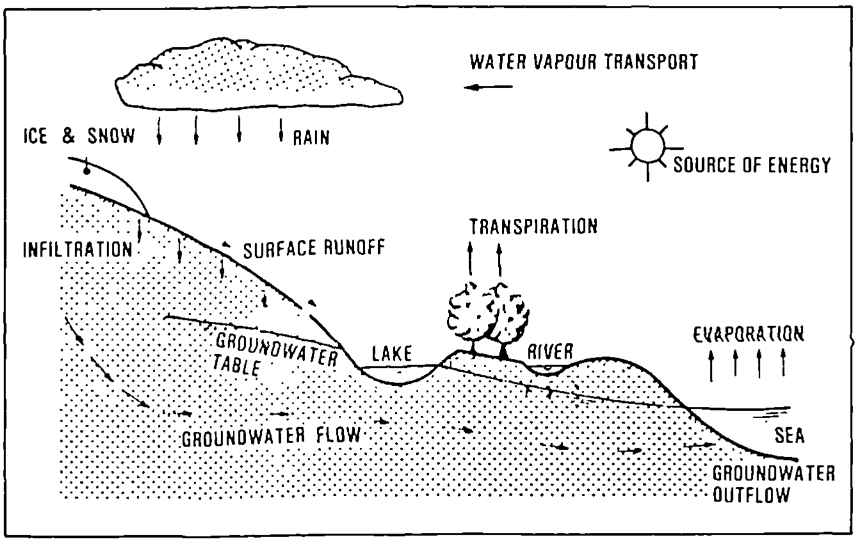



Fig 3.1: Circulation of the water.

Source: Hofkes et al·(1986)

As can be seen from figure 3.1 the driving force of the circulation is the radiant energy from the sun. Moreover, Ehler and Steel in 1959 divided the hydrologic cycle into three phases: Precipitation, runoff, and evapotranspiration. Precipitation includes rain, hail, and snow and is the primary source of water. Of the precipitation, some evaporates, and some immediately percolates into the soil. Most of the runoff becomes surface water in streams or lakes and finally enters the ocean. Somewhere in its passage, evaporation will return some of it back to the atmosphere, from which it will again be precipitated. Transpiration is loss of water from plants. Most plants take water through their roots; it is expelled by transpiration from the leaves.

The water which percolates into the soil passes through a zone of saturation and then laterally to a discharge point or outlet. The upper surface of the zone of saturation if unconfined by an impervious formation becomes the "water table" and can be referred to in terms of elevation (Ehler and Steel, 1959). The level of the water table may vary from place to place and in relation to the confining impervious layer (Cairncross and Feachem 1978). Wherever the water table outcrops at the ground surface, water will appear as a spring, pond, swamp, or stream (Ehler and Steel, 1959).

Finally, the water is returned to the atmosphere through evaporation from the streams, rivers, lakes, seas and oceans. The whole recycling process then begins again.

By far the greatest part of the water on earth is found in the oceans and seas( Hofkes,et al;1986). However, this water is saline. The fresh water contained underground and in all rivers, streams, pools swamps and lakes amounts to less than 1% of the world's water stock, and it is available for human use (Marrack, 1980). The supply of the fresh water available for human use depends on the global hydrological cycle (Davis, et al; 1989).

As it is continuously being renewed through nature's hydrologic cycle, water is consider to be a renewable natural resource. Various estimates have been made of the total volume of water on earth and its distribution between the oceans, ice caps, surface streams, rivers, lakes and underground aquifers. It is commonly stated that some 97% of the earth's water is in the oceans and 3% is on the land. Of the later, some 77% is stored in ice caps and glaciers, 22% is ground water and the remaining tiny fraction is present in lakes, rivers and streams (Hinnawi and Hashmi, 1982). Table 3.1 illustrates the distribution of world's water resources.

Table 3.1 Distribution of world's water

| Location | Percentage |
|---|---|
| Ocean | 97.3 |
| Fresh: | 2.7 |
| **Distribution of fresh water:** | |
| - Ice cap and glacier | 77.2 |
| - Ground water and soil moisture | 22.4 |
| - Lake and swamps | 0.35 |
| - Atmosphere | 0.04 |
| - Stream channels | 0.01 |

Source: Hinnawi and Hashmi (1982)

## 3.3: Choosing a source of water

The first step in designing a potable water supply system is to selected a suitable source of water. If the chosen source is not able to supply enough water for the community, then other sources will be required (Cairncross and Feachem,1978). Walker in 1978, also emphasised that the choice of water supply source is very important from the water engineers and hydrologists point of view .

The selection of the source determines the adequacy and reliability of the quantity and to a considerable extend the raw water quality prescribes the treatment require to make the supply potable (Schiller and Droste, 1982). Because of the unreliability of treatment plants under most rural conditions in developing countries the best sources of water are those which do not need treatment (Cairncross and Feachem, 1983).

As, Schiller and Droste expressed in 1982, a good source of water is the first protective barrier in a "defense in depth" against water borne disease. A constant supply of safe clean water is essential for domestic purpose in rural areas (Davies, 1977). A good source has a significant impact on human health caused by the reduction of adverse impacts such as water borne diseases.

The purification of polluted water in the rural areas of developing countries may be expensive and it needs the supervision of trained workers. It is therefore better to use a source that provides naturally safe water, and then protect it from pollution (Cairncross and Feachem ,1978). Feachem, et al; in 1977 also stated that, in hot climates the sources of water are very much more restricted, often extremely variable in quantity and of low microbiological quality.

According to Fair et al· (1971), the nature of the water source commonly determines the planning, design , and operation of the collection, purification, transmission, and distribution works.

Walker, in 1978 stated that, the choice of water source is of primary importance; its monitoring and for a river derived water supply, upstream control of the river if at all possible, are paramount considerations in the operation of a safe and wholesome water supply. He also added that some rural communities may be so fortunate as to have a choice of safe water supply from spring, well, river or lake.

According to Carincross et al: in 1980, many factors can affect peoples' choice of water source such as distance, payment, palatability, reliability, or one or more social factors. A new water source must be brought to a point close enough to peoples' houses for them to use it in preference to old sources.

Cairncross and Feachem (1978) and Hofkes et al. in 1986, stated that the process of choosing the most suitable source of a potable water supply in rural areas depends on a few aspects of the local conditions. The process of choosing a good potable water supply in rural areas are outlined by the author in figure 3.2

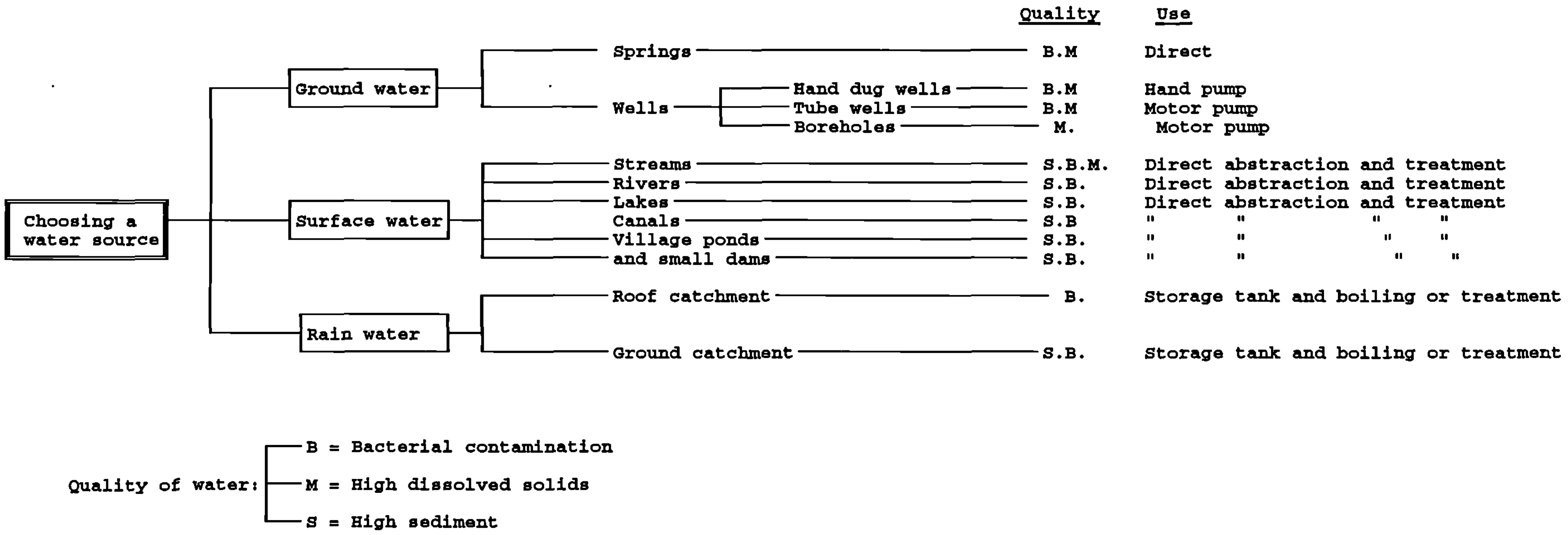



Figure 3.2. Process of choosing of a water source in rural area of developing countries

As the above figure shows, in areas where a spring of sufficient capacity is available, it is usually the most suitable source of water, because of high water quality and direct use. It is important to choose springs which have adequate water throughout the year. Where springs are not available, or are not suited to development, the next best chance is usually to raise water from underground resources, using a tube well, a dug well, or a borehole. Water may be raised by a hand pump and or motor pump( see ground water section on page 78). Before well digging, it is necessary to look for ground water in the area. The best places to look are where the water table is near the surface.

In some areas, where the ground water may be too deep, or may contain high levels of minerals make it unobtainable or unpotable. In other cases, if ground water is not available, or where the costs of digging a well or drilling a tube well would be too high, it will be necessary to consider surface water from sources such as rivers, streams, lakes, or village ponds and small dams. These sources are liable to serious pollution, and purification of some kind will normally be required before they are safe for rural people to use( see surface water sources on page 107).

Finally, where the rainfall pattern permits rainwater harvesting, and storage during dry periods can be provided.

Rainwater harvesting may be adequate for households and small scale community supplies and with large ground catchment areas, considerable quantities of potable water may be obtained. Water may be collected in a storage tank and it should be treated before drinking( see rainwater section on page 119).

## 3.4: Ground water sources

### 3.4.1: The benefits and problems of ground water sources

Traditional, ground water served the majority of people who live in the rural areas of developing countries both as individual and community water supplies. In 1966 Johnson reported that, in many instances ground water has been accumulating over a period of many centuries, rainfall each year adding only slightly to its volume. Lvovich (1973) suggested that, ground water may be reserved in seasons or years when surface water is plentiful and used in low surface water periods.

Using information from Okun and Mcjunkin (1967); Lvovich(1973); Hinnawi and Hashmi (1982); UNEP (1989) and Knowles and Rajnew in 1978, Table 3.2 was produced to illustrate the major benefits and problems of ground water sources.

Table 3.2 Advantages and disadvantages of ground water

| Advantages | Disadvantages |
|---|---|
| - Groundwaters can be found in the close of vicinity of rural people.<br>- Ground waters are often most practical and highly economical to obtain and distribute.<br>- It may be possible to use water without further treatment.<br>- Groundwaters are less turbid reducing capital requirements for treatment.<br>- The quality of groundwaters are more uniform throughout the year.<br>- The rate of abstraction may increase gradually as the requirement grow.<br>- Groundwaters do not suffer evaporative loss while stored against a coming dry season.<br>- They are biological clean (if uncontaminated by human action)<br>- They are becoming the preferred source of supply for irrigation | - Ground water often contain high mineral.<br><br>- To withdraw water, they need to pump and energy.<br><br>- The persistence of contamination. |

As can be seen from Table 3.2, use of ground water sources in rural areas of developing countries, has many advantages and beneficial impacts for rural communities.

### 3.4.2: Development of ground water sources for public usage in rural areas

#### I: Development of springs:

Wright in 1956 reported that a good spring is a sure source of a water, and that although good springs are not common, where they do exist they should be seriously considered as a source of potable water supply.

According to Bartram and LIoyd in 1992, spring sources, where available, often provide a source of high quality of water but the flow may vary seasonally. Where supplies can be gravity fed they are also a cheap source of water for small community water supply.

To find the location of springs in rural areas may be difficult, but according to Hofkes,et al; (1986) Carincross and feachem (1978), the best places to look for springs are slopes of hill- sides and river *valleys*. *Green vegetation* often indicates a spring in a dry region. They also stated that , in rural areas the local people are the best guide for finding springs.

After finding a spring, it is necessary to develop it. Jayakaran (1988) and Wright (1956), reported that, the objectives of spring development are primarily to increase the flow of water, to improve usability and to protect it from contamination. If the flow is sufficient the other objectives can be met by constructing suitable collection and storage structures - a process is called spring capping.

**II: Spring Capping**

For the capping a spring it is first of all necessary to dig back into the hill-side to the water-bearing layer, to where the water is flowing from the 'eye' of the spring. Loose stones are then put against the eye of the spring. The point where the water emerges, should be covered with carefully selected sand or gravel. If this material is too coarse, the spring water may erode the soil behind it or it may block the flow (Carincross and Feachem, 1978).

A spring may sometimes flow very strongly for a short period after rain, and the whole structure must be sound enough to resist erosion. Fine sediment is suspended in the water from most springs. A spring box therefore should be built so as to prevent this sediment from settling over the eye of the spring and blocking its flow. This is best done by ensuring that the overflow pipe is not above the eye. It is also important for the spring box to have a removable cover, so that it can be cleaned out from time to time (Jayakaran 1988; Cairncross and Feachem,1978;1983).

Cairncross and Feachem in 1978 pointed out that, one or more small springs may be connected to a 'single trap' where the silt is allowed to accumulate and is periodically cleaned out. The out let pipe should be almost 100mm above the bottom of the spring box and its end inside the box should be covered with a screen, to prevent rubbish and gravel from blocking the pipes. To carry the excess flow from the spring in the wet season, there should be an overflow pipe higher in the top up than the out let pipe. Fig 3.3 shows the construction of a spring. Protection and sanitary measures of springs will be dealt with in a later chapter.

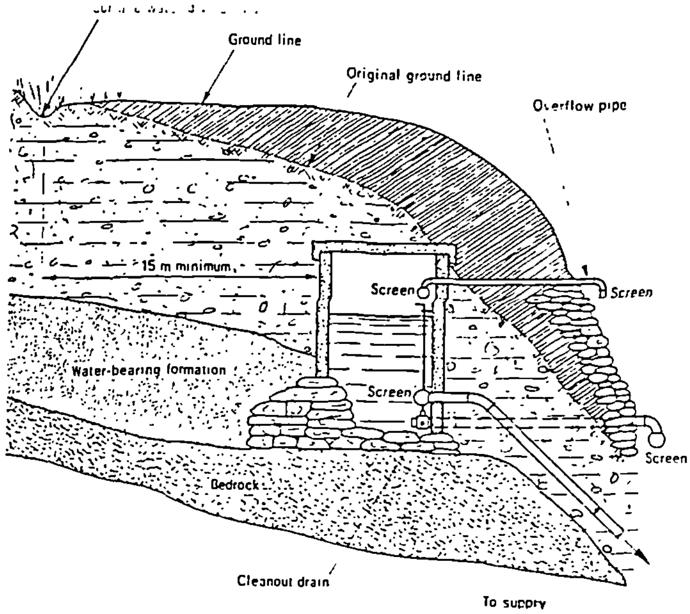



Figure 3.3 Construction of a spring water source

Source: Cairncross and Feachem (1978)

## III: Development of Wells:

As mentioned earlier in this chapter, for small potable water supply after spring water, wells should be the preferred water source. According to Hofkes et al. (1986) wells and other ground water sources, both for drinking water supply and for irrigation purposes, date back to ancient times. In China, wells were drilled at least 3000 years ago with hand operated churn drills, to depths as great as 100m and lined with bamboo casings. The technology for tapping ground water at great depth through tube wells is of more recent date. He also stated that, the first type of water well drilling which came into general use was the cable - tool (percussion) method. Over a period of several years it developed from crude forms to the modern refined drilling techniques.

In developing countries problems such as poor economies, lack of skill workers and difficulties of operation and maintenance, may make high technology methods not applicable and traditional systems may be used.

Several authors have classified wells: Davies, (1977); Hofkes et al· (1986); Cairncross and Feachem (1978) and Wright, (1956). Using this information I grouped well types as follows:-

1- Hand dug and step wells
2- Driven tube wells
3- Bored tube wells
4- Jetted tube wells
5- Boreholes

In the following section the construction and application of types of wells are discussed, and the protection and sanitary measures will be considered in the later chapter.

**IV: Construction and application of wells**

The construction of a well should be planned and carried out so that it is adapted to the geologic and ground water conditions existing at the site of the well so as to utilize fully every natural sanitary protection afforded. The installation should be designed to facilitate any supplementary construction that may be required to provide a sufficient and safe water supply and to conserve the ground water source (Johnson, 1966). The construction and application of wells in rural areas of developing countries, based on above classification are as follows:

**(a): Hand dug and step wells:** According to Mammo (1980) this type of well is constructed using traditional methods of digging a hole with a hoe or pickaxe in rural areas and Ehler and Steel in 1959 pointed out that, they are usually shallow, ropes and buckets being used for water withdrawal. In recent years, however, in many rural areas electric or small diesel pumps are used to raise the water. This change of technique is of great importance for areas remote from repair or spare facilities as the loss of a motor powered pump will threaten crops and the lives of many animals as well as domestic supplies. In 1976 Watt and Wood pointed out that, most hand dug wells may not yield large volumes of water and that using a powered pump will empty the well faster than water can flow in. Thus, it is likely to cause the movement of sediment from the aquifer into the well, and ultimately possible collapse of the well lining. Over pumping the well can be prevented by suspending the suction pipe or pump unit at an appropriate depth below the water table.

The application of modern materials, tools and equipment has transformed the hand dug well from a crude hole in the ground, uncertain in results, dangerous to its constructors and users, and the focus of parasitic and bacterial diseases, to a safe structure based on sound engineering principles, and a hygienic and reliable source of water. As a result this change has many beneficial impacts to the health of rural communities in developing countries. Cairncross and Feachem (1978) described the procedure for hand dug well construction which is commonly used in rural areas of developing countries as follows:

**(1)** The hole is excavated to the desired diameter and depth, or to a point where the ground water appears unstable and cribbing becomes necessary in the hole to support the walls. In loose soils, dug wells must be cribbed ( cribbing is an under water structure serving as a pier and/or water intake) in order to protect the men who are working inside the wells.

**(2)** When water is reached it will be necessary to bail the water out of the well along with material excavated. The more efficiently the well is kept dry, the deeper it can go into the ground water and therefore the more water it will give.

**(3)** When the deepest possible point of excavation is reached round stones should be laid around the well to form the first 0.5- 1 metre of well casing. If possible, brick work should then extend to the top of the well,with an extra heavy wall for the top 3 meter, well grouted to provide a water proof casing. The best materials for improving lining are brick work and reinforced concrete.

**(4)** At the end of the construction of a well, it is necessary to construct a well head and this is the most important part of a hand dug well from the point of view of protection. Figure 3.4.

Watt and Wood in 1976, pointed out that, hand dug wells are used for a variety of purposes and that their design may vary accordingly. They are widely used for irrigation and domestic potable water supply in rural areas of developing countries.

Construction of step wells is similar to that of hand dug wells but they are larger. Step wells can be converted into draw wells by constructing a high parapet all round and with an impervious apron. When pulley and bucket arrangements are used, the pulleys should be installed over a high parapet on the corner platform. Spill water should be collected in a peripheral drain for subsequent disposal through a soakaway. It may possible to deepen large step wells where local hydrology is favourable, thus increasing the yield. This type of well is popular and used in Asia (Rajagopalan and Shiffman, 1974).

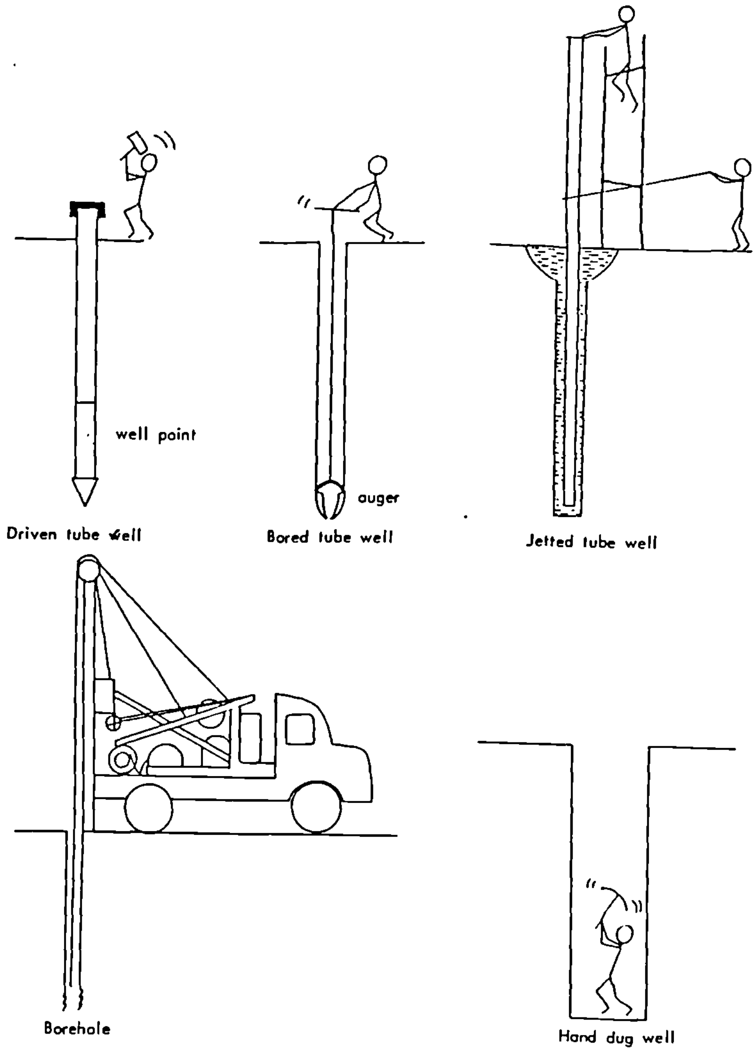



Figure 3.4 Construction types of wells

Source: Cairncross and Feachem (1983)

<u>(b) Driven Tube Wells</u>: Driven wells are constructed by driving a "well point" into the water bearing formation (Hofkes.et al 1986). The well point is re-usable, but it is expensive and normally lasts only about 5 years (Cairncross and Feachem, 1978 ). FAO in 1977 stated that well points can be made locally from galvanized iron pipe

but these are more liable to clogging than commercial well points.

The depth of ground water is another important consideration in the selection of driven wells in a given locality. In individual installations where the ground water is very shallow, within 7.5 m of the ground surface, the pump cylinder is usually attached directly to the top of the rising pipe (Wagner and Laniox, 1959).

As figure 3.4 shows, as a well point is driven further into the ground, lengths of steel pipe are fixed to the top. Sometimes a well point can be pushed into the ground by twisting it, or by pumping water down the pipe. More usually, it is driven by hitting the top of the pipe with a heavy weight. To make sure that the pipe joints stay tight, the pipe should be twisted after each blow of the hammer ( Cairncross and Feachem, 1978).

Rajagopalan and Shiffman in 1974 stated that, driven wells are very useful in many parts of the Western Hemisphere, South-East Asia and in delta areas where the good quality water supplies may be sparse.

**(c): Bored tube wells:** A simple method of construction of small diameter wells of shallow depth is the use of an earth borer, also called an earth auger. As figure 3.4 illustrates a small hole 30-50 cm deep, and of sufficient diameter to allow the introduction of the borer, is dug in the ground with an ordinary pick or crowbar. From them on, boring proceeds to the desired depth by the use of a hand turned auger. These wells can be dug to a depth of about 25 meters (Okelly, 1982).

Several accessories to the earth borer have been designed by manufactures to facilitate boring, especially in soils containing either wet sand or loose gravel (Wagner and Laniox, 1959).

Wright in 1956 pointed out that, this method is particularly useful in soft ground such sand, soft lime stone, and chalk. Hofkes et al: (1986) suggested that, the boring technique is especially useful in deltaic areas where these types of ground are common. Otherwise, he pointed out that, bore wells are mainly used in soft unconsolidated ground formations. In contrast, Wagner and Laniox in 1959 reported that, when hard ground formation such as rock or stone are encountered boring is stopped and a new well location selected several meters away.

**(d): Jetted tube wells**: In many rural areas the jetted tube method can be used to sink wells up to 80 meters deep. As figure 3.4 shows, It involves pumping water down a hole. The water over flows from the hole carrying with it soil from the bottom and loosening further soil. Thus a pipe can be pushed down in the hole (Okelly, 1982).

Cairncross and Feachem (1978) suggested that, another method of jetting a well called the slugger's *method and* can be used when no pumping is available. It can be used in fine loose soils, such as silt and sands and but when the water level is more than 10 meters deep it is difficult. He also pointed out that, it is more appropriate for delta regions when the soil is suitable and ground water is close to the surface. Jetted tube wells are used extensively in India for small diameter wells.

**(e): Boreholes**: In rural areas, where the aquifer is deeper or the ground hard and can not be penetrated by hand drills, a drilling rig may be used (Kashoro, 1980). Rural areas of developing countries do not often have easy access to drilling equipment because drilling wells is very specialized work and needs trained personnel(OKelley, 1982).

Boreholes are dug by drills and lined by tubes, and water is raised by electric or diesel pumps on a large scale to supply potable domestic water to a town, or a village, and /or irrigation and for industrial consumption. The depth of boreholes may vary from 100-250m (Honari,1979).

As figure 3.4 on page 87 shows a drilling rig is a large machine usually installed on a truck, and so may not be able to reach remote areas.

According to the Environmental Protection Agency in the U.S.A (1973), construction of a drilled well is ordinarily accomplished by one of two techniques; (a) percussion and or (b) rotary hydraulic drilling. The selection of the method depends primarily on the geology of the site and availability of equipment.

**V: Advantages and limitations types of wells**

According to Cairncross and Feachem (1978); Wright (1956); Hofkes,et al;(1986); Bath (1987); Kashoro (1980); Watt and Wood (1976); Okelly (1982) and many others the supply of potable water through wells in rural areas of developing countries has both advantages and disadvantages which I have summarized in Table 3.3.

Table 3.3 Advantages and limitations types of wells

| Advantages | Limitations |
|---|---|
| **Hand dug wells** | |
| - They have a large storage capacity.<br>- They are simple, shallow and water can be lifted by rope and bucket.<br>- They need little equipment to construct.<br>- Hand dug wells can be improved on traditional methods.<br>- They are one of the cheapest methods for providing a small potable water supply. | - The deepening of wells is more complicated.<br>- They are polluted very easily by ropes, animals and debris.<br>- Digging a hand dug well is often dangerou particularly over 10m.<br>- In a depth of more than 10m,digging of wells is very expensive.<br>- Hand dug wells in the upper aquifer water table tend to dry up in the dry seasons.<br>- The accumulation of sediment in the bottom of wells may restrict the flow of water. |
| **Driven tube wells** | |
| - They can be driven quickly and into operation rapidly.<br>- well lining can be pulled out and reused if only a temporary water supply is required.<br>- They can be successfully driven through compact soil. | - Limited to wells of less than 10-15 m in depth.<br>- It is difficult to dig these wells in sand stone or in heavy beds of clay.<br>- Screen opening may be clogged during the driving. |

Table 3.3...continued advantages and limitations types of wells

| Advantages | Limitations |
|---|---|
| **Jetted tube wells**<br><br>- They are much faster to dig and mechanical force is not required.<br>- Plastic pipe instead of steel can be used for casing.<br>- They are very suitable for exploration provided that plenty of water become available for sinking.<br>- Sandy aquifers are best fitted for this method.<br>- clogging of well screen opening is no problem. | - jetted tube wells need some pipes, plenty of water and motor pump plus various special fittings. |
| **Bore- holes**<br><br>- bore holes can be drilled rapidly more than 100 m.<br>- Deep water- bearing strata are less likely to be contaminated from sewage system, barn yards, out- door privies.<br>- deep holes water sources are less affected by drought as the water bearing formations are more likely to be extensive in area. | - Drilling into an existing bore-hole to deepen it is generally uneconomic.<br>- Bore holes are very expensive for remote rural areas.<br>- In depths of more than 60 m a mechanical pump must be provided.<br>- They need trained personnel to operate them.<br>- deep wells are more likely to provide high concentration of minerals. |
| **Bored tube wells**<br><br>- They can be constructed cheaply with local materials.<br>- In the sandy and clay solids with no large rock formations bored tube wells may be bored to considerable depth.<br>- Bored tube wells are reasonable in cost and can produce good results.<br>- Auger can be drawn up and used again elsewhere. | - bored tube wells need a strong pipe normally made of steel.<br>- It is difficult to dig these wells in hard soils.<br>- Depth of bored tube wells limited to 25 m.<br>- Tube well deterioration is mainly caused by caning - screen corrosion.<br>- Sand intrusion in the well and drop in the water table can create major problem. |

In selecting a suitable well for rural areas it should kept in mind that the main advantage of a tube well is that it can be easily drilled down to such a depth that a lowering of the water table will have little or no impact on productivity. On the other hand, it is obvious that the maintenance of hand dug wells and their continued operation can be secured without major difficulty.

In 1982 Falkenmark pointed out that, in areas where the maintenance of pumps is not likely to be provided adequately, it is preferable to dig hand dug wells, although the process may be much slower, expensive and require a large number of abundant personnel. Nevertheless, several studies have been made on the subject of the comparative benefits and disadvantages of hand dug wells and tube wells and the maintenance aspects seem to be the decisive factor when a choice is to be made.

**VI: Infiltration Galleries (Qanats)**

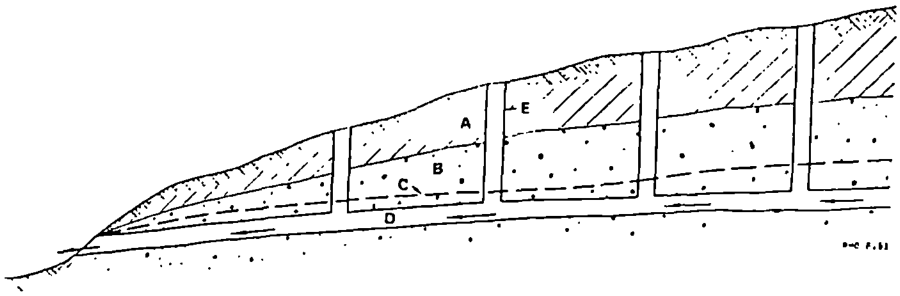
Infiltration galleries are nothing more than horizontal wells which collect water over practically their entire length. Where the construction of such galleries is feasible, a potable and wholesome supply of water can be obtained (Wagner and Laniox, 1959). A tunnel is driven into a water bearing strata which then functions as an infiltration gallery, the collected water being led out by gravity to the point of supply (Rajagopalan and Shiffman, 1974). This system of water collection is known as a qanat. Qanats or drained wells are mentioned in the Bible, and many are found in Iran (United Nations,1973).

The qanat system became used in many other countries such as those of the Eastern Mediterranean and North Africa. It is still widely used and occasionally new ones are constructed (Smith, 1951; Rajagopalan and Shiffman, 1974). In Egypt and the Sahara they are known as Foggaras, which in Morocco they are called Rhettaras (United Nations, 1973) and in Turkey they are known as Karez (Furon, 1963).

**VII: Construction of qanats**

In 1951 Smith pointed out that qanat construction represents, along with certain type of mining operation, the first serious activity in the difficult and dangerous enterprise of tunnelling. The construction of a qanat is usually a professional matter. A chief qanat digger or "mukanni bashi", determines the actual location for the mother well, he picks a desirable location and the digging is started. When water is encountered, the depth is measured by a string, and calculations are made to determine the nearest point on the land surface from where water can be made to flow by gravity to the point of extraction (Muse, 1961).

Work on the actual tunnel begins at the mother well point and additional vertical shafts, are dug at intervals of about 50 meters between the portal and the mother well are sunk to provide ventilation and facilitate the removal of the excavated material. By joining the bases of the these shafts the near horizontal adit is built up (Smith 1951; Muse 1961; United Nations 1973). Fig 3.5




A = Ground surface (undulating country or foot of hills)
B = Water-bearing formations
C = Ground-water table
D = Small tunnel (approximately 70 × 90 cm, or 28 × 35 in.), the sides of which may be supported by rubble masonry or brick walls
E = Aeration wells

Figure 3.5: Construction of qanat water source

Source: ( Wagner and Laniox,1959)

Mounding of the dirt around the wells keeps flash floods from entering the well and contaminating or even destroying the system(Muse, 1961). Nevertheless, Behnia (1988) and Honari in 1979 reported that, many factors cause qanats to deteriorate and collapse. Hence, the most important of them are as follows:-

1. Drop of water table
2. Digging wells next to qanat
3. Lack of maintenance
4. Natural disaster such as; earth quake, flooding,

drought and the spreading of sand dune in desert areas.

## VIII: Advantages and disadvantages of qanats

The provision of potable water supply from qanats in rural areas of developing countries which have access to them has many advantages and disadvantages. Behnia(1988); Smith (1951): Wagner and laniox (1959): Honari (1979) and United Nations in 1973 and many others have reported and then I have summarized their findings in Table 3.4.

Table 3.4 Advantages and disadvantages of qanats

| Advantages | Disadvantages |
|---|---|
| - It does not require any kind of power or energy to run.<br>- The water flows by gravity.<br>- It does not need to be supervised and continuous attention and guarding are not needed.<br>- Repairing qanats can be done by local people.<br>- When qanat has been constructed it may flow for hundreds of years.<br>- Foreign exchange is not required to buy machinery equipment and spare parts.<br>- Short and low depth of qanats can be dug.<br>- The water may be used for drinking without treatment and for irrigation, In a some large scale qanats also as a power source. | - The construction of a qanat is very slow and expensive and dangerous.<br>- Qanats are not practicable where the water table dips in the ground.<br>- Qanat waters are subject to contamination either by accidental or deliberate act.<br>- Qanats are not practicable in ground where the slope is very low |

With regard to benefits and limitations of qanats, it seems that, qanat water is a traditional ways of tapping ground water and but that due to increased population in many rural areas a water supply through only this system will not be sufficient, and therefore it is increasingly necessary to coordinate the use of qanats and tube wells.

From the point of view environmental impacts, the qanat system has a drainage role in an area and thus withdraws water from surrounding land may have adverse impact on the environment because they alter the balance in underground waters.

### 3.4.3: Environmental impacts of more excessive usage of ground water

As pointed out earlier, ground water is an important source of water thus, over pumping may create serious problems to environment. Because ground water is not an obvious component of the hydrologic cycle, it is easy for planners and others to forget that some of their actions may have deleterious impact on water resources and ecology over a wide area (Dunne and Leopold, 1978). Ground water is extensively used in many rural areas and this has resulted in the excessive exploitation of some water-bearing formations (Hinnawi and Hashmi, 1982).

In 1991 AL-Ibrahim reported that in most areas, ground water is the property of the owner of the land, and excessive withdrawal of water from wells is not possible without being liable for the damage excessive extraction may cause to the neighbours' water and or environment. Goudie in 1981, indicated that, increasing population levels and the adaption of new exploitation techniques (for example, the replacement of irrigation methods involving animal or human power by electric and diesel pumps) can increase the water extraction and so cause environmental problems. I have summarized the most significant adverse impacts of over pumping ground water on the environment. They are as follow:

**1.Depletion of ground water and lowering of the water table**

Withdrawing ground water from an aquifer in excess of the long -term rate of recharge is known as ground water depletion, mining or ground water overdraft (Canter, 1986). Ground water resources are highly vulnerable to the excessive exploitation associated with rapid industrial development and possible resultant population growth (Nair, 1991).

Depletion of ground water is a gradual process indicated by two common and interrelated symptoms: (a) decline of ground water levels and (b) decrease of well yields (UNEP, 1989; AL-Ibrahim, 1991). Furthermore, more usage of ground water disturbs the state of equilibrium of underground reservoirs resulting in for instance; decreased pressure in the aquifers and changes in the speed and direction of the flow of water.

In many rural areas of developing countries especially in arid regions over - pumping of ground water has created serious environmental and economic problems. For instance:- over much of Saudi Arabia, the water table of deep aquifers has steadily and rapidly declining resulting in decreased water withdrawals and increase pumping costs (AL-Ibrahim, 1991). In some rural areas of the country, wells have been abandoned, while in other regions, wells have had to be deepened and pumps had to be lowered to reach lowered water tables. For example, the ground water table has dropped ten meters during the last three decades in the area around Riyadh (Kaltham, 1978).

The striking problem of the over extraction of groundwater affects all water users in a village, but particularly small communities dependent on low cost shallow wells with hand pumps. The result is that many of the village level operation and maintenance (V L O M) hand pump and shallow well systems are not sustainable and many wells may run dry (Lee and Bastemeyer, 1991).

One study, reported by Honari in 1979, in the desert areas of Iran indicated that the water table had dropped in Aradakan Plain, at a rate of about 0.5 meter in a year due to the over use of the ground water by tube wells in the area.

Similarly, several other studies have been carried out in different parts of developing countries concerning the rate of drop of water table. For example; in Tamil Nadu in southern India the water table dropped 25 -30 meters in a decade (Davis et al; 1989). In 1989, UNEP, reported that in a part of Bangladesh a drop of water table of one meter per year. Bastemeyer and Lee in 1992 stated that in the Yamen, groundwater levels fell by 20 m in the 1970; on the Sana's Plain as a result of the uncontrolled sinking of over 10,000 wells. As a result, yields have fallen and the cost accessing groundwater has increased dramatically.

**2: Degradation of water quality**

Degradation of ground water quality results from a wide variety of causes, both natural and Man made, and these will be dealt with in chapter four.

**3: Land subsidence**

Ground water withdrawals accompanied by the decline of its level often cause land subsidence or land surface settling (UNEP, 1989; Davis et al· 1989; AL-Ibrahim, 1991). Land subsidence as a major environmental problem may occur on a large scale with a drop from 1 to 50 cm per 10 meters in the ground water level depending on the thickness and compressibility of the water bearing formations (Hinnawi and Hashmi,1982; UNEP,1989). For example; impressive cases of land subsidence have been reported by Gui and Zhong in 1989 in Beijing, in China, where an area of 600 square kilometres of land dropped during the period 1966-1983. In Shanghai another city in China's a cumulative amount of subsidence equal to 2.63 meters was recorded over the period from 1921 to 1965 ( UNEP, 1989).

Nair in 1991 reported that the maximum rate of subsidence was 1.14 meters in Bangkok between 1940-1980. He also pointed out that land subsidence has created serious problems:- in the design, construction and maintenance of buildings; roads and drainage systems, canals; conduits and pipelines. The potential cost of land subsidence is considerable (Al-Ibrahim, 1991). Another major adverse impact of land subsidence is damage to well casings and water transmission pipes that are connected to pumping wells (Nair,1991).

**4: Other environmental impacts**

The long term impacts of over pumping of ground water may lead to make water shortages in an area. According to Nair in 1991, in India and Pakistan, tens of thousands of villages are now faced with water shortages. In many rural areas and cities and most townships water may only be available a few hours a day. In China, fifty cities and many rural regions are now face with acute water shortages.

Farrar in 1974 stated that, water shortage was observed in the Sahelian zone of west Africa during the drought of 1971-73. He also concluded that some of these water shortages were caused by excessive pumping of wells.

According to Speidel et al·(1988), one of the most obvious environmental consequences of ground water extraction is the drying up of once-perennial streams and rivers where they are in "hydraulic contact" with the ground water that is being over drafted. For instance; in many rural and city areas of China the lowering of water-table resulted in the long term in the disappearance of spring water in many areas (Gui and Zhong,1989).

In 1982, Hinnawi and Hashmi reported that, drying of the plants could be increased by the deterioration of plantations due to the reduction in the moisture and or water coming to their roots from the water table. Moreover, he also indicated that this undesirable environmental impact occur in coastal regions where intrusion of salt water from the sea may occur. In 1977 Feachem et al; pointed out that, the installation of reliable improved potable water supply can be associated with overgrazing in some places.

In conclusion, it seems that, more drilling of boreholes and excessive use of groundwater in many rural areas of developing countries may have adverse impact on environment and economic situation of rural people. Hence, it is suggested that may be EIA a suitable tool which may be used to predict and assess all these problems. In the following section the controlling method and mitigation measures to reduce adverse impacts of more use of ground water is considered.

### 3.4.4: Controlling Ground Water Resources and mitigation measures

The excessive use of ground water and associated problems make it imperative to adopt a comprehensive ground water management program to minimize the social, economic, and environmental impacts of the deterioration of ground water quality and the depletion of ground water quality (AL-Ibrahim, 1991).

The negative and harmful consequences of the overdraft of ground water in many parts of developing countries should be taken seriously by those responsible for the management of water resources. A number of measures have been reported by Furon (1963) and AL-Ibrahim (1991), which should be taken so as to avoid the adverse effects of ground water exploitation. The most important are:-

1. **Prevention from depletion of ground water:** To prevent depletion of ground water sources, safe yields of aquifers have to be determined and should not be exceed by pumping.

2. **Reduction of subsidence:** In order to decrease and stop subsidence, demand for ground water must be reduced by using alternative sources and in some cases, ground water extraction may need to be stopped and replaced by other water sources.

3. **Artificial recharge:** Artificial replenishment or recharge has been defined by the American Society of Civil Engineers, in 1972, as "the process of replenishment of water retained in the ground water storage through works provided primarily for that purpose". The primary goals of artificial recharge are:

**(a):** Increase the insufficient natural recharge of aquifers to meet the current and future demands of ground water sources, thus extending the life of these aquifers.

**(b):** Combat the adverse impacts accompanying the more excessive use of ground water such as sea water intrusion, land subsidence, and deepening of wells.

Artificial recharge of ground water resources by the infiltration of surface water may be successfully applied if the quality of water injected is satisfactory (AL-Ibrahim, 1991).

In 1989, UNEP, suggested that, the fundamental principle of artificial recharge of ground water is to accumulate water in the wet season for the use in a dry season, i.e. the overdraw of ground water before flood period in order to enlarge the retention capacity of aquifer and to recharge aquifers during the flood period by seepage. The artificial recharge of aquifers may prove to be an important method for mitigating the adverse impacts of ground water degradation and depletion.

**4. Farmer education:** It is highly desirable to educate the farmers about the water requirements of plants and the potential harm over irrigation may cause.

**5. Water conservation:** saving water is an efficient way of reducing the overuse of ground water resources. It is not only decreases the amount of the water withdrawn, but may also reduces the threat of pollution.

**6. Mandatory regulations:** Great importance should be attached by the governments of each country to the protection of water resources through effective legislation.

## 3.5: Surface Water Sources

Surface waters largely originate from rainfall and are a mixture of surface run-off and ground water. They include rivers, ponds and lakes and small upland streams either from springs or for catchment run-off (Ehler and Steel, 1959).

### 3.5.1:The problems of surface water sources:

The provision of safe and otherwise satisfactory potable water from surface water sources such as streams, rivers, small lake and village ponds for single homes or rural communities in developing countries presents basic problems and often require heavy expenditure and technical knowledge and expertise (Ehler and Steel, 1959).

Surface waters will always require some storage and treatment to render them safe for human consumption and use. They may also require pumping because they are often remote from points of water demand. The costs and difficulties associated with the treatment of water particularly the day-to-day problems of operation and maintenance of water treatment plants in rural areas need to be carefully considered (Hofkes,et al; 1986).

For much of the surface water the critical problems of water use are related to its limited volume and to the fluctuations in its flow from season to season or over the year. Regulation and storage works are designed to even out stream flow, but they also alter channel characteristics and sub-surface drainage and create new aquatic environments (Holdgate,et al; 1982).

According to Hofkes,et al; in 1986, in tropical countries surface waters such as rivers have high amounts of suspended solids and turbidity, thus, the provision of potable water supply from such sources may not be acceptable. He also expressed that, in dry season organic matter frequently gives a colouring to the river water. But, Feachem,et al; in 1977 pointed out that such water can, nevertheless, be employed for irrigation.

River water intakes on the banks may suffer wet season flood damage and in the dry season yields flows may be reduced to zero as river flows falls below the intake ( Bastemeyer and Lee, 1992).

Flooding may have a major adverse impact of surface water supplies in many tropical countries. For instance; seasonal flooding in Bangladesh has been exacerbated by deforestation in the Indian Himalayas, resulting in flood damage of water supply systems and the contamination of water sources by polluted flood water (Bastemeyer and Lee, 1992).

## 3.5.2: Provision of safe water from surface water sources for public use in rural areas

Fair et al: in 1971 pointed out that, communities living near rivers, ponds and lakes may withdraw their water supplies by continuous draft if the capacity of the surface water source is high enough at all seasons of the year to supply the required water volume. Collecting works are as follows:-

1. An intake crib
2. An intake conduit
3. Possibly a pumping station

From intakes close to the village the water must generally be lifted to treatment works and then to the distribution systems. Water may be taken from a canal, river, lake or pond. For rural communities a basic survey of water quality and availability needs to be made before design work proceeds to deciding on the place and design of the intake.

### (a): River intakes

Rivers are a major source of water and many civilizations have developed along river banks and on flood plains. Throughout the ages structures have been built to divert water from rivers for domestic water supply and for irrigation (Koch, 1989).

Lvovich in 1973 stated that, rivers have been studied more thoroughly than the other parts of the hydrologic cycle. In assessing the possibility of using river water for a rural community one should take into account the season when the water is lowest and of prospects of regulating the flow of river water.

According to Carincross and Feachem (1978), the design of the intake arrangement needs careful thought and whenever possible river intakes should be built upstream of inhabited communities.

If the design of the intake is incorrect it may be damaged or carried away by floods or it may be clogged by silt when the water levels fall. Thus, the place and stability of the intake structure should be secured, even under flood conditions (Hofkes et al·1986). Standard designs can not be used for water intake structures because each location and each river has its own special characteristics and demands a design tailored to place's conditions. The increasing demand for water results in growing and sometimes conflicting forms of interference with the natural river system and other users. Conflicts may even have a negative impact on the operational efficiency of the chosen system itself (Koch,1989).

Locating an intake structure near a deeper section of a river will result in erosion and scour problems, while an intake beside a shallow section might malfunction because of excessive sedimentation or low flow (Koch, 1989).

Wagner and Laniox in 1959 stated that, intakes from small streams usually need the construction of small diversion dams. In which case provision can be made for a sufficient depth of water at all times above the intake pipe to as to reduce the silting by suspended matter, and thereby reducing the turbidity of the water and also for keeping floating leaves and other debris from obstructing the intake structure.

A submerged weir across a river can be constructed downstream of an intake to ensure that the necessary depth of water will be always available (Hofkes,et al; 1986).

Koch in 1989 stressed that, initial scour down stream of a weir may endanger the stability of the weir itself as well as that of other structures along the river, while upstream the bed levels and stages will rise, increasing the risk of floods.

The water taken from a river can be extracted either by pumping or by gravity (Hofkes,et al; 1986; Koch, 1989). If the variation between the high and low water level in the river is not more than 4 meters, a suction pump placed on the river bank can be employed. Figure 3.6

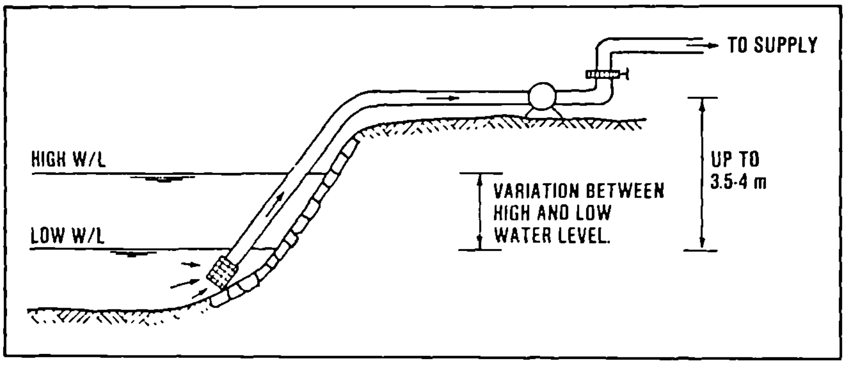



Figure 3.6 Pumped river water intake.

Source: Hofkes et al(1986)

Koch in 1989 pointed out that, from the hydraulic point of view, an intake structure should be designed so as to minimize head losses, restrict the intake of sediments from the river and prevent sedimentation in the intake. Sedimentation in the main supply and distributary canals will reduce the efficiency of a scheme and will result in costly maintenance. To avoid this a sedimentation trap is frequently constructed between the actual intake and the main supply line. If possible, the use of a pump should be avoided.

**(b): Canal water intake**

In some rural areas canals can be used both for irrigation and the supply of water. From the point of view water supply, it may possible to install an infiltration gallery in a canal and bed either across or along the course of the canal with a suitable clear water collecting well by the bank. If the canal is unsuitable for this purpose because of the size it may be feasible to draw off a supply of raw water through a pipe into a bypass channel, and pass this water through an infiltration gallery (Rajagopalan and Shiffman, 1974; Cairncross and Feachem, 1978).

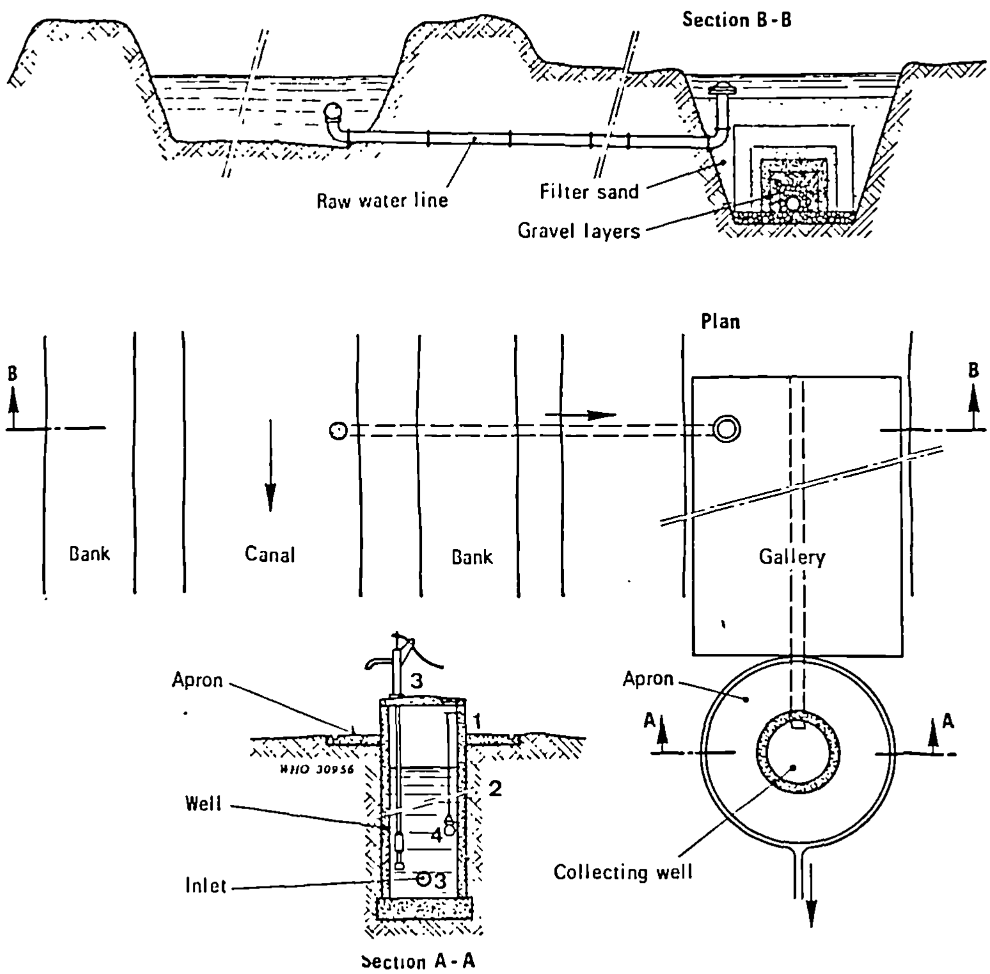



Figure 3.7 Canal water intake

Source Cairncross and Feachem (1978)

As figure 3.7 shows, to obtain clean water for drinking purpose, water from a canal may be collected in a well or storage tank. The well should be covered with a hand pump and sanitary measures should be carried out. For more details about sanitary measures see the next chapter.

**(c): Natural small lake water intake**

According to Lvovich (1973), lakes and rivers are usually inseparably linked within the hydrologic cycle. Very few rivers are independent of lakes as they usually flow into, from or through them.

Hofkes,et al in 1986 stated that, lake water is often free from viruses and pathogenic bacteria at some distance from the shore. Algae may be present, however, and especially in the upper water layers of lake. When taking water for supply purposes, water from deeper strata will have the advantage of a practically constant temperature. Hence, the provisional water supply should be from some depth below the surface. He also suggested that, in shallow lakes, to avoid the entrance of soil, the intake should be sufficiently high above the bottom of lake.

Finally, in some developing countries for small communities, the quantity of water needed being small a very simple intake structure using flexible plastic pipe may be used (figure 3.8)

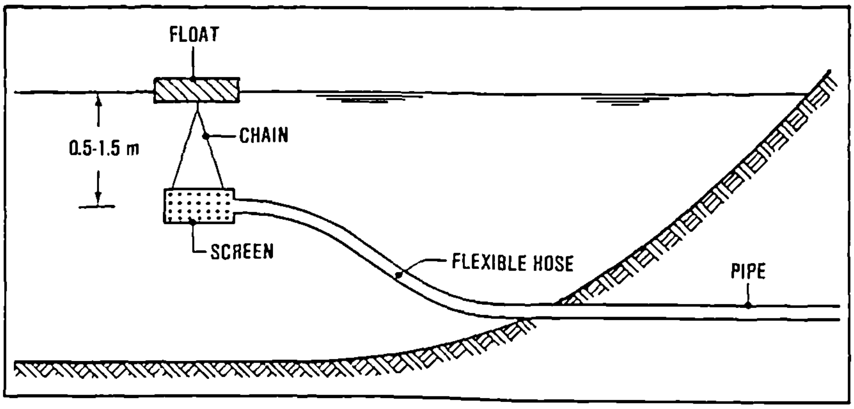



Fig 3.8 Simple water intake structure from lake.

Source: Hofkes,et al;(1986)

Another method of taking water from a lake uses a floating barrel to support the intake pipe inside the lake. Figure 3.9 shows a floating intake device which may be appropriate and plastic pipe can be employed instead of galvanized iron for the collection pipe. A well may be dug near the bank and intake pipe driven from the well into the lake.

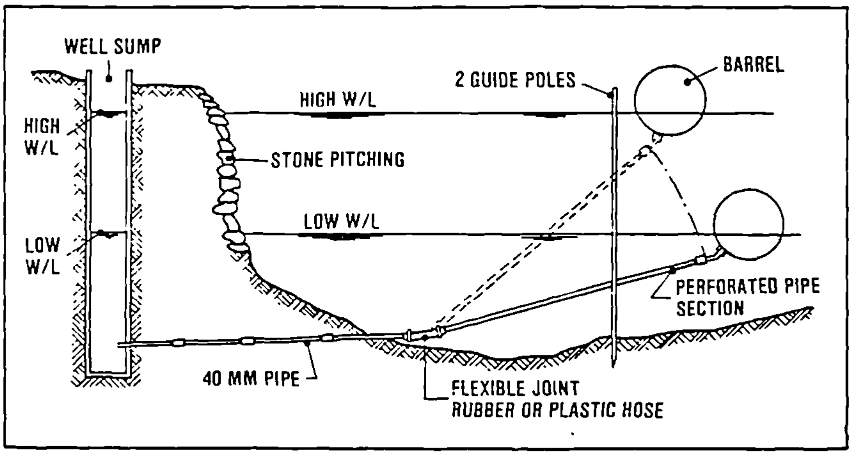



Figure 3.9 Simple water float intake structure.

Source:Hofkes,et al;(1986)

Consequently, the provision of a potable water supply from a lake even if in a rural area requires facilities such as an intake, possibly a pump, and treatment and maintenance by trained people. Nevertheless, a simple intake construction may be useful for rural communities in developing countries.

**(d): Village ponds and small dams**

There are small communities in developing countries whose only source of water in rural areas is a small pond or dam. These are known as "tanks" (India), "ponds" (Eastern Africa),"Hafie" (Sudan),"tapkins (Nigeria), "represa" (South America) or other local names( Hofkes,et al,1986).

Wright in 1956, pointed out that, a pond should be located where the soil is of such a nature that it will hold water. Hence, heavy clays are best, but still clays and clay loams are suitable. Sandy soils are, however, not appropriate.

According to Hofkes,et al; in 1986, small dams and village ponds can be entirely natural in origin or specially constructed for the purpose. If Man made they may have been excavated for the expressed purpose of holding water.

The water in village ponds and small dams may be full of silt or colloidal matter, particulary soon after the rains. This is negative impact from the potable water supply point of view. In ponds where the water has high turbidity, the water is best taken from below *the surface* for water supply. However, a floating intake device may be used for the collection of water.(Hofkes,et al;1986) (see previous section).

To determine the site of a small dam requires considerable topographical and geological knowledge. Failure in designing an earth dam may have a disastrous impact on the construction of dam, which if it fails may kill many people. Weakness can be caused by erosion of earth, by percolation of water through the structure and for several other reasons. Finally, evaporation of water in the dry season is another significant impact which should be taken into account ( Wagner and Laniox, 1959).

Small earth dams are widely used in southern and eastern Africa for watering cattle and for the supply of domestic water to villages and isolated farms. But it is not always appreciated that these dams provide a very inefficient form of water storage. For example, in Swaziland, the annual loss of water from small dams may amount to 50% of the volume collected. Thus many factors such as loss of capacity by silting, high evaporation losses and seasonal rainfall may mean such dams in semi-arid areas of Africa are not effectively used (Farrar, 1974).

Pacey in 1977, suggested that, one technique for controlling evaporation is to use reservoirs filled with sand and loose rock. Water is stored in the pores between the particles, and is protected from evaporation below the surface of the sand. Small sand - filled dams in comparison with earth dams have many advantages. For example; they can store water for long periods, and provide water during years of total drought, because when the water table is more than a metre below the sand surface, evaporation ceases for all practical purposes. The water is drawn off by a drainage pipe through the dam wall, or by a well dug into the sand, and water does not need any treatment because it is filtered through sand ( fig 3.10)

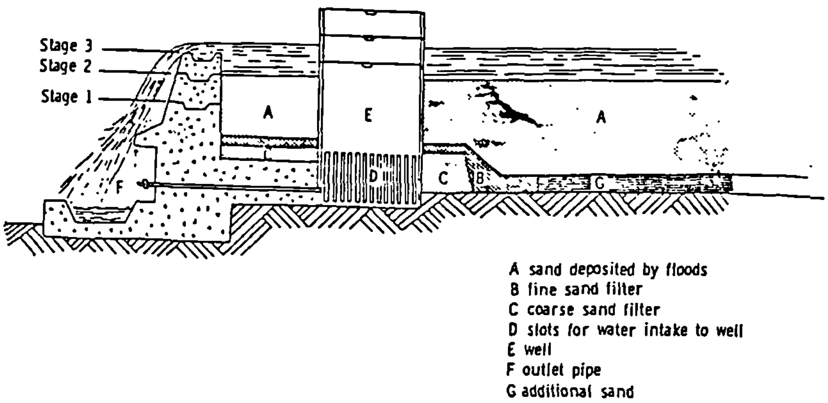



Figure 3.10 The principle of the sand fill dam.

Source: Pacey(1977)

Pacey (1977), also pointed out that, small sand -

filled dams using this principle have been constructed in semi-arid areas of Africa, and have been proposed in Botswana for the supply of drinking water for rural communities and livestock. Of great potential value in arid and semi-arid zones, this technique is environmentally appropriate only to those particular regions where floods carry a large sediment load and where the sediment include significant amounts of gravel or sand. However, most water conservation techniques, have to be specifically appropriate to particular environment.

## 3.6: Rain water harvesting

### 3.6.1: Rainwater as a source of water supply

In most developing countries particularly in rural areas where springs and streams are none-exist in the dry season, where open storage of water is impracticable because of high evaporation losses, and where ground water resources are poor, rainwater harvesting is the only feasible potable water supply method (Maddocks, 1975; Cairncross and Feachem 1978; Jayakaran, 1988).

Hofkes,et al in 1986 stated that, historical sources mention the use of rain water for domestic water supply some 4000 years age in the Mediterranean area. The cities and villages of the Roman Empire were planned to take advantage of rainwater for potable water supply. But

Critchley in 1989 pointed out that, in recent times rain water harvesting is a term which only become widely talked about in the early 1980s.

Providing all domestic demands from rain harvesting would minimize both transport cost and health hazards from surface water sources (White, et al, 1972).

The use of direct rain water storage as a source of potable water is practised extensively in several regions of the world. Because of continuing energy shortages and increasing difficulties in providing other sufficient source of potable water supply, it is expected that this method will be employed widely in the future (Schiller and Droste, 1982).

Work in the U.S.A, Australia and Jamaica has shown that the provision of potable water supply from rain water units using artificial catchments in areas of low or average rainfall is not cheap and that this source of supply is only justified where the water is to be used by humans or livestock. These units are not suitable supply for large scale irrigation (Maddocks, 1975). Hofkes,et al; in 1981 noted, however, that rain water units continue to be the only source of domestic water supply in some tropical regions.

According to Maddocks (1975), rain water units are only be used where there is no alternative potable water supply. He also concluded that in many rural areas in developing countries the national economic status will prevent the large capital expenditure associated with big public water supply projects and rain units can provide an appropriate alternative. In arid and semi- arid regions where the population is widely scattered or nomadic settlements rain water units for small communities or single households can be an effective means of providing a good potable water supply for domestic purpose.

### 3.6.2: Types of rain water harvesting

The methods of collection rain water in rural areas of developing countries can be classified into two major groups (a) roof catchment and (b) ground catchment (Maddocks, 1975; Schiller and Droste, 1982).

The components of a rainwater catchment unit in a rural regions are very simple. They are including: a catchment system, a conduit system and a storage tank. Sometimes a sediment trap for disposing of dirty water may be included and if the storage tank is below the ground surface, a pump may be needed to withdraw the water. Finally, a method of purification such as slow sand filter may need to be used in system (Schiller and Droste, 1982).

**(a): Roof catchment**

According to Cairncross and Feachem (1983,1978), potable pure rain water can be collected from roofs which are made of galvanised iron, aluminum, tiles, slates or asbestos cement sheeting. But thatched or lead roofs are not suitable because they have health hazards and thus a deleterious impact on consumers. Cairncross and Feachem in 1978 also noted that bituminous roofs caused the water to have an unpleasant taste and to be unpotable.

Schiller (1982) suggested that, roof catchment rainwater systems are used extensively in many areas of the world, notably in Bermuda, Israel, Thailand, Australia, Hawaii and Middle East. They are typically employed in dry countries, particularly in African countries.

Bermuda is one of the countries that has a long history of the application of rainwater catchment systems. These systems are described in use in the early seventeenth century (McCallan, 1984), and today it is required by law that all building shall be provided with a tank and a catchment for securing a potable water supply (Schiller, 1982).

According to Cairncross and Feachem in 1978 it may be better to keep the water for domestic use in a storage tank near the house, and run the overflow to an underground tank for other purposes such as irrigation or washing ( see Figure 3.11).

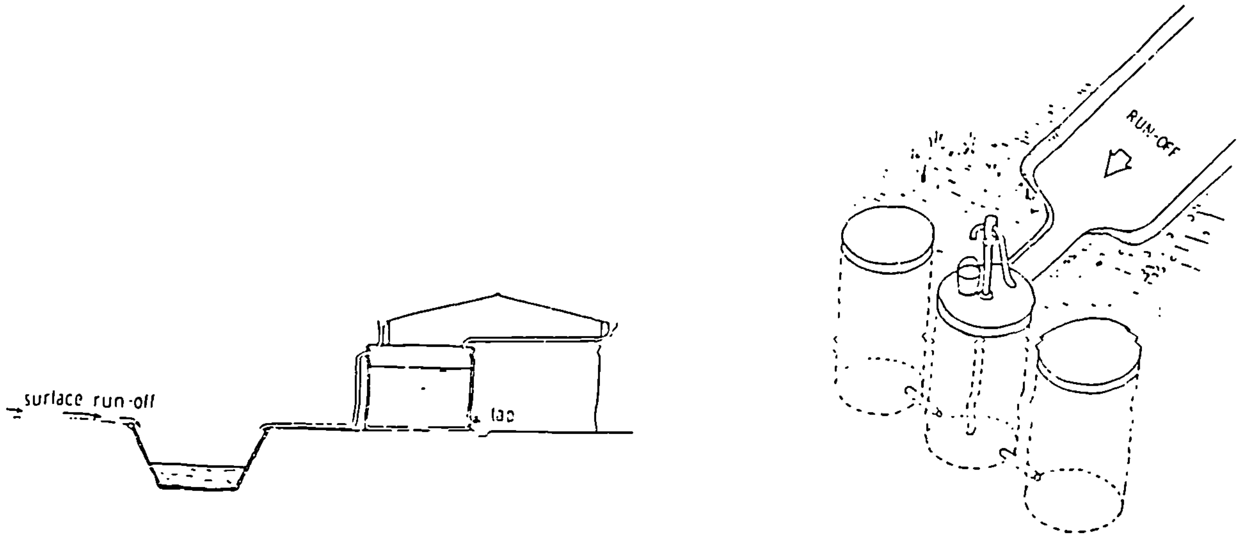



Fig 3.11 Roof catchment tank alongwith excavated tank

Source:(Pacey, 1977)

(b):Ground catchment of rainwater

Ground catchments are also often employed for collecting rainwater runoff. This method can be used for water supply and irrigation and Critchley in 1989 stated that the basic concept of rainwater catchment for plant production is very attractive instead of allowing run-off to cause erosion, it is collected and concentrated in the fields of better crops. It has also a beneficial impact on productive soil and water conservation. Consequently, it makes very good sense for the semi-arid regions of sub-Saharan Africa where a third or more of the meagre rainfall is lost through runoff.

The amount of rainwater that can be collected in ground catchments dependents on whether the catchment is flat or sloping ,and the watertightness of the top layer. A sufficiently quick flow of the water through the preparation of the ground surface to the point of collection and storage must be assured in order to mitigate evaporation and infiltration losses (Hofkes,et al; 1986). Even so, in practice it is impossible to collected 100% runoff (Stern, 1978).

According to Hofkes,et al; in 1986 the portion of rainfall that can be harvested ranges from almost 30% for, flat catchments, to over 90% for sloping strip catchments covered with impervious materials.

Studies done by Critchley in 1989 have shown that, traditional rainwater catchment systems are, in Africa only found in certain semi-arid areas. Such systems are limited, for example, to regions where the soil is of clay and where therefore significant runoff occurs. The systems are normally environmentally sound; by definition rainwater harvesting is moisture and soil conserving.

In rural areas where the people use the ground for collection of rainwater, they need to employ a wide range of materials to cover the soil including: tiles, corrugated iron sheets, asphalt, cement, or even materials such as heavy butyl rubber or thick plastic sheets. When properly applied these materials can give good water catchment efficiency with a yield as high as 90% of the rainfall runoff from the catchment area. Additional advantages are low maintenance and long useful life. However, these materials are too expensive for use over large ground catchment areas(Hofkes,et al;1986).

The above materials are not practicable in many areas of developing countries, but according to Maddocks(1975); if the soil contains some clay then compaction and shaping of the surface will improve its resistance to erosion and produce runoff more rapidly. It seems that a long term solution needs the use of an impermeable surface. In the U.S.A, Jamaica and Australia thin metal sheets have been used to form large catchment areas (Maddocks, 1975).

According to Hofkes,et al; in 1986, thin plastic membranes covered with 1-2 cm of gravel and attached to the ground surface by a bitumen tar are much cheaper than metal sheet but that they are easily damaged by animals, plant roots, and repairs are difficult.

Finally, treated ground catchments of suitable size can provide a potable water supply for a whole rural community but they usually require proper management and maintenance and protection against pollution and damage Figure 3.12.

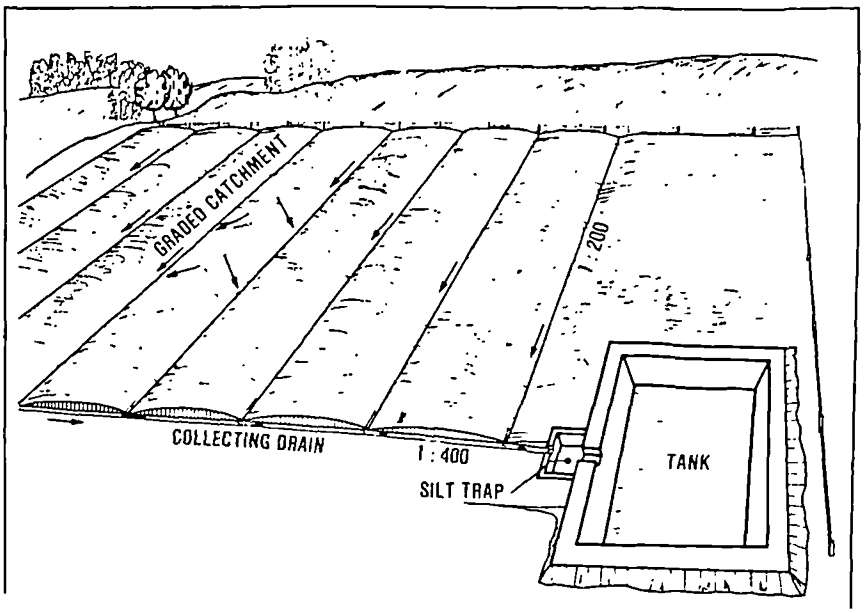



Figure 3.12 Ground rainwater catchment.

Source:(Hofkes et al·1986)

From the point of view environmental impacts, Critchely in 1989 stated that, ground catchment rainwater schemes demand awareness of possible dangers to the environment particularly when earth bunds are employed to retain collected water. The concentration of water can often lead to bund breaches in the early seasons after construction and before the bunds have consolidated.

Erosion is an adverse impact in ground catchment rainwater especially in the traditional system, so that Critchely also in 1989 pointed out that, wind erosion can cause great destruction where fields are clear in semi-arid regions, but this problem of erosion is restricted to sandy soils, where rainwater harvesting is not practised. Moreover, Pickford (1977) suggested that, the use of vegetable cover around rain water collection areas can reduce erosion and hence decrease the suspended solids at the intake.

**3.6.3: Rainwater storage**

The collection of rainwater requires a storage system. Such storage facilities can be made either above or below ground (Schiller, 1982). In Bermuda they are constructed below ground (Schiller and Droste,1982).

Storage tanks also have advantages that they can be constructed near to the place where water is required ( Wright,1956; Farrar,1974). It must, however, be kept in mind that relatively small quantities of water are collected.

There is wide choice of materials for construction of storage tanks. For small tanks volumes, vessels made of wood, clay or water proofed frameworks may be used (Hofkes,et al;1986). Cisterns may be built of brick or stone masonry, or of reinforced concrete (Wagner and Laniox 1959). On the other hand, the most common type of storage tank used in South Africa is a galvanised corrugated cylindrical tank (Farrar,1974). Figure 3.11 (page 123) shows the principal of both type of catchment tank, and indicates how the two may be used together with an overflow roof tank occasionally contributing water to an excavated tank. A household using the two type of tank together in this way would tend to draw his drinking water from the roof tank, because this is the cleanest source , and would use the second tank as a source for washing water or for other uses where high quality was not essential (Pacey, 1977).

Underground cisterns are generally easier to construct and have the general advantage of keeping water cooler and protected from evaporation (Hofkes et al·1986; Schiller, 1982; Wright, 1956 ). They can also be a saving in space and cost of construction where the storage is moulded directly in the ground by simply compacting the earth (Hofkes,et al;1986). But, Schiller in 1982 stated that, a disadvantage of this tank is that the water requires to be lifted out, usually by pumping.

Catchment tanks excavated in the ground can be lined with any impermeable material to make them watertight, one particularly novel form of lining uses polythene sheeting and mud to provide a water proof membrane. There are also various ways of covering tanks to prevent evaporation; one of the most unusual is a hollow domed structure inside the catchment tank, a backfill of sand is then spread on top of the domes and levelled up with the ground surface. Water entering the tanks is thus filtered through the sand and stored inside the domed structure and in the sand fill between them (Pacey, 1977). Figure 3.13 illustrates a cross section of an underground storage tank.

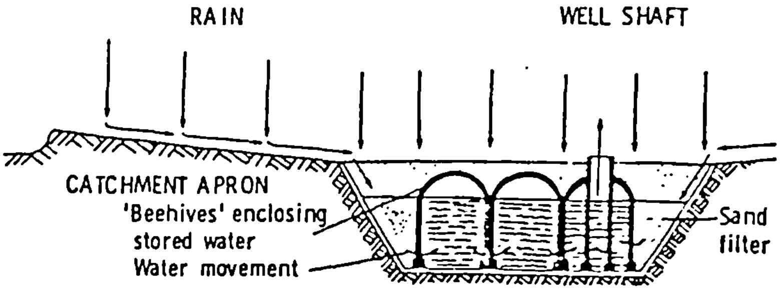



Figure 3.13 Cross section of a bee-hive tank.

Source: Farrar (1974)

As the above figure shows storage tanks (cisterns) consisting of "beehive" structures. They are built of lengths of polythene tube filled with a weak cement mixture and sealed at the ends. These are laid in place before the cement mixture sets, and readily take up the required shape.

Hofkes,et al (1986) and Pacey in 1977 stated that, tanks of this kind are limited in size, the largest of a series built in Botswana and Swaziland had a capacity of 90,000 litres. Tanks of the bee-hive type have now been built in Jamaica, Swaziland, Botswana, Brazil, and Sudan.

Concrete containers are popular in the Far East and throughout Africa, especially in Kenya where they are said to be the most popular "appropriate technology" at the

UNICEF centre for appropriate technology (Hofkes,et al;1986).

Schiller in 1982 stated that, above ground storage tanks should be strongly built and well covered. An advantage is that, water is extracted from them by gravity. However, indoor cisterns are more difficult to protect from pollution and rodents ( Wright, 1956). I have summarized the desirable and undesirable features of rain catchment techniques in Table 3.5

Table 3.5 Desirable and undesirable features of rain water supply

| Water supply technique | Desirable feature | Undesirable features | Mitigation | Direct impact | Indirect impact |
|---|---|---|---|---|---|
| **Rain water:**<br>**1.** roof catchment | -Local<br>-Soft water<br>-Useful in the dry and wet season | -May be dirty<br>-It may have little quantity of water<br>-Evaporation<br>-Corrosion | -Filtration<br>-Treatment<br>-selection another water source<br>-Anti-corrosion materials may be used | -No walk<br>-Better health | -Increased productivity |
| **2.**Ground catchment | -It is suitable for large communities<br>-Local<br>-Soft water | -Wind erosion<br>-It needs more land<br>-Evaporation<br>-Infiltration losses<br>-Turbidity of water and suspended solids | -It should be covered with vegetation<br>-It should be covered with plastic sheets<br>-Compacting of soils with some materials<br>-Treatment of water | -Better health<br>-Walking | -Increased productivity |

## 3.7: Summary

In this chapter I have tried to outline the advantages and disadvantages of various way of obtaining water for potable supply. Each technique has its own beneficial and adverse characteristics. In those areas of the world where ground water availability is adequate health and constructional considerations make ground water extraction the most desirable source for supply.

# CHAPTER 4

# ENVIRONMENTAL IMPACT OF CONTAMINATION ON WATER SOURCES AND SANITARY MEASURES

## 4.1: Introduction

Contamination of water is a significant problem in many developing countries. As Ayoade in 1988 reported the contamination of water effectively limits the quantity of water available for most consumers. In addition, it can have harmful and deleterious effects for both Man and the aquatic life on which Man depends for some of his food.

Profiles of different types of water source pollution in different environments and their vulnerability to environmental factors might form a basic for decision making. Environmental Impact Assessment (EIA), is a tool which may be used by planners and water engineers to predict, monitor and assess all adverse environmental effects of water source pollution before and after implementation of a project and to help to develop remedial and preventive solutions for such pollution.

Water pollution in rural areas is not a subject on which a great deal has been written. The significance of any pollution is evident from its consequences, and although there is serious pollution in rural area, it is mainly from the consequences of urban pollution that we have learned the importance of pollution generally (Key, 1967).

In this chapter, the author presents the environmental factors affecting water source pollution, types of contamination of water sources including; ground water, surface water, rain water and he also covers protection and sanitation measures. Various aspects of natural and human activities cause pollution of both ground and surface waters for instance; agricultural (fertilizers, pesticides, animal wastes), over pumping, human waste and industries under rural conditions are discussed. The adverse environmental impacts of these types of pollution are considered in this chapter. The health effects of some of these pollution will be dealt with in chapter 6.

## 4.2: Definition of water pollution

Water pollution is a broad and generic term with a variety of meanings. In 1972, however, the WHO stated that "water is considered polluted when it is altered in composition or condition so that it becomes less suitable for any or all of the functions and purposes for which it would be suitable in its natural state". This definition includes changes in the physical, chemical and biological properties of water, or such discharges of liquid, gaseous or solid substances into water as will or are likely to create nuisances or render such waters harmful to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, wild animal, fish and other aquatic life.

## 4.3: Classification of water pollution sources

Numerous sources of pollution may adversely affect water quality and the environment. Canter (1977) and Marrack in 1980 classified water pollution sources into two main groups, (a) point sources and (b) non- point sources. This classification has an advantages from the protection point of view.

**(a) Point sources:** These are sources of pollutants contained in someway, such as by a pipe or channel, where flow and composition can be readily monitored, either continuously or by dip samples. These discharges may derive from pit latrines, septic tanks, municipal sewage or industrial waste treatment plants.

**(b) Non- point sources**: These sources contain pollutants that are diffuse and possibly also irregular in their entry into water bodies such as urban and agricultural run-off. Both point and non-point sources of water pollution in rural areas of developing countries are important-from both the human and natural environmental pollution points of view.

## **4.4:Environmental factors affecting water sources pollution**

As noted earlier in chapter 3 (page 73), choosing a suitable water source from the quality and quantity point of view for planning and design of a water supply project for rural areas is very important. Bastermeyer and Lee in 1992 reported that, any assessment of environmental factors demands a *systematic analysis of the rural situation.* The International Water Resource Centre (IRC) concluded that to identify the causes of the pollution problems of water sources, the project planning water engineers should focus on the linkage between the sources of water in their catchment area, and the activities of the water consumers and non consumer communities and additional any external factors. Figure 4.1 illustrates in outline the suggested linkages.

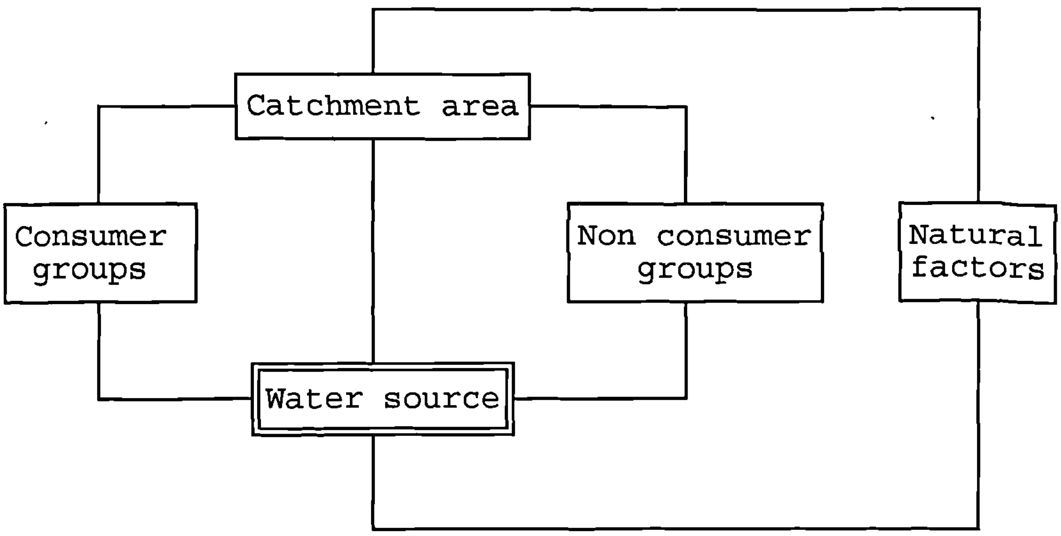



Figure 4.1 Direct and indirect links between the source of water and various factors

Source : Bastemeyer and Lee (1992)

Figure 4.1 illustrates, the direct (to the source itself) and indirect (through catchment) relationship between the source of water, catchment area, natural environmental factors, water consumer and non consumer communities.

According to Lee and Bastemeyer (1991) direct linkages concern immediate impacts at the water sources and the surrounding area upon the quality or quantity of the water supplied to consumers. Indirect linkages concern changing conditions in the catchment area that affect the reliability of the water source.

Various water sources such as; rain water, springs, wells, rivers, streams, canals, lakes, and ponds may be used in rural areas for drinking and other domestic purposes (see chapter 3). But these sources can be easily contaminated by the various environmental factors and water users . Any change in catchment area may also affect the quantity, quality and or timing of water flows into the source.

Rural communities are the chief consumers of water for drinking and other domestic purposes from water sources. According to Bastemeyer and Lee in 1992, there may be multiple user communities located upstream and downstream from the others. Thus, each group may affect the quantity, quality and reliability of the water source for those down stream and itself.

Furthermore, non consumer communities are people located upstream of the user communities who do not consume the water source, but whose activities may have adverse impact on the quality of water source. For instance; mining operation that directly may contaminate the source of water.

Many environmental impacts may stem from natural episodes such as climatic changes, flooding and earthquake and evaporation which can have deleterious impact on the quality and quantity of water source. However, many environmental factors may contaminate the rural potable water sources. Table 4.1 shows the problems of water sources pollution and solutions.

Table 4.1 Environmental factors affecting rural water source pollution

| Source problem | Unacceptable quality | Insufficient yield |
|---|---|---|
| Nature of problem | Contamination<br>Taste/odour<br>Physical appearance<br>Chemical pollution<br>High turbidity | Rainfall fluctuation<br>reduced water levels<br>Depletion |
| Environmental factors | Septic tank overflow<br>Pit latrine seepage<br>Insufficient design<br>open defecation<br>Human waste disposal<br>Waste disposal in catchment area.<br>Washing and bathing<br>Animals around source<br>Waste disposal next-to water source.<br>Environmental-degradation<br>Cutting trees<br>Accumulate organic waste | Insufficient design<br>Wastage<br>Increased demand<br>Vandalism<br>Industrial demand<br>Irrigation<br>Overgrazing<br>Expanding agriculture<br>Burning grass and shrubs in catchment<br>Deforestation<br>Water losses |
| Solutions | Improved sanitation<br>Improved hygiene<br>Waste water treatment<br>Catchment protection<br>Maintenance<br>Drainage<br>Emptying of pits<br>Physical protection of wells, including;slabs and drainage<br>Organized waste disposal | Improved agriculture practice<br>Water use rules<br>Improved designs<br>Alternative energy source<br>Community control<br>Repair |

Source: Lee and Bastemeyer ( 1991)

As Table 4.1 illustrates, many of the environmental factors affecting water sources pollution in rural areas most seriously are contamination by source consumers and pollution from on-site sanitation. The water consumer and non consumer communities in rural areas can have a significant role both, directly by the depletion and contamination of water source, and indirectly through impacts on the yield and quality of surface and subsurface runoff from the catchment area. Many of these problems can be solved by the water users in rural areas through maintenance, protection of water sources and improved sanitation facilities.

It is concluded, however, that, to obtain safe water from a water source, it is essential to protect and prevent it from contamination, and all direct and indirect links between water source and environmental factors should be brokendown (see figure 4.1 on page 136). In the following sections some important environmental factors which may pollute the water sources in rural areas and protection and sanitary measures are considered.

## 4.5: Ground water pollution and sanitary measures

### 4.5.1: Pollution of ground water sources

As stated in chapter 3, (page 73) the principal water source for domestic use in the rural areas of developing countries is ground water. But the quality of ground water is threatened by many of the activities which may occur in the whole environment.

Holdgate, et al; in 1982 pointed out that the vulnerability of ground water to contamination is determined by the hydrological setting of the aquifer, the nature of the contamination and the effectiveness of regulatory action. Moreover, contamination of underground aquifers is usually a consequences of peoples's misuse of the environment(Rail, 1989).

The FAO in 1979, indicated that ground water quality changes are brought about through Man's introduction of foreign chemical and biological material into the subsurface environment, through quantitative interference with natural flow patterns, by a completely natural process, or through various combinations of these procedures.

## 4.5.2: Natural degradation of the ground water quality

Most ground waters contain some natural dissolved salts. These salts most often originate from contact of the water moving in the hydrological cycle with various rock and soil minerals. The result of these contacts is that water accumulates various amounts of natural impurities due to solution or chemical reaction followed by solution. These natural mineralization processes are most important in arid lands, but the resulting quality is a function of nature, not of man and is generally referred to as a background level of quality ( FAO, 1979).

The concentration of most bulk and trace inorganic constituents may be found in ground water varies by area and, in many instances, also over time. Some of these materials may have harmful impacts on health such as nitrate, fluoride, arsenic, water hardness and selenium (Craun, 1984). For example, arsenic and fluoride can be present in harmful amounts owing to rock decomposition in ground water in parts of Latin America and East Africa (WHO, 1987).

Other substances found naturally in ground water, while not necessarily harmful, may impart a disagreeable taste or undesirable property to the water and include; magnesium sulphate, sodium sulphate, and sodium chloride (Environmental Protection Agency, 1973). Carruthers in 1973 reported that in East Africa the most common chemical contamination is an excess of sulphate and that a troublesome form of chemical pollution is fluoride in borehole water, a particular problem in parts of Tanzania. In Kenya some of the boreholes in the Rift Valley have potentially harmful levels of fluoride (i.e. above 1.5 ppm).

The FAO in 1979, pointed out that there are other natural sources of lowered quality of water. For instance; along the sea coast there exist a natural meeting place of fresh ground water moving toward the ocean and saline ground water from the sea, sometimes giving rise to salt contamination.

## 4.5.3:Degradation of ground water quality by Man's activities

The most important contamination of ground water in rural areas is related to Man's activities. The FAO, in 1979 noted that there are many human activities which may pollute or otherwise damage the environment and that ultimately many of these will cause the pollutants to enter to ground water. The most important of these activities in rural areas are as follows:

1- Salt water intrusion problems associated with the over pumping of ground water in coastal areas
2- Agricultural activities including; the use of chemical pesticides, and fertilizers, irrigation practices, and the use of animal waste as manure.
3- domestic waste(bacterial pollution)
4- Industrial activities

## I: Impacts of over pumping on ground water quality on coastal areas

As noted in chapter three (page 98) over pumping of ground water may lead to the degradation of ground water quality. Salt water intrusion or encroachment is another serious problem associated in the groundwater withdrawals (United Nations, 1990). In coastal areas over exploitation of ground water may lead to salinization of coastal fresh water aquifers owing to the intrusion of salt water from the sea, with considerable detrimental impacts on quality of ground water, soil and vegetation (Goudie, 1981; UNEP, 1989; Hinnawi and Hashmi, 1982). In coastal areas, sea water intrusion is the most serious threat to ground water resources and the result may be the eventual abandonment of pumping wells (FAO,1979). For example; in Bangkok since the late 1960s many wells have been abandoned by the MWWA (Metropolitan Water Works Authority) and private well users because of their increased salinity (Nair, 1991).

Furthermore, intrusion of sea water has been reported in the coastal zones of Bangladesh, China, India, Viet Nam and the South Pacific islands, where excessive extraction of ground water is widely practised (Goudie,1981). A similar case was reported by Assez in 1973 in the Niger Delta area of Nigeria.

## II: Adverse impacts of the agricultural and chemical wastes on ground water

Water is a vital resource for Man and agriculture and a significant habitat for many other living species. Of all the activities of Man that influence the quality of ground water, in rural areas, agriculture is probably the most important, as a diffuse source of contamination (UNEP, 1981a and FAO, 1979).

Robbins and Kriz in 1969 presented a survey concerned with relation of agriculture to ground water contamination. In their study many agricultural sources of contamination were reviewed, including animal waste, fertilizers, pesticides and plant residues. From the survey it is clear that, of the main nutrients are nitrogen, phosphorous and potassium fertilizers. Nitrogen in the form of nitrate is the most common cause of degradation of ground water near agricultural lands (Holdgate,et al;1982). High nitrate levels have been found in ground water into the arid zone and in the industrialized Northern Hemisphere (WHO, 1987). According to Davis, et al; in 1989, nitrates, primarily from fertilizers, are becoming a serious drinking water pollutant as the use of fertilizers spreads throughout the third world.

Furthermore, nitrate pollution is also a growing problem in some Latin American cities such as Buenos Aires and Suo Paulo, primarily because of leaching from surrounding farmland into wells supplying these cities.

According to Bastemeyer and Lee in 1992, the siting of pit latrines too close to wells may lead to long term nitrate pollution. For instance; in Botswana, in 1980, between 5 and 10% of all groundwater samples analyzed had nitrate levels greatly in excess of WHO recommendation levels. In Andhra Pradesh, and elsewhere in India, nitrate pollution of ground water by infiltration from insanitary septic tanks has become a major environmental problem.

**III: Degradation of ground water quality by pesticides**

Pesticides are a large and heterogeneous group of toxic chemicals which can be used in agriculture. The use of pesticides in agriculture has permitted agricultural producer to promote food at a lower cost(Loehr, 1984). Although pesticides are an effective instrument for the control of insects, diseases and weeds, reports have, pointed out that they have deleterious impact on environment, food and human (Santos, 1992).

In 1979, the FAO indicated that the three main insecticides of importance in relation to ground water contamination are the organochlorides because of their persistence in the environment, the organophosphorous because of their relative mobility, and the carbamates. They are very toxic to human and animals.

Bastemeyer and Lee in 1992 reported that, in Sri Lanka many shallow drinking wells are placed next to paddy fields, where chemical fertilizers and pesticides are applied. In Juba, Sudan, many boreholes had high DDT concentrations close to villages in which 23% of households use pesticides in their latrines to control fly problems.

A typical pesticide known to migrate easily into the soil, and which may then find its way into aquifers which are used for drinking water in the widely employed water-soluble compound weed killer 2,4-D which is used as a weed killer (OECD, 1986).

**IV: Location of wells and bacterial contamination of ground waters**

In many rural areas of developing countries due to the proximity of the wells to the source of pollution the chance of pollution of the wells with bacteria are numerous. As pointed out earlier in chapter 3 (on page 78), although ground water quality is usually good there is always the possibility of contamination and particularly in areas where shallow wells are used with a depth of less than 10 meters there is a risk of percolation and thus of faecal contamination from pit latrines, cesspools, seepage pits, septic tanks and farm yard waste (Hofkes et al. 1986;WHO, 1975).

The United Nations in 1987 noted that, Bacterial pollution of ground water can occur when;(a) inadequate attention is paid to the design of pit latrines and (b) inadequate spacing is provided between heavily use latrines.

Several authors have been concerned over the effects of the proximity of wells to latrines and the travel of contamination through ground water. The results of their studies showed that two factors such as porosity and permeability of the soil are very significant in the travel of bacteria (Wagner and Laniox, 1959). Furthermore, Canter in 1977 indicated that the distance of travel of bacteria such as coliform and Escheria coli through soil is of considerable significance since contamination of ground water supplies may present a health hazard. He also reported that a number of environmental factors may influence the travel rate, including soil moisture, temperature, rainfall, PH and the availability of organic matter.

According to UNEP in 1989 a peculiar feature of bacterial pollution is its local character, i.e. it does not spread far from the sources of pollution. It rarely exceed 0.05-1.0 km2, although it may be greater in karst areas only (up to 5-10 km2). Bacterial pollution of ground water is often temporary and affects mainly the ground waters close to the surface. All these features are due to the limited survival period of pathogenic bacteria in ground water.

According to Hofkes, et al; (1986) when assessing the possible health hazards of ground water sources, one should pay more attention to travel- time of the water through the ground water strata than to the distance the water has to flow to the point of withdrawal. The statement applies particularly in uniform subsoils such as sand and alluvium.

Many investigations showed that the contamination (of wells) from the pit latrines tends to travel down ward until it reaches the water table, then moves along with the ground water flow across a path which increases in width to a limited extent before gradual disappearance (Wagner and Laniox, 1959).

Bacteria will not penetrate to more than 1-2 in most unsaturate soils, but they can travel over 100 meters in gravel below the water table and in rock fissures (Carincross and feachem, 1983; WHO, 1975). Figure 4.2 illustrates the contamination of ground water through a pit latrine and its impacts on humans.

The United Nations in 1987 reported that, soil pollution by pathogens and parasites from human excreta may lead to crop and ground water contamination and direct infection of people and livestock with worms and disease carrying pathogens, as a result of; (a) poorly designed and or maintained latrines and (b) inappropriate latrine design for local soil and water table conditions.

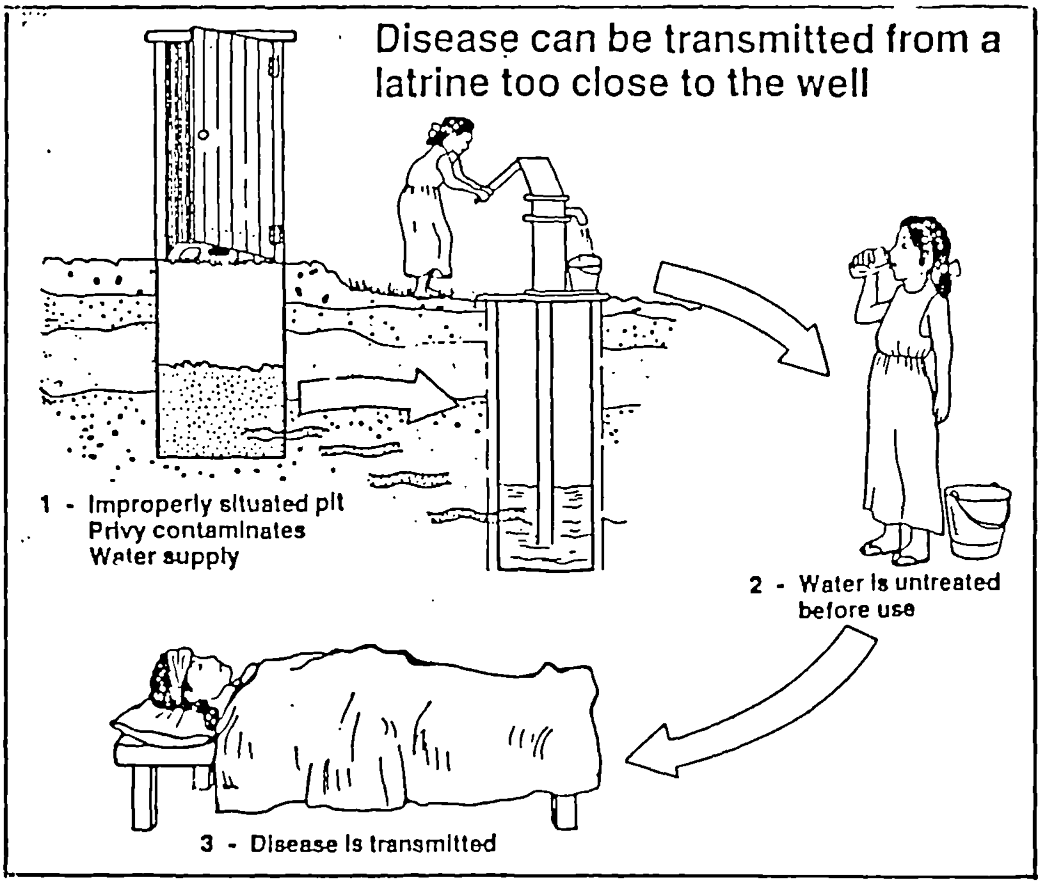



Figure 4.2: Bacterial pollution of ground water and its impact on Man. Source: taken and adapted from Braun(1990)

As can be seen from above figure, in rural areas where latrines are located uphill and very close to a water supply source such as a well there is a significant risk of transmission of bacteria to drinking water.

As a general rule, pit latrines should be built at least 15m from a well or other drinking water source and should not be located uphill from the water source. The danger of contamination may increase if the pit latrine is dug down to the water table or to fissured rock(Cairncross and Feachem,1983).

According to Johnson in 1966, the minimum distances from a well to possible sources of pollution should be great enough to provide reasonable assurance that subsurface flow or seepage of contamination water will not reach the well. Moreover, barn yards should be down slope from wells and the distance should be at least 15m away, depending on drainage conditions. Table 4.2 illustrates the distance types of sewage from wells.

Table 4.2: Distance types of sewage from wells

| Types of sewage | Distance |
|---|---|
| -Cesspool receiving raw sewage | 30 m |
| -Seepage pit, drain field or earth pit privy | 20 m |
| -Septic tank or sewer of tightly joined tile | 15 m |
| -Cast iron sewer with leaded or mechanical joints | 10 m |
| -Cast iron sewer, leaded joints and encased with 6 inches of concrete. | 1.5m |

Source: Taken and adapted from Johnson (1966)

## **4.5.4: Contamination and sanitary measures of wells**

### **(a): Hand dug wells**

Among the wells hand dug wells are very susceptible to pollution. In many rural areas of developing countries there are many open hand dug wells, many or all of which are liable to pollution. Thus according to Cairncross and Feachem (1978) and Watt and Wood in 1976 open wells can be polluted by any of the following means:

**1-** Seepage water from the surface

2- The vessels used from drawing water

3- Polluted ground water

4- Rubbish thrown down the well

5- Spilt water

6- Surface water(the surface water may be washed straight)

7- The corrosion of well casing and imperfectly sealed wells have also caused considerable pollution of ground water from industrial and domestic waste water especially high during periods of flooding.

**(b): Protection and sanitary measures of hand dug wells**

Johnson in 1966 reported that good well construction practices and regulations to protect the health of those using the water must be accompanied by applying reasonable sanitary measures that will prevent pollution of potable water supplies. Providing sanitary protection involves all the steps in well design and construction that are needed to guard against introducing contamination into the water as it is taken from well.

To-day, sanitary protection of wells is used widely in rural areas of most developing countries, so that from the point of view of the author of *this thesis, sanitation* measures are the best method to be used to mitigate the harmful and to increase the beneficial impacts of potable water supply on rural contamination.

Rajagopalan and Shiffman (1974) and Watt and Wood in 1976 and many others stated that to prevent open hand dug wells from the forms of pollution mentioned above the following protection and sanitary measures should be done:

1- **Well head:** An open hand dug well without a well head is always potentially dangerous. Properly designed well heads can completely prevent guinea worm transmission at a well and considerably reduce other health risks (see chapter 6). Hence, the head well should be raised sufficiently high above the ground surface to prevent anything from washing or flowing into the well mouth.

2- **Apron:** By constructing a concrete apron all round the well head to provide an impervious lining to a depth of 3m This apron should be drained and the drainage taken to a soakaway a safe distance away.

3- **Covering of well:** By covering the well with a water tight slab(with a manhole and cover).

4- **Installation of a pump**: Installation of a pumping unit (either mechanical or hand operated with the educator pipe properly sealed).

5- **Prevent from seepage:** The sides of well should be made water tight for three meters below ground level, so as to prevent seepage from the surface soil layers.

6- **Disinfection of well:** It is essential to disinfect wells completely immediately after construction or after any improvements are completed. If possible, continuous and effective disinfection should be arranged by a pot chlorinator. Figure 4.3

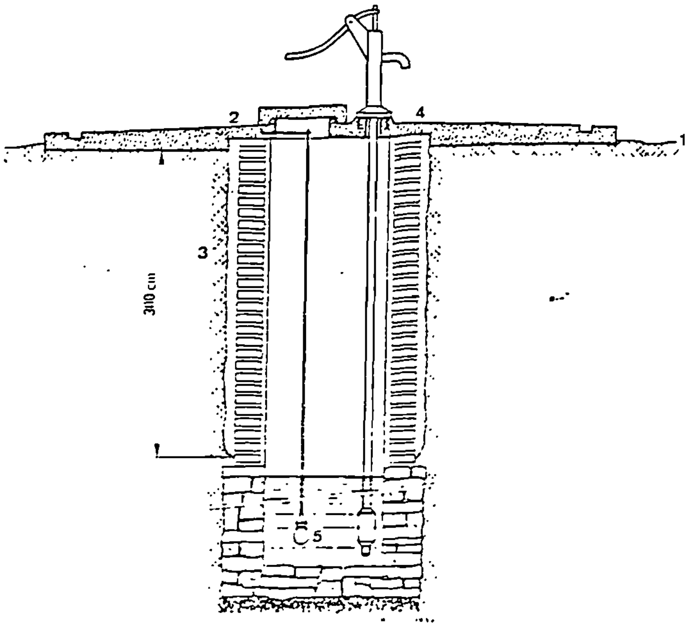


Figure 4.3 : Sanitary protection of hand dug wells

Source: Rajagopalan and Shiffman(1974)

**(c): Protection and sanitary measures of Driven tube wells:**

According to Wagner and Laniox (1959); Rajagopalan and Shiffman in 1974 the protection and sanitary measures from tube wells are as follows:

**1**- A water tight concrete platform with a drain all round should be provided. The area within 15 meters of a driven well should be kept free from pollution with liquid and solid wastes.

**2**- Plain tubing should extend to a depth of 3 meters, the performations being confined to the lower depths.

**3**- The pump should be in good repair and leaks should be prevented.

**4**- Disinfection of these wells due to the small diameter is not feasible. Frequent bacteriological checks of the water are, therefore, essential. Figure 4.4

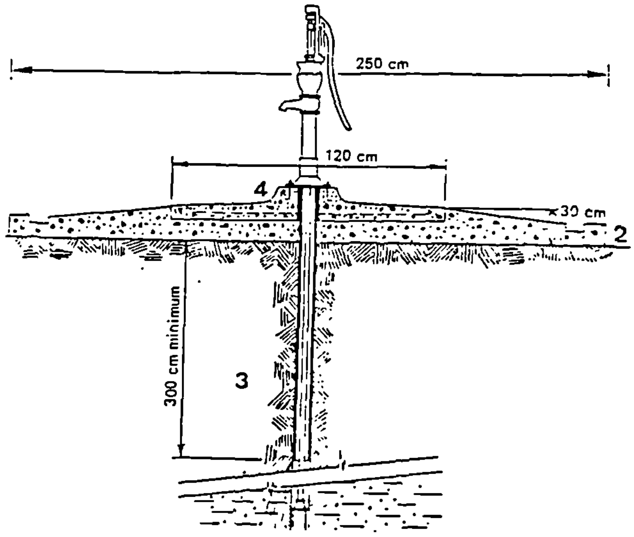



Figure 4.4: Sanitary Protection of tube wells

Source: Rajagopalan and Shiffman (1974)

**(d): Protection and sanitary measures of boreholes:**

Boreholes should normally be free from diseases producing agents, although contamination may occur through the pump parts or at the delivery points. Deep water bearing strata are less likely to be contaminated from sewage systems, barn yards, and outdoor privies, than are shallow wells (Cairncross and Feachem 1978; Wright,1956; Rajagopalan and Shiffman, 1974).

Occasionally, deep drilled wells contain considerable nitrate. The nitrate enters the well either by surface leakage through poor well seals or from nitrogen high deposits within lower soil zones (Loehr, 1984).

Boreholes as in the case of wells, can also be protected from contamination by a concrete slab, at least 2 meters across, used as a base for the pump, in order to prevent surface water from reaching the casing and running down along it to the ground water. Disinfection of these wells like tube wells is difficult due to them being deep and the small diameter of the pipe. But disinfection after improvement of the construction of well must be done( Wagner and Laniox, 1959).

**(e): Protection and sanitary measures of infiltration galleries**

All the general rules given above also apply to infiltration galleries. These structures should be located away from all possible sources of pollution. Diversion ditches should be built around the galleries in order to prevent surface water from running directly over them and entering without adequate natural filtration (Wagner and Laniox, 1959). The quality of open canal waters is not suitable for human drinking due to pollution by animals and villagers. Thus, water should be treated for drinking purposes (see chapter 5).

**(f): Protection and sanitary measures of springs**

Spring water may become contaminated if it stands in open pools or if it flows over the ground(Cairncross and Feachem, 1978). In most rural areas due to the lack of adequate health education, sanitation and maintenance, spring water may become contaminated and have deleterious impacts on the health of rural communities. Thus, Rajagopalan and Shiffman(1974); Hofkes,et al;(1986); and Ehler and Steel (1959); Cairncross and Feachem (1978) pointed out that spring water is more likely than any other source of water to be polluted and should be protected from surface water catchment, sewage disposal systems, animal manure fields or any other source of contamination. The sanitary and protection measures of springs are as follows:

1- To prevent surface water from running into the spring box, it is necessary that the top of the spring box should be at least 300mm above the ground.
2- A ditch should be dug on the up hill side of the spring to divert surface waters.
3- A fence should be made on the hill side to help to keep animals and people away.
4- New spring boxes and silt traps should be disinfected by scrubbing on the inside with bleach solution.

The protection of springs may have various effects including; the flow of a small spring may be reduced by the walling and pipe insertion so that waiting time is increased and use of the source diminishes. Furthermore, a successfully protected spring with good flow may attract a large number of users. The degree of contamination is decreased but the population exposed and the number of potential polluters may be increased(White, et al 1972).

Finally, the supply should then be piped to a distribution tank near the community and chlorination should be available in emergencies. Figure 3.3 (page 82) in chapter 3, shows protection and sanitary measures of springs.

## 4.6:Pollution and sanitary measures of surface water sources

### 4.6.1: Pollution of surface waters

As stated earlier in chapter 3 (page 107), surface waters largely originate from rainfall and, after reaching the ground surface, pick up considerable amounts of mineral compounds and organic matter in the form of debris of vegetable and animal origin, soil particles and micro-organisms. Surface run-off reaches streams, rivers and lakes where it is open to further pollution from human and animal life and plants(Hofkes,et al; 1986). All types of developments, agricultural, industrial, and domestic may create amounts of detritus and contaminated materials which then find their way to the channels draining an area (Bale and Smith, 1988).

Surface water sources such as rivers, lakes, streams, and ponds in rural areas may be polluted by both point and non-point sources. In 1981, Goudie reported that the causes and forms of surface water pollution which may arise from Man's activities are many and that the most important are as follows:

1- Infective agents; eg. bacteria
2- Sewage
3- Organic chemicals
4- Sediments (turbidity)
5- Other chemical and mineral substances
6- Heat (thermal pollution)
7- Radioactive substances

Many human activities can contribute to change the quality of water including; mining, irrigation, industry, agriculture, domestic waste disposal. Of these, the most important are:- agriculture, domestic waste and industry disposal.

## I: Pollution of surface waters by agricultural activities

As pointed out on page 135 of this chapter, agricultural waste is the major source of pollution in rural areas. According to Goudie in 1981 agriculture may be one, if not the most, important cause of contamination of surface water, either by the production of sediments or by the generation of chemically hazardous wastes. In the past, feedlots and other confined animal facilities have been located and designed without regard to soil, topography or hydrologic conditions. As a result the organic matters from these facilities directly entered surface waters and degraded the quality of water for the domestic purposes (FAO,1979).

Ayoade in 1988 reported that agricultural activities can contribute to surface water pollution in various ways. Where pastoral farming is practised, large quantities of animal waste are generated and may be washed into river systems. Animal wastes have received considerable attention in recent years because of the major trend toward large confined livestock and poultry operations. The runoff and solid organic matter from these operations is a source of nitrogen and phosphorus, which can contaminate surface waters (FAO, 1979).

According to Ayoade in 1988, in arable lands, farmers commonly employ pesticides and herbicides to control pests and disease and weeds respectively. Similarly, chemical fertilizers are used to improve soil fertility and crop yields. Surface runoff may carry higher amount of these hazardous chemical compounds from nearly arable lands to the rivers and lakes. These substance can also reduce the quality of drinking water for rural people and their animals by increasing concentrations of nitrates in surface waters (Canter, 1986).

Canter (1986) also pointed out that while pesticides usage aided increasing agricultural productivity, potential detrimental health and environmental impacts may occur. For instance; the destruction of non target organisms; the deposition of residues that magnify in food chains and eventually injure predatory animals including Man; and the direct health effects of pesticides on employers.

According to Goudie in 1981, much of the most adverse criticism of pesticides has been directed against the chlorinated hydrocarbon group of insecticides, which include DDT, dieldrin and others. These insecticides are very toxic and also highly persistent for a long time in environment. The deleterious and harmful impact of DDT on surface waters are illustrated in figure 4.5.

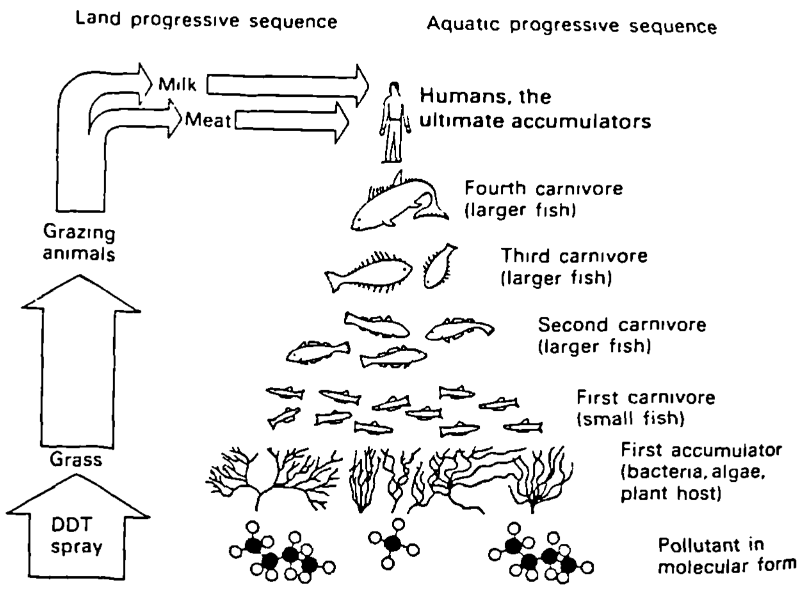



Figure 4.5: Impacts of DDT on aquatic environment

Source: Goudie (1981)

DDT, is still widely used in many developing countries.

For instance; the United Nations in 1990, reported that in Thailand, organochlorine residues were identified in 50.5 % of river and reservoir waters, 90.6 % of fish and shellfish and in 96.6 % of soil from agricultural fields. In Tanzania, pesticides, and in particular DDT, are sprayed directly onto water sources to control water borne insect vector. These water sources are used by small communities in rural areas (Lee and Bastemeyer, 1991). Nevertheless, the adverse effects of pesticides may be decreased by suitable training in the use of pesticides.

**II: Effects of over enrichment (eutrophication)**

Water pollution may cause the water to become rich in basic nutrients, such as ammonia, nitrogen, nitrates and nitrites. A process known as eutrophication (Southwick, 1972). It is also a naturally occurring process but it can be accelerated by the runoff of fertilizers from agricultural lands and by discharge of industrial effluent and domestic waste (Rast and Hoodland, 1988; Goudie, 1981). This process leads to excessive growth of algae followed in some cases by a serious depletion of dissolved oxygen as the algae decay after death (Goudie, 1981). In addition there are other, several adverse environmental impacts of over enrichment which have been reported by Rast and Hoodland (1988); Holdgate, et al; (1982) and Southwick in 1972. The most important of them are as follows:

1- Increase in plankton blooms which may produce undesirable odours and tastes in water and thus, may cause the degradation of water supply quality and ultimately increase the cost of water treatment processes.

**2**- Excessive algae and aquatic plant growths are highly visible and can detract significantly from the aesthetic quality of a water body. Moreover, recreational activities may be harmed. With dense quantities of algae in the lake, the transparency of the water is greatly reduced, and the water body can acquire an undesirable green colour.

**3**- Increase in the growth of aquatic plants which in turn may lead to the economic problems such as the impairment of fish, and shellfish production.

**4**- The growth of blanket weed in enriched streams, and on the shores of lake destroying flora is a major environmental problem.

**III: Impacts of domestic waste on surface waters**

Domestic waste water is a main source of bacterial pollution and in many watersheds it is a serious problem for the environment. Around many fresh water lakes public swimming areas may be unsuitable for use due to high bacterial pollution (Southwick, 1972).

Most bacterial pollution of surface waters is caused by the rural communities. The nature of these problems have been reported by many authors (Lee and Bastemeyer, 1991). Figure 4.6 shows the nature of contamination of stream water through user communities.

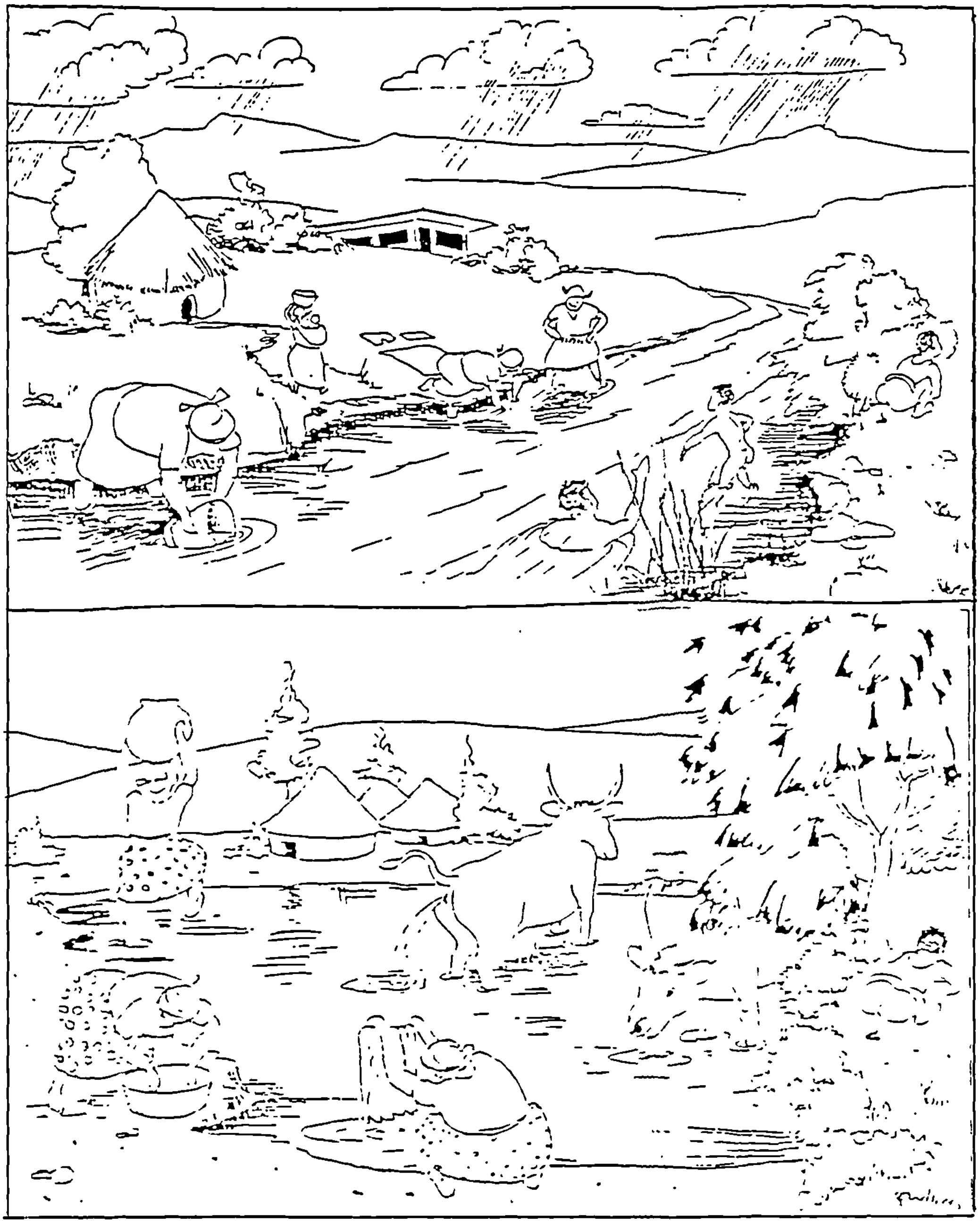


Figure 4.6 pollution of stream water by user communities

Source: Lee and Bastemeyer ( 1991)

As the above figure shows, villagers took baths and wash clothes next to water source, and animals were allowed to drink water freely. According to Myhrstad and Haldorsen (1984), in Kigoma Region, a study by the Norconsult Water

Master Plan team in 1979 and 1980 revealed that 98% of the surface water sources of the region were heavily polluted by faecal bacteria.

Braun in 1990 reported that there are several ways in which the human excreta may get into the surface waters. The first occurs when rural people defecate or urinate in the bush, the rains may then wash the excreta into streams or rivers. Moreover, Lee and Bastemeyer in 1991 reported that the faecal material may be transferred to the water source by rural people or animals. Animal grazing in water catchment areas are also a main cause of faecal and parasitic larvae being carried into the surface water sources. The second results from latrines which are located uphill and very close to a water sources such as a streams and rivers and village ponds.

According to Jannalagaddo,et al in 1989, domestic wastes are mainly responsible for the deficiency in dissolved oxygen of the receiving waters due to oxygen depletion as a result of decomposition of the organic load in the water. Hence, this leads to increased the BOD ( Biochemical Oxygen Demand) water and the degradation of water quality.

According to Diamant in 1978, apart from health hazards, domestic waste water also may cause sanitary nuisances. Sanitary nuisances are threats that affect

Man's senses for example, the development of very unpleasant odours from polluted waters.

**IV: Impacts of industrial wastes on surface waters**

The contamination of surface waters with industrial waste relates both to the number of industries in an area and the type of their activities. As Mashuri and Mayo in 1989 reported, industries can pollute the surface waters at a widespread level and some wastes are difficult to treat. In 1972 Southwick pointed out that the increasing use of powerful and toxic chemicals in industrial operations increases the risk of environmental damage through accident. Moreover, many industrial effluents produce serious chemical or biological pollution unless they are treated before release to environment (Furon, 1963).

Ayoade (1988); Marrack (1980); Southwick (1972) amongst others have reported on the adverse environmental impacts of industrial pollution on environment, the most important of which are as follows:

1- Changes of the chemical and physical characteristics of water, such as colour, odour and temperature.
2- As a result of heat pollution by industrial effluents, the dissolved oxygen level of water is reduced and less oxygen may have undesirable consequences on aquatic life.
3- Toxic chemicals such as cyanide and heavy metals like

Hg,Cu, Pb, Zn, which even in low concentrations have harmful impacts on plant, animal life and Man.

According to Marrack(1980); Mashuri and Mayo in 1989 the heavy metals (Mercury, Lead, Cadmium, Arsenic and Chromimum) are bound to be transported by the food chain to Man and can have harmful and possibly fatal impacts(see chapter 6,page 233). The Environmental Protection Agency in 1973 emphasized that, if an analysis of a water supply shows that these substances exceed the concentrations which are listed in Table 4.3, the water must not be used for drinking.

Table 4.3 Maximum concentrations of toxic substances

| Substances | Concentrations(ppm) |
|---|---|
| Arsenic (AS)........... | 0.05 |
| Barium (Ba)............ | 1.00 |
| Cadmium (Cd)........... | .01 |
| Chromium (Cr + 6)...... | .05 |
| Cyanides (CN).......... | .02 |
| Lead (Pb).............. | 0.05 |
| Selenium (Se).......... | 0.1 |
| Silver (Ag)........... | 0.5 |
| Mercury (HG).......... | 0.001 |

Source: Environmental protection Agency (1973)

**4.6.2: Protection and sanitary measures of surface waters**

According to the WHO in 1985, surface waters because of open accessibility may be easily contaminated by biological and chemical pollutants, so that, under most rural conditions, it is virtually impossible to protect them and to observe complete sanitary control over the entire watershed. However, the following sanitary measures at least should be considered:

1. The siting of the water supply intake is very important and should be up stream of or as far away as possible from sewage out falls and drainage runoff from agriculture.
2. The mouth of intake tubes should be not less than 30 cm below the water surface, to prevent the entry of any floating matter.
3. Water taken from surface water sources for drinking purpose should be treated before distribution to rural communities.
4. The bacterial examination of water should be done frequently based on any break down or changes made in time sanitary construction or protective measures related to the supply.
5. The treatment facilities should be inspected daily and the disinfection equipment should be checked to make sure, it is operating satisfactorily.

Besides above protection and sanitation measures, health education to rural people may increase awareness of them to environmental problems and protection and sanitation measures such as; preventing from open air defecation and regular use of sanitation facilities.

**4.7:Environmental impacts of improved water supply**

The provision of piped potable water supplies in rural areas causes the creation of waste water which may lead to contamination of the environment (Bradley, 1974). Particularly in areas which potable water supplies have not previously existed, steps must be taken to reduce these adverse impacts (Falkenmark, 1982).

In 1974, Bradley pointed out that in rural areas with single taps on limited flow devices a full sewerage system may be unnecessary but that problems can still arise in areas with a high water table or if water finds its way into pit latrines.

In many rural areas of developing countries due to financial problems and lack of expertise, sanitation projects may not be carried out simultaneously with water supply projects. Thus in 1977 White reported that the easiest disposal of sanitary waste water from taps is out of the door, and villagers may select this way. In humid areas this act causes water to stagnate in the village's land, creating dampness and so creating places for the breeding of mosquitoes (Falkenmark, 1982).

Perhaps the greatest potential danger is the possible increase in numbers of the **mosquito** Celux **pipens fatigans.** This mosquito, a vector of bancroftian filariasis, breeds preferentially in stagnant polluted water.

Consequently, the proper design, operation and maintenance of water supply and sanitation facilities is required to decrease the adverse impacts of these projects on environment.

**4.8: Pollution of rain water and sanitary measures**

The provision of potable water supply from rain water, can take two forms; (i) the use surface catchments and (ii) the use of cisterns. Both need protection from contamination.

In rural areas of the developing countries where the rural communities use rain water and rainfall is seasonal, it is advisable to let the water from roof run to waste for the first day or until the roofs have been well washed ( Okelly, 1982; Schiller,1982).

According to Cairncross and Feachem (1978) and Okelly (1982) the collection of rain water requires clean roofs, so that the roofs and gutters should be cleaned and supervised regularly. Dust, de d leaves and bird dropping may fall on roofs during dry periods and these will be washed off with the first new rains and will then pollute the water. Hofkes,et al in 1986 pointed out that bird dropping have been reported to cause health problems in users in Jamaica.

Galvanized iron tanks roofing which is extensively used in the tropics, provides an excellent and smooth surface for the collection of rain water for use in cisterns. To strain out suspended matter a sand filter may be built at the entrance to a cistern (Wagner and Laniox, 1959).

It should be realized, however, that cistern waters are subject to pollution. Hence, according to Ehler and Steel(1959); Schiller (1982) and many others the following protection and sanitary measures should be carried out:

1. The first portion of each rainfall, should not be collected until the roof or other collecting surface has become rinsed completely.
2. Cisterns should be sited on higher levels than the surrounding area and at least 30 meters away from cesspools, septic tank, privies, fields drain and other sources of contamination.
3. Proper facilities for raising water from cisterns such as pumping equipment should be considered.
4. Uncovered cisterns, or tanks , or manholes covers

which are not tight- fitting, should be well protected and covered from contamination.

5. Underground cisterns should be isolated because, any cracks in walls may permit to the entrance of shallow contaminated ground water to the cistern.
6. Cistern waters should always be boiled or disinfected by chlorine before using. (A chlorine pot may be employed to disinfect of cistern waters)
7. The quality of cistern waters should be checked frequently by bacteriological test.

In the case of ground catchment surfaces, protection and sanitary measures should be taken against erosion by the use of vegetation covering (Wagner and Laniox, 1959). For example; to mitigate to turbidity of the water, trees and shrubs surrounding the ground catchment area can also be planted to limit the entry of the wind blown materials and dust into the ground catchment region. It may be essential to provide fencing. An intercepting drainage ditch at the upper end of the catchment area, and a raised curb around the circumference may be needed to avoid the inflow of contaminated surface runoff (Hofkes, et al; 1986). Treatment of rain water with slow sand filter both in the case of individual and community use is essential.

**4.9: Summary:**

This chapter outlined various ways in which the pollution water sources occur and of mitigating method in rural areas of developing countries. The contamination of water sources concerns both the quality and the quantity of the water. Both these aspects determine the reliability of water sources. The vast majority of rural people in developing countries may be affected both locally and regionally as they largely depend on small water supply systems often without treatment facilities. Environmental factors affecting water sources are contamination by water users and pollution from on site sanitation. However, management of water sources, protection and sanitary measures, improved sanitation facilities and education of rural people associated with water source pollution and environmental problems can be used to reduce pollution.

# CHAPTER 5

# ENVIRONMENTAL IMPACT OF THE WATER TREATMENT PROCESS

## 5.1: Introduction

As mentioned in chapter 3, rural water supply should be designed around the need for safeguarding the quality of the natural water selected. Unfortunately, there is no such thing as a simple and reliable water treatment process suitable for small rural community water supplies, and it is better to select a water source which provides naturally potable water, and then to collect that water and protect it from contamination, since treatment will not be necessary.

Pickford in 1977 stated that when water is provided for low income people in rural areas there should be the minimum possible treatment, and the best supply is one which needs no treatment. Treatment should only be considered if it can be afforded and reliably operated.

The EIA side of this research falls into two main parts; (a) the actual water and sanitation and (b) the wider implications. In this chapter the author describes plans and problems of water treatment in developing countries, the appropriate treatment and disinfection techniques which can be used both for rural community and individual households, such as slow sand filtration and chlorination and boiling of water, with respect to environmental and socio-economic aspects.

**5.3: Plans and program of water treatment process**

The addition of any form of treatment process to a supply design in rural areas will add a major new cost factor and will increase the operation and maintenance problems, and the risks of failure, by an order of magnitude. This is especially true of a treatment process sophisticated enough to produce water which meets WHO quality standards (Pacey, 1977).

It should be the policy of the responsible control agency to restrict the use of water treatment under rural conditions to only those cases where such treatment is absolutely required and where proper plant operation and maintenance can be secured and supervised (Wagner and Laniox, 1959).

Eliassen in 1963 reported that treatment plants capable of working under unusual environmental *conditions* must be designed. Engineering judgement of the first order must be applied to work out standards with public authorities, so that the health objectives of water treatment can be met.

There is plenty of evidence of outbreaks of typhoid fever, cholera and epidemic jaundice because of break down of treatment ( Wagner and Laniox 1959).

According to Pickford (1977), in the plans and programmes of water treatment process in rural areas of developing countries the following factors should be taken into account:

**I. Field studies**: It is essential that plans for water supply should be based on full and correct information. The field study must ensure that plans for all but the simplest water treatment are based on a properly measured analysis of water quality (Physical, chemical and bacteriological).

**II. Simplicity**: In the design of water treatment, all schemes should be as simple as possible, even where semi-trained personnel and adequate supervision are available.

**III: Planning land use**: The implementation of water treatment processes such as the installation of storage tanks and slow sand filters requires adequate space. Land must be available, and the selection of the area for the plant is very important. It must be able to carry water and avoid contamination. Allowance should also be made for extensions in the future. Adequate space should be left for additional capacity and any structures, pipe work or valves should be planned, so that, they can be combined into a future larger project.

**IV. Labour and incentive** : Many people in rural areas of developing countries are not fully employed throughout the year and their activities are agricultural. Thus, this group of people is a valuable resource and can be utilized in the programmes and plans for water projects. Although technical skill is required, particularly in relation to treatment process, the most significant factor in the treatment of water is the education of users (Feachem, et al; 1977).

## 5.3: Priorities of choosing water treatment scheme

In accordance with the type of water source used and potential for contamination, different technical structures and treatment installation will be required (WHO, 1985).

Pacey in 1977 reported that there will be conditions when treatment is essential and in fact the designer of water supply is encountered with four possibilities:

1. To supply treated water
2. To supply water without treatment
3. To supply water without treatment apart from 48 hours storage within the water supply system.
4. To abandon the idea of a supply based on the proposed

source.

The criteria of "health and sanitary appropriateness" relevant to this choice have been illustrated by Feachem et al.(7) in 1977, and they are as follows:

**(I) Supply without treatment:**

**(a)** If the water is less contaminated than a specified limit (defined below) and if there is no schistosomiasis or guinea worm among the people.

**(b)** Or where water is more contaminated than the specified limit, only if a treatment plant can not be maintained or afforded, if there is no schistosomiasis in the community, if water borne infections are not prevalent, and if risks due to large numbers using the source of water are within specified limits.

**2. Supply without any treatment apart from 48 hours storage:**

When there is schistosomiasis in the rural people, but if conditions 1(a) or 1(b) are otherwise fulfilled.

**3. Supply with treatment:** If water is more contaminated than specified limit, and if a treatment plant can be afforded and maintained.

**4. Abandon the proposed water source and search for an alternative:**

If the water is more contaminated than the specified limit, if water borne diseases are prevalent, and risks are increased by large numbers of consumers, and if a treatment plant can not be afforded and maintained.

**5.4: Problems of water treatment in developing countries**

The design of water treatment plants for developing countries is very difficult due to the many constraints involved from their conception through to their operation.

Some of the commonest constraints to be considered in the planning of rural water treatment are set out by Arboleda in 1987. They are as follows:

1. lack of funds for the initial investment.
2. Inadequate availability of trained personnel for operation and maintenance.
3. Lack of facilities for the repair of treatment equipment.
4. Insufficient foreign exchange to import spare parts.

**5.5: Simple water treatment techniques**

In many rural areas in developing countries the quality of water is not satisfactory unless treated. According to Mann and Williamson (1973); Wright ( 1956);

Hofkes, et al; (1986); Feachem,et al; (1977); and Schiller and Droste (1982) the treatment of water for small communities can be considered in five parts such as; storage, coagulation and flocculation, aeration, filtration and disinfection.

**I: Storage:** Storage of water can be regarded as treatment and it has a significant role in the process of treatment. Besides providing additional protection against emergency demands it has more advantages than disadvantages ( Schiller *and Droste, 1982). Some of the desirable and* undesirable features of water storage and mitigation needs are summarized in Table 5.1

Table 5.1 Desirable and undesirable features of water storage

| Desirable features | Undesirable features | Mitigation needs | Direct impact |
|---|---|---|---|
| 1.Reduce the silt and turbidity of water<br>2.Die off bacteria during storage of water<br>3.Schistosomas cercaria is killed within 48 hours<br>4.Control of snails in the schistosomiasis life<br>5.Ironing out fluctuation in raw water quality, thereby making treatment easier and more effective | 1.Evaporation<br>2.Growth of algae and may encourage mosquito breeding<br>3.Surface pollution by the animals and birds | 1.By covering the storage<br>2.By using some chemical materials such as copper sulphate<br>3.Fencing around the storage | 1.Improved water quality<br>2.Better health |

In many rural areas the simple holding of water will be sufficient treatment to provide a reasonably safe supply. Instead of adding more treatment process facilities, the engineer should aim at achieving greater public heath benefit by using available funds to effect a wider distribution of reservoir water(Wagner and Laniox, 1959)

Although, the improvement in the quality of water that results from simple storage can not be easily predicted. But the amount of equipment and skill is small and the benefits are more and real.

**II. Coagulation and flocculation:** Coagulation is destabilization of colloidal particles and flocculation is agglomeration of the particles into particles that will settle rapidly. The operations needed to achieve these phenomena are not simple(Schiller and Droste, 1982).

Hofkes, et al; in 1986 reported that the substances that frequently need to be removed by coagulation and flocculation, are these that cause turbidity and colour. Surface waters in tropical countries often are turbid and contain, colouring material. Turbidity may result from soil erosion, algal growth or animal debris carried by surface water. Colour may be created by decomposed organic matter, leaves or soil such as peat.

According to Wagner and Laniox (1959) because the reduction of turbidity caused by colloidal matter may take considerable time, unless a chemical coagulant such as aluminium sulphate is used in specially designed sedimentation tanks to accelerate the settling process. The nature and characteristic of the suspended matter in the raw water are very significant and must be considered before using treatment.

Thus it can be seen that, water treatment process involving the use of chemicals are not so suitable for small rural community water supplies. Hence, a process such as slow sand filtration would reduce the colour and turbidity of water to acceptable level.

**III. Aeration processes and their impact on water quality**

The intention of aeration is that the water should be brought into maximum contact with the air so that, it becomes saturated with oxygen (Hofkes,et al: 1986).

In many rural areas, heavy concentration of iron and manganese in the ground water can give it an unpleasant taste, and give a brownish colour to clothes washed in it. Moreover, the oxides prevent people from using that water, so that aeration is used to add dissolved oxygen and so to remove them from the water (Cairncross and Feachem, 1978).

Schiller and Droste in 1982 and many others reported about the impacts of aeration on water. *Thus, the most* significant of them are as follows:

**(a)** Reducing the carbon dioxide content. Carbon dioxide removal may adversely affect the stability of water with respect to calcium carbonate deposition. Furthermore, excessive of carbon dioxide in water makes the water more corrosive, and it can be an adverse impact on iron on piping system (Merrill,1978; Lowenthal and Marais 1978).

**(b)** Dissolved oxygen concentration will increase.

**(c)** Hydrogen sulphide, methane and various volatile organic compounds responsible for taste and odour may be removed.

Many methods such as; cascades, gravity aeration, including apron and tray aerator systems may be used in the aeration of water (Schiller and Droste, 1982). Under rural conditions, however, it is normally uneconomical to provide pumping solely for the purpose of aeration. It might be possible, however, to combine the aeration process with pumping from the source to storage. Moreover, in a gravity system ample head may be available to provide for aeration.

**IV. Filtration techniques**: The term filtration is defined by Mann and Williamson in 1973, and is the process whereby water is purified by passing it through a porous material for instance a sand bed which will retain the suspended solids. Filtration is the most important treatment process. There are two types of sand filters: (a) rapid sand filters and (b) slow sand filters (Schiller and Droste, 1982).

**(a): Rapid sand filters**: Rapid sand filters are very mechanically and hydraulically complex and they are not usually suitable for small rural water supplies. Because they are complex and their functioning is complicated and they need a good technical knowledge and extensive training in the use of such equipment. They are,however, capable of treating highly turbid surface water (WHO, 1985; Mann and Williamson, 1973; Schiller and Droste, 1982)

**(b): Slow sand filtration as appropriate technology**

The major purpose of slow sand filters is the removal of pathogenic organisms from the raw water, especially viruses and bacteria liable to spread of water related diseases (Hofkes,et al; 1986).

Slow sand filters are highly efficient in removing harmful organisms, and may remove between 99% and 99.9% of bacteria (Pickford, 1977; Pacey, 1977). In addition, in the 1970 Mcjunkin reported that a well operated slow sand filter can remove all cercariae of schistosomiasis.

According to Hofkes,et al; in 1986 slow sand filters are also very effective in removing suspended matter from raw water. Their effectiveness depends very much on the style of operation and maintenance in rural areas (McCutcheon, 1989).

After a period in service, slow sand filters inevitably become clogged and must be cleaned; this is one of only two maintenance tasks, the other being to check and adjust the rate of water flow. Both these tasks are simple but must on no account be neglected (Pacey, 1977).

Huisman and Wood in 1974 pointed out that no other process can effect such an improvement in the physical, chemical and bacteriological quality of normal surface water. According to Wagner and Laniox (1959) slow sand filtration is an excellent method of water treatment process for rural areas.

Wegelin in 1987 reported that slow sand filters offer the great advantage of being safe and stable simple and reliable and can therefore be considered a most suitable water treatment technology in developing countries.

Finally, Pickford (1977) and Schiller and Droste in 1982 indicated that employing slow sand filters in rural areas in developing countries have some benefits and limitations. I have summarized these and their mitigation needs in Table 5.2.

Table 5.2 Desirable and undesirable features of slow sand filtration

| Desirable features | Undesirable features | Mitigation needs | Direct impact |
|---|---|---|---|
| 1. It removes all turbidity of water to less than 1 NTU.<br>2. Complete removal of the Cercariae of schistosoma<br>3. It can be operated without power<br>4. It produces very less sludge<br>5. It is useful for rural areas<br>6. It can be constructed by the local materials<br>7. Maintenance is very simple<br>8. No chemical materials are necessary<br>9. Iron and manganese largely can be removed | 1. In ~~the~~ higher turbidity of water it is not useful<br>2. During the cleaning of filters the land may be polluted by harmful micro organisms<br>3. It requires a large land area<br>4. It is not suitable for freezing climates | 1. Pretreatment may solve the problem of high turbidity of water | 1. Improve quality of water<br>2. Improve health |

With regard to the information in Table 5.2, it is concluded that, slow sand filters should be used wherever possible.

## 5.6: Disinfection techniques

As previously stated, the process of water treatment such as storage, sedimentation, coagulation and flocculation and slow sand filtration can reduce by varying degrees the bacterial content of water. But from the point of health view the quality of this water for drinking is still not good and it must be disinfected after filtration with a simple and economical disinfection system. Hence, as Pacey (1977); Pickford (1977) and Richard in 1987 emphasized that the final safe-guarding against water borne disease is disinfection.

The WHO in 1985 reported that the importance of the disinfection of water supplies in controlling microbial contamination can not be overemphasized.

According to Hofkes et al·(1986) disinfection of water provides for destruction or at least complete inactivation of deleterious micro-organisms present in the water. Many factors effect the disinfection of water since the most important of them are as follows:

1. The type and concentration of the disinfectant employed.
2. The time of contact.
3. The nature and number of the micro - organisms to be

destroyed.

4. The nature of the water to be disinfected, the higher the temperature the more rapid is the disinfection.

Richard in 1987 reported that if disinfection is to be effective, water must be clarified and filtered. The WHO in 1985 recommended that the turbidity of water after disinfection should be less than one NTU (NTU = nephelometric turbidity unit, a unit of turbidity).

**5.6.1: Types of disinfectants and their characteristics**

There are many disinfectants which may be used for disinfection of water. They are classified into two parts, (a) physical disinfectants and (b) chemical disinfectants.

The two principal physical disinfection methods are boiling of water, and radiation with ultraviolet light (Hofkes, et al., 1986). Light radiation is an effective disinfection method for clear water but it is rarely employed in developing countries, especially in rural areas, as it is difficult to maintain and expensive. Boiling is only used for households and is not a feasible method for whole communities.

Many chemical disinfectants such as; ozone, potassium permanganate, iodine and chlorine can be used for water disinfection. But Hofkes, et al. in 1986 pointed out that a good chemical disinfectant should possess the following significant characteristics:

1. Readily soluble in water concentrations required for the disinfection, and capable of providing a residual dose.
2. Fast and effective in killing pathogenic micro-organisms present in the water
3. Readily available at moderate cost
4. Not toxic to human and animal life
5. Not imparting taste, odour, or colour to water

Chlorine is the most effective and economical disinfectant which can be used in the rural areas of developing countries and fulfils most of the above requirements.

**5.6.2: Chlorination technology for rural water supply**

Technically, disinfection by chlorination can give a satisfactory solution for rural and small community water supply. Chlorine in one form or other is a common disinfectant. Its action is to destroy the enzymes essential for the existence of micro-organisms (Pickford, 1977).

The WHO in 1985 emphasised that a policy of proper disinfection of water supplies, normally using chlorine, can be used to minimize the risk of diseases resulting from water in the rural areas of developing countries.

According to Cairncross and Feachem(1978); Wagner and Laniox in 1959 the compounds of chlorine which can be used for disinfection of water are as follows:

1. **Bleaching powder** which is a mixture of calcium hydroxide, calcium chloride and calcium - hypochlorite. It has 20% - 35% available chlorine, it is easy to handle although it is bulky and comparatively unstable (Pickford, 1977; Gill, 1988)

2. **High Test Hypochlorite (HTH)** a granular material with higher available chlorine 70%, it is more stable than bleaching powder particularly in tropical countries, but it should also stored in a covered container in a cool dark place (WHO-IRCCWS, 1973).

3. **Sodium-Hypochlorite:** a solution of sodium hypochlorite usually contains 15 % available chlorine in the commercial product. Household solutions of sodium hypochlorite contain only 5% available chlorine.

Part of any chlorine applied is used by organic matter forming chloramine. Enough chlorine must therefore be applied for reaction with both organic matter and micro - organisms (the chlorine demand), and to leave a surplus to deal with further infection by pathogens. This surplus is called the "residual chlorine". The effectiveness of disinfectant potential is therefore expressed as residual chlorine after a certain contact time (Pickford, 1977).

The WHO in 1985 reported that, for rural water supplies with or without treatment the amount of 0.5 mg/L chlorine residual is recommended. Chlorine residual of 1 mg/L after 30 minute will kill schistosomiasis cercaria. Moreover, Carincross and Feachem ( 1978) and Pickford (1977) stated that the amount of 2 mg/L free chlorine residual after 30 minute can kill amoebic cysts. At these higher concentrations the taste of the water is unpleasant.

**5.6.3: Benefits and limitations of chlorine**

According to Rajagopalan and Shiffman (1974); Schiller and droste (1982); Pickford (1977) and the WHO in 1984, employing chlorine for disinfection of water in rural areas from the both community and individual household water supply point of view has beneficial effects on protection of health by removing of harmful micro-organisms in the water. Some of the most important benefits and limitations are listed in Table 5.3.

Table 5.3 Benefits and limitations of chlorine

| Benefits | Limitations |
|---|---|
| 1.It removes taste and colour.<br>2.It oxidize iron, manganze and hydrogen sulphide.<br>3.It has very strong germicidal ability.<br>4.It controls algae and slime.<br>5.It aids coagulation, because it is an oxidizing agent.<br>6.Easier availability.<br>7.Ease for handling and measurement.<br>8.Low cost.<br>9.It can be adapted to any scale of plant. | 1.Taste and odour effect on consumer in high concentration.<br>2.It should be stored because in the sunlight it loses its strength. |

## 5.7: Types of chlorinator and application

The simplest type of chlorinator for rural areas is a pot containing a mixture of coarse sand and bleaching powder, which is hung under water in a well or rainwater catchment container. Coconuts or glass jars may be used as containers and the chlorine sand mixture placed inside a plastic bag within the container (Schiller and droste, 1982; Cairncross and Feachem, 1978). Figure 5.1 shows three simple type of pot chlorinator.

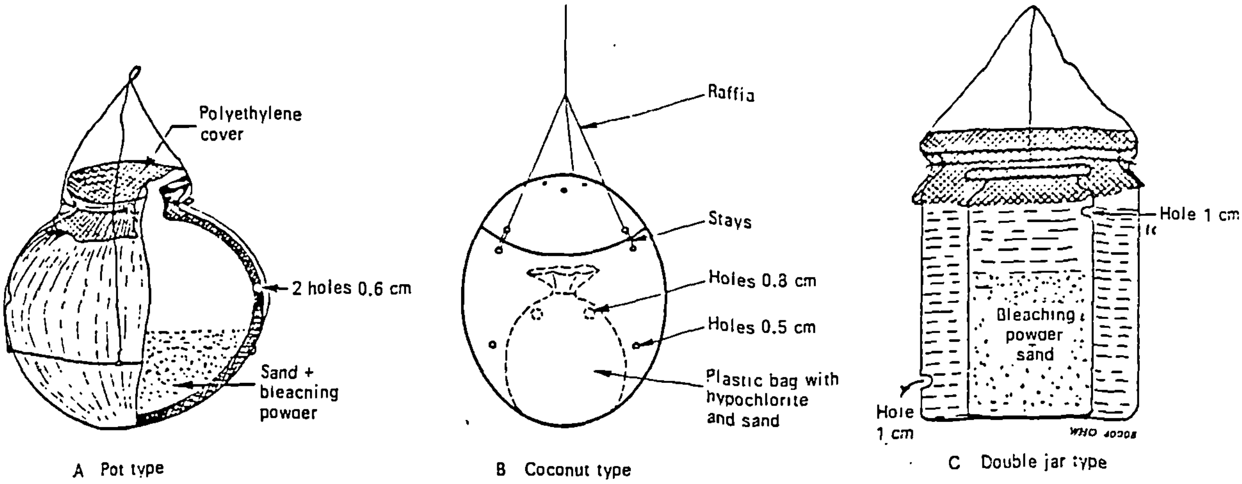



Figure 5.1 Simple chlorinator pots

Source: Rajagopalan and Shiffman (1974)

There are two types of pot chlorinator which may be used in rural areas. The single pot will serve up to 60 people if it holds 50% more bleach powder and sand, but it requires replenishing every two weeks. For wells serving large communities, more pots would be required (Cairncross and Feachem 1978).

The double pot is suitable for a well serving up 20 people and needs to be refilled with 1 kg of bleaching powder and 2 kg of coarse sand every 3 weeks (Hofkes et al. 1986; Cairncross and Feachem, 1978).

There are many other types of chlorinator such as; inverted bottle, floating bowl, siphon-feed and carboy hypochlorinator, all of which may be used in rural communities, and gas chlorinators which are not suitable for rural areas because the chlorinator requires careful maintenance and is very expensive (Rajagopalan and Shiffman, 1974).

Pacey in 1977 pointed out that all methods of chlorinator will fail if supplies of chemicals are not reliable, and if they are not stored properly. These are important constraints. The duties of plant attendants operating chlorinators are more exacting than for plain filtration.

## 5.8: Treatment of water on a domestic scale

In many rural areas of developing countries because of the spreading of villages and for economic reasons, it may not be feasible to provide potable water supply for all rural communities(Wagner and Linox, 1959).

Cairncross and Feachem in 1978 reported that the simplest and cheapest methods of purification of water on an individual or domestic scale is boiling, chemical disinfection and filtration. Some benefits and limitations of them are summarized in Table 5.4

Table 5.4 Benefits and limitations of domestic water treatment

| Method | Benefits | Limitations |
|---|---|---|
| 1. Boiling | -It can destroy all forms of harmful organisms including; bacteria, cysts, ova, and virus.<br><br>-Boiling is an effective method of disinfection in clear or cloudy water. | -Boiling alters the taste of water because it drives out dissolved gases, such as $CO_2$.<br><br>-It is expensive ( roughly one kg of wood is required to boil a litre) and the water takes a long time to cool to a suitable temperature for drinking.<br><br>-To be safe, water should be boiled violently for at least 20 minutes. |
| 2.Household sand filter | -Easy to build<br>-It can remove the cysts, ova, larvae, schistosoma and other larger organisms as well as silt.<br>-It can be made of local materials such as a drum and sand. | - It requires maintenance and regularly cleaning. |
| 3. Chemical disinfec-tions such as:<br>(a) Iodine compounds | -They have been made into tablets which are effective against amoeba cysts, cercariae, leptospira and some viruses as well. | -They are not suitable disinfection for water which is cloudy, or muddy, or water having considerable colour.<br><br>-Turbid water should be filtered.<br><br>-The higher dosage produces a medicinal taste. |

Table 5.4..Continued benefits and limitations

| Method | Benefits | Limitations |
|---|---|---|
| (b) Potassium permanganate | - It is a powerful oxidizing agent.<br>- It may be effective against the cholera vibrio. | - It produce a dark brown precipitate in the water.<br>- It is not satisfactory disinfectant. |
| (c) Chlorine | - Chlorine as tablets can be used to treat individual drinking water.<br>- Chlorine is easiest to apply in the form of solution as 0.01 available chlorine.<br>- More benefits have been explained on the page. | - It may give rise to a chlorine taste to water in the higher concentrations. |

As can be seen from the above Table, the benefits of chlorine disinfectant on the scale of household treatment of water are greater than for other methods.

**5.9: Comparison of treatment techniques**

The information which has been stated in water treatment processes, is compared in Table 5.5.

Table 5.5 Comparison of treatment techniques

| Process | Action | Operation cost | Operation and Maintenance | Construction cost |
|---|---|---|---|---|
| -Storage tank | Reduction of bacteria and turbidity. | Low | Low | High |
| -Aeration | Removing of Iron, Manganese, taste and odour. | Low | Low | High |
| -Slow sand filtration | Reduction of bacteria and turbidity. | Relatively Low | Medium | High |
| -Chlorination | Reduction of bacteria. Protection of health. | Relatively Low | High | Low |

Source: Wagner and Laniox ( 1959)

As can be seen from Table 5.5 the storage tank in comparison with others can be the most economical method of obtaining a satisfactory rural potable water supply but from the construction cost point of view it is expensive. Moreover, if reduction of bacteria is the only requirement, ~~since~~ simple chlorination should be the cheapest technique, but it requires more care and maintenance from the operation point of view.

## 5.10: Comparison of the impacts of water treatment techniques in removing of impurities of water

As mentioned earlier of this chapter the main aim of treatment is the removal of the overall impurities of raw water and obtaining the best quality of water. The impacts of water treatment processes on impurities of water especially surface waters in rural areas are shown in Table 5.6.

Table 5.6 Comparison of the effects of water treatment process

| Treatment techniques / Water quality parameters | Sedimentation | Aeration | Slow sand filtration | Rapid sand Filtration | Coagulation& Flocculation | Disinfection |
|---|---|---|---|---|---|---|
| 1.Carbon dioxide removal | o | - | ++ | + | o | + |
| 2.Dissolved oxygen | o | + | - - | - | o | + |
| 3.reduction of turbidity | + | o | ++++ | +++ | ++ | + |
| 4.Taste and odour removal | + | + + | + + | + + | + | + |
| 5.Bacterial removal | + + | o | ++++ | + + | + | ++ ++ |
| 6.Removing of Iron and Manganese | + | + + | ++++ | ++++ | + | o |
| 7.Colour reduction | + | o | + + | + | + + | + + |
| 8.Removing of organic matter | + + | + | +++++ | +++ | + | + + + |
| Total | 8+ | 5+ | 21+ | 15+ | 9+ | 13+ |

Source: Taken and adapted from: Hofkes,et al;(1986)

Key:

Increasing positive impact + + + +

Negative Impact -

No Impact o

As can be seen from the Table 5.6, slow sand filtration with 21 positive (+) impacts has the best potential impact in removing impurities in water in comparison with other processes. Finally, chlorination processes with 13 positive impacts(+) in the second stage of removing impurities of water after slow sand filtration, is very significant process.

## 5.11: Impacts of water treatment

The implementation of water treatment projects in rural areas of developing countries may have both beneficial and deleterious impacts on the environment, social behaviour and health. They are as follows:

### 1. Environmental Impacts:

The significant environmental impacts associated with water treatment techniques such as storage tank and slow sand filtration on environment including;

(a) Direct impact on land

(b) Destruction of flora and fauna

(c) Adverse impacts stemming from the transportation of equipment and materials to villages possibly air pollution from dust and road traffic.

(d) A further negative impact on land may be the transmission of the organisms through slow sand filter during washing and changing the sands.

**II. Health and socio economic Impacts**

Treated water, has beneficial direct impact on health and indirect effects on economic status of rural people. The importance of water treatment can well be considered in terms of economics-the improvement of health to make the individuals more productive and thus to enhance the economy of their family and village.

The significant health and socio economic impacts of safe potable treated water will be dealt with in the next chapter.

# CHAPTER 6

# HEALTH, SOCIAL AND ECONOMIC IMPACT OF POTABLE WATER SUPPLY AND SANITATION PROJECTS

## 6.1: General Introduction

In the previous chapters, on the EIA of water supply techniques, approaches to the contamination of water sources and adverse impacts of them on the natural environment were discussed. In this chapter, the implications of potable water supplies and sanitation projects on the health and socio-economic status of rural peoples is discussed.

An improvement in potable water supplies and sanitation in rural areas of developing countries may generate interrelated improvements in health, economic and social welfare. Many possible beneficial and adverse impacts may arise from these improvements. In this chapter the various aspects of potable water supplies and sanitation will be considered in their main parts.

1. The provision of potable water supply and sanitation facilities leading to reduce of water and excreta related diseases (health effects) and so, indirectly

to improved productivity.

2. The possible beneficial and adverse impacts of improved water supply on rural population (social effects).
3. Directly derived economic benefits that results from water provision.

## 6.2:HEALTH EFFECTS

### 6.2.1: Introduction

Firstly, in this section, a brief description of water related disease and their classification will be given together with descriptions of the ways in which water supply and sanitation projects reduce such diseases. Secondly, direct and indirect impacts of investment in water supply and sanitation project on health, quantity of water used, and the effects of chemical quality of water on health will be discussed.

### 6.2.2: Water-related diseases and their link with Man

Since creation, Man has recognized his need for water in sustaining his life. Also, from a very early time in history, Man has noted that his water supply use, is in some manner, associated with the quality of his health and so of his life. An early example was King Hezekiah who in about 730 B.C., improved the public water supply of

Jerusalem by damming mountain stream and bringing water into the City through a conduit. Also, in the sixth century B.C., Cyrus, the Persian, took boiled water in silver flagons on his military journey (Taylor, et al; 1967).

Not until modern times, however, did Mankind find the direct link between water supply and disease. Snow (1855) was the first to show a precise relation of disease to water in his well known studies of the London epidemic of Asiatic cholera which was caused by drinking contaminated water from the Broad Street pump. In the years that followed, scientists and physicians found that not only cholera but also typhoid fever, dysentery and other enteric diseases were spread mainly by contamination of water supplies (Taylor et al· 1967).

Water related disease affecting Man's health are widespread in rural regions of developing countries. The incidence of water related diseases depends on many factors such as local climate, geography, culture, sanitary habits and facilities, and very importantly on the quality and quantity of the local water supply, and waste disposal system (Saunders and Wardford, 1976). Most of the epidemics of water related disease are associated with unforeseen pollution of safe supplies (Awad EL Karim, et al, 1985).

**6.2.3: Classification of water and excreta related diseases**

In order to promote an understanding of the likely impact of alternative forms of water investment it is useful to distinguish between forms of water related diseases (Carruthers, 1973).

White et al;(1972); Bradley (1971); Saunders and Wardford (1976); Feachem (1977); Cairncross, et al; (1980); Carruthers and Browne (1977) and many others have reported on water related diseases.

In recent years a conceptual system for understanding diseases related to water has been developed and is now fairly widely employed(Carincross and Feachem,1983). More recently a similar conceptual system for diseases associated with excreta has been proposed(Falkenmark,1982).

The diseases caused by or related to water and excreta can be either non-infectious such as fluorosis, from high fluoride levels, or infectious such as cholera and malaria, which depend on disease causing organisms(pathogens). The great part of water-related diseases in developing countries are infective diseases (McCutcheon,1988).

The water and excreta related infections are characterized by four different water related and one excreta related mechanism of transmission. These are shown in Table 6.1 and are related there to the environmental strategies for disease control which are suitable to each mechanism ( Cairncross and Feachem, 1983).

The WHO in 1986 classified some of the important diseases related to water supply and sanitation and the interventions need for the control. These diseases are shown in Table 6.2. The mix of interventions and their emphasis vary considerably; for instance for some disease, satisfactory excreta disposal is more important than a protected water supply.

Table 6.1 Classification of water and excreta related infections.

| Category | Example | Preventive method |
|---|---|---|
| **1. Water - borne:**<br>(a) classical<br>(b) non classical | cholera and typhoid.<br>Infective hepatitis. | - Improve quality of water.<br>- Prevent casual use of other unimproved sources. |
| **2. Water - washed:**<br>(a) Superficial<br>(b) Intestinal | Trachoma, Scabies<br>Bacillary, dysentery | - Increased water quantity used.<br>" " " " " " " " " "<br>- Improve accessibility and reliability of domestic water.<br>- Improve hygiene. |
| **3. Water - based:**<br>(a) Penetrating skin<br>(b) Ingested | Schistosomi -asis<br>Guinea worm | - Water access and excreta disposal.<br>- Control snail population and protection of users.<br>- Water access, water quality and protection of water sources. |
| **4.Water - related insect vector:**<br>(a) Water biting<br>(b) Water breeding | Gambian sleeping sickness.<br>Onchocercia -sis | - Water piped from source.<br>- Improve surface water management.<br>- Destroy breeding site.<br>- Decrease need to visit breeding site. |
| **5.Soiled- Based:** The excreta organism is spread throughout the soil | Hookworm | Excreta disposal |

Source: Taken and adapted from : White et al. (1972); Bradley, (1974); Cairncross and Feachem (1983).

Table 6.2: Diseases related to water supply and sanitation interventions for control of diseases.

| Disease | Water quality | Water quantity | Personal hygiene | Waste water disposal/ drainage | Excreta disposal |
|---|---|---|---|---|---|
| **Diarrhoea** | | | | | |
| (a) Viral | .. | ... | ... | x | .. |
| (b) Bacterial | ... | ... | ... | x | .. |
| (c) Protozoal | . | ... | ... | x | .. |
| **Poliomyelitis and hepatitis A** | . | ... | ... | x | .. |
| **Worm infections** | | | | | |
| (a) Ascaris | . | . | . | . | ... |
| (b) Hookworm | . | . | . | x | ... |
| (c) Pinworm, dwarf-tapeworms | x | ... | ... | x | .. |
| (d) Schistosomiasis | . | . | x | . | ... |
| (e) Guineaworm | ... | x | x | x | x |
| (f) Other worms* with aquatic hosts | x | x | x | x | .. |
| **Skin infections** | x | ... | ... | x | x |
| **Eye infections** | . | ... | ... | . | . |
| **Insect - transmitted** | | | | | |
| (a) Malaria | x | x | x | . | x |
| (b) Urban yellow fever, dengue | x | x | .* | .. | x |
| (c) Bancroftian filariasis | x | x | x | ... | ... |
| (d) Onchocerciasis | x | x | x | x | x |

Source: WHO (1986) * Vector breeds in water storage containers

Degree of importance of intervention

Key: ... High .. Medium . Low **x** Negligible

As can be seen from Tables 6.1 and 6.2, the role of water quality and quantity, safe excreta disposal and improved hygiene is very important. Thus they have positive beneficial impact on the reduction of the incidence of disease in the rural areas of developing countries. Because of this importance, the author will be dealing with them in the following section.

### 6.2.4: Impacts of the improved potable water supply and sanitation facilities on diseases

In many rural areas of developing countries due to the lack of sanitation and potable water supply, infectious water related diseases occur in many villages (Carincross, et al; 1980).

Poor environmental conditions arising from unhygienic disposal of excreta and sullage and an accumulation of solid waste can also be a significant in the transmission of disease. They lead to the contamination of water supplies both at source and also in the home via food. They may also encourage the breeding of vermin and insects, further increasing the spread of disease (McCutcheon, 1988).

As table 6.1 and 6.2 show, both water - borne and water - based disease depend on faecal access to domestic water sources. Hence, it is not possible to separate water related diseases completely from those affected by sanitation (Bradley, 1974).

Both potable water supply as well as safe disposal of human excreta in rural areas are needed to break the chain of transmission diseases (Carincross, 1988; Bradley, 1977).

Changes in water supply may affect different groups of disease in different ways; one group may depend on changes in water quality, another on water quantity and availability and another on indirect effects of standing water which is related to sanitation( Saunders and Wardford, 1976). The impacts of the potable water supply and sanitation on the types of water related diseases include:-

**Group 1: Water borne-diseases**

Water - borne disease are transmitted by water, which acts as a passive vehicle for the infecting agents such as bacteria, viruses and protozoa (Aqua, 1980; Warner, 1973, Saunders and Wardford, 1976).

The public health engineer is most concerned with this category diseases since the *incidence of such diseases has* been shown to be affected by water quality. As can be seen from Table 6.1 cholera and typhoid are two common example and these are contained in group 1(a); the main consideration being that water should be free of the pathogenic organisms causing the disease. Other diseases in this group, such as paratyphoid, amoebic dysentery, infectious hepatitis and gastroenteritis have been shown to be water borne on occasions, but either the relationships are not clear,(e.g.infectious hepatitis ) or the infective dose is so much greater(e.g. paratyphoid), that White et al; in 1972 have classified these diseases as "non-classical" water borne, belonging to group 1 (b).

Taylor,et al;(1967) stated *that virus infections are* often said to bé related to drinking water, but only in the case of infectious hepatitis is the evidence conclusive. It would appear that non-classical diseases may also be caused in other ways. Saunders and Wardford in 1976 pointed out that all of these diseases depend also on poor sanitation.

Studies conducted by Azurin and Alvero (1974) in the Philippines revealed that the provision of sanitary facilities alone reduced the incidence of cholera by as much as 68% while the provision of safe water led to a reduction of 73%. Where both a safe water supply and toilets were provided a 76% reduction was observed. Moreover, Degoma, et al; in 1980 in Bangladesh found that, better water quality did not significantly reduce morbidity and mortality rates attributed to cholera. They also positively correlated education of the inhabitants and the quantity of water available to them to reduce in cholera and dysentery levels.

**Group 2 : Water - related Diseases**

Lack of water and poor personal hygiene create conditions favourable for the spread of water - related diseases (Saunders and Wardford, 1976; Aqua, 1980). Thus, increasing the quantity and availability of water and improving personal hygiene leads to a decrease of the severity or incidence of these groups of diseases. As Table 6.1 shows, skin or superficial infections are classified II(a) and the intestinal disease as II(b).

Diarrhoea infections including gastero enteritis, are of enormous importance in the tropics as a cause of serious morbidity and mortality particularly amongst infants ( Feachem, 1977; White et al· 1972 ). It was estimated in 1964, that diarrhoea diseases caused over 5 million death among infants under one year old (Taylor, et al; 1967).

The adverse impacts of diarrhoea on children leads to significant economic loss in the family and country because they have to be looked after by their mothers and require treatment (Esrey, 1990).

The WHO in 1986 estimated that improvement in water supply and sanitation could result in a 25 % reduction in the morbidity of diarrhoea disease. Table 6.3 shows the major potential impact of improvements in water supply and sanitation on the reduction in morbidity of water related diseases.

Table 6.3: Potential impact of improvements in water supply and sanitation

| Diseases | Estimated% reduction in morbidity |
|---|---|
| Cholera, typhoid, guinea-worm leptospirosis, scabies. | 80 - 100 |
| Trachoma, conjunctivitis, yaws, schistosomiasis. | 60 - 70 |
| Tularmia, paratyphoid, bacillary dysentery, amoebic dysentery, gastroenteritis, louse- borne diseases, diarrhoea diseases, ascariasis, skin infections. | 40 - 50 |

Source: WHO ( 1986)

Although 67 studies from 28 developing countries have shown the improvements in water supply and excreta disposal reduce both the mortality and morbidity from diarrhoea, the impact is far from universal and varies considerably (WHO, 1986).

White et al;(1972); Feachem,(1973); Saunders and Wardford (1976) and WHO (1986) have all reviewed a number of investigations which have shown that the improvements in water availability with the volume of water used and sanitation have a greater impact than improvements in water quality on diarrhoea disease.

The second type of water-washed infection is the infections of the skin and eyes. These infections are rarely, fatal, but they are extremely common and account for one third of admissions for water related disease to hospitals in East Africa, and two thirds of out-patients (White et al: 1972). These diseases, may make many people miserable. For example, 70% of pre-school children in Ankole, Uganda have either skin ulcers infected by bacteria or scabies due to a small mite that burrows in the skin (Bradley, 1977). Related to these are the eye infections, particularly trachoma, which are common in many rural areas of tropical countries and may cause much disability and blindness (Feachem, 1977; White et al· 1972). It appears that, these infections are clearly related to poor hygiene and that increasing the volume of water used for personal hygiene has significant positive effects on reducing these diseases.

**Group III. Water-based infections**

Water-based infections are related to aquatic animals that are a necessary part of the life cycle of infecting agents. Some of these are able to penetrate the skin e.g. when water is used for washing of clothes. For other infections the water has to be swallowed e.g. when swimming in a river (Aqua, 1980).

Table 6.1 shows, schistosomiasis (bilharzia), as an example of type III (b), which affects more than 200 million people in tropical and subtropical of the world ( Barrett, 1972; Biswas 1980; Witt,1982). Furthermore, it occurs in almost every country in Africa and has become a main problem around most Man-made lakes, and in irrigation projects (Cairncross and Feachem, 1983). For instance, Milligan and Thomas in 1986 pointed out that dam and irrigation schemes may create ideal conditions for the transmission of schistosomiasis by snails.

Most of the studies which have been carried out in relation to schistosomiasis have suggested that the presence of water supplies can be instrumental in increasing the risk of infection due to the pollution of water sources by infected children in rural areas ( Carruthers, 1973 ).

The provision of protected potable water supply may thus, be a first step in restricting this disease in rural areas. If this is combined with an effective environmental sanitation programme and with education of the rural people and protected recreational facilities, for instance; for rowing, some progress can be anticipated(Carruthers, 1973; WHO, 1982).

In 1983 Tebbutt reported that transmission pattern of schistosomiasis is relatively complex in comparison of water borne diseases. Because, the infection of Man cannot occur by immediate drinking polluted water. The causative organism of schistosomiasis spend part of its life-cycle in water or in the intermediate host in water or in the intermediate host which live in water contaminated by excreta. Figure 6.1 shows the infection life cycle of schistosomiasis.

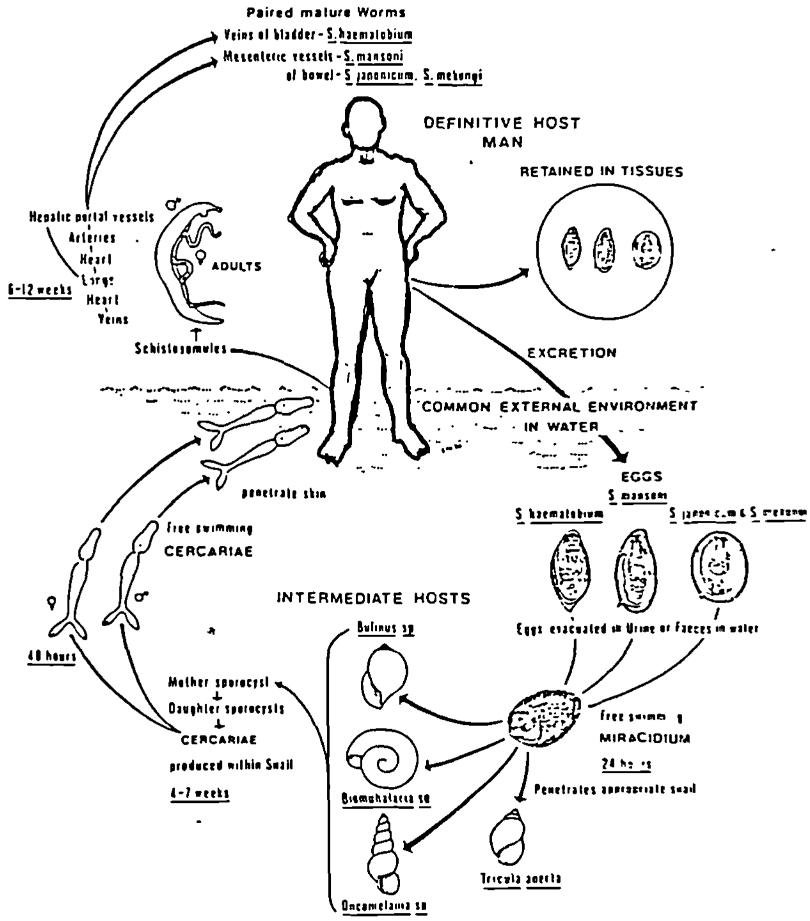



Figure 6.1: The infection Life cycle of Schistosomiasis

Source: Edwards (1992)

As can be seen from the figure 6.1, the eggs of schistosomiasis may be excreted by an infected person, break open on reaching water, releasing a tiny parasite (miracidium) which swims in search of its next host a fresh water snail in which it can develop further. Inside the snail, the parasite divides into thousands of new forms (cercaria) which re- enter the water, this time in search of a human host. It penetrates the skin, sometimes causing slight itching, and presently becomes an adult worm.

According to Edwards in 1992, exposure may take place while rural people who are playing, bathing, washing, collecting water, working in flooded fields or fishing.

The transmission cycle can also be interrupted and can be controlled through the adequate disposal of human excreta (Witt, 1982). It would appear that, improving water supplies will not produce dramatic health improvement unless it can be made certain that only improved supplies will be employed for all water activities in rural areas e.g. washing clothes, bathing and washing utensils. Several studies in southern Africa have given good evidence of health benefits from such improvements(Bradley, 1974).

In rural areas where schistosomiasis exist it is important to prevent cercariae from snails entering the water supply system. This may be affected by the careful design of storage tanks and water treatment facilities ( Carruthers, 1973).

Guinea worm is another water based diseases which is widespread in the tropics. For instance; It occurs in North West Africa, in the Middle East and in the arid savannah zone of Africa (White et al, 1972).

Bradley in 1977 found that the prevalence of this disease in affected villages may exceed 70% and, according to White et al; 1972, its economic impacts are very great. Because, the majority of infected people may lose their capacity to work.

As pointed out in chapter three (on pages 84-86) shallow wells, step wells, water holes, and unprotected domestic public water supply in rural areas can have a significant role in the transmission of Guinea worm. In this case the intermediate hosts are cyclops species. Cyclops are a small crustacean, and human infection occurs following the ingestion of water containing infected cyclops (Tebbutt, 1983).

According to Cairncross and Feachem in 1983, the larvae of which escape from infected Man through blisters on the legs and develop in small aquatic crustacea. Man is re-infected by drinking water containing these crustacea. Figure 6.2.

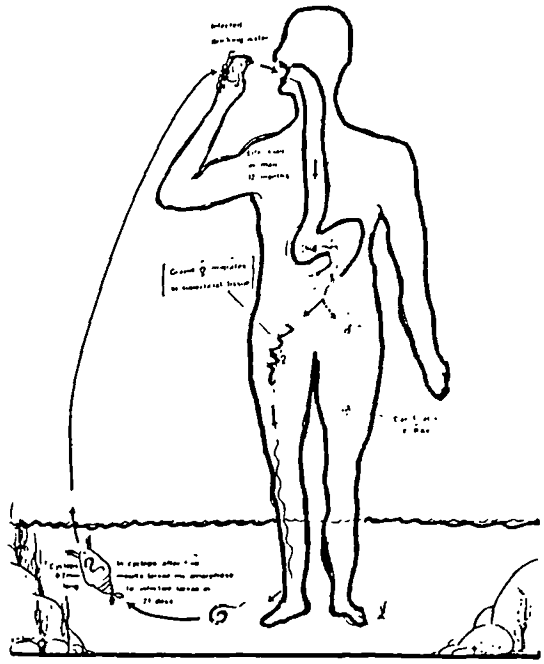


Fig 6.2: The life cycle of Guinea worm

Source: Cairncross and Feachem (1983)

The improvement and protection of water sources such as wells, ponds and springs can have positive impacts on the prevention of disease (White, et al; 1972; Tebbutt, 1983).

## Group IV: Insect vector diseases

As Tables 6.1 shows, the fourth mechanism is water-related insect vectors. These vectors can cause diseases. The insects feed or breed next to water. The first group of disease is trypanosomiasis (gambian sleeping sickness) is transmitted by the riverine tsetse fly which bites near water and it is widespread in Africa (Feachem, 1990; Cairncross and Feachem, 1983).

The second type of insect vector diseases may spread by insects which breed in water include malaria, onchocerciasis (river blindness), yellow fever, and dengue. The significant feature in the transmission of these diseases is the physical environment of the water sources (Farrar, 1974).

Irrigation or the provision of water without adequate drainage may lead to the creation of breeding places for mosquitoes and other infected vectors of diseases. In such cases water development projects may even make adverse impacts on health (Carruthers, 1973). The WHO in 1964 pointed out that in the humid zones, land reclamation can improve health by eliminating breeding places for mosquitoes.

Open tanks constructed for cattle and people in semi-arid areas may be a source of malaria mosquitoes, the perennial water supply may ensure continuity of the insects through the dry season (Carruthers, 1973). Adequate potable water supplies may remove people from the biting areas and that the construction of covered canals for the disposal of waste water in rural areas has a positive beneficial impact on the destruction of mosquito breeding sites.

**Group V: Excreta related disease**

As can be seen from Table 6.1, a group of diseases is related to excreta. Worm infections in rural areas of developing countries is high. An excreta-related infection is one related to human excreta (urine and faeces). According to Falkenmark (1982) there are two different transmission mechanisms; (a) transmission via infected excreta and (b) transmission by an excreta -related invertebrate vector.

These infections are one extreme of a spectrum of diseases, mostly water washed together with a group of water-based type infections most likely to be acquired only by eating uncooked fish or other large aquatic organisms (Saunders and Wardford, 1976).

There are a few infections, of which the human hookworm is most important, where sanitation is much more important than water because transmission is from faeces to soil and by direct penetration back through the human skin (Bradley, 1977).

The use of sanitary latrines is one of the important ways of preventing the spread of worms in rural areas ( Aziz; et al; 1990). Moreover, improvement in sanitation facilities, safe disposal of excreta, personal hygiene and village cleanliness, undertaken to prevent and control excreta-related diseases, are dependent on the availability of good water (Saunders and Wardford, 1976).

Health benefits will not follow from the construction of sanitation latrines unless education is also given to their proper use, regular cleaning, and effective maintenance (Pacey, 1978).

## 6.2.5: Direct and Indirect Impacts of investment in the Provision of Potable Water Supply and Sanitation on Health

As indicated earlier, the provision of an adequate, safe water supply and sanitation has positive impacts on the health of users by greatly reducing the incidence of communicable enteric related diseases. According to Taylor et al; (1967) the reduction of the incidence of these diseases results in reduced mortality rates, especially among infants; and life expectancy also rises. They also pointed out that, where the expectancy of long life is greatest, lower rates of population growth may occur.

Shuval et al· in 1981 reported that the results of analysis collected data from 65 developing countries showed that at the same level of socio-economic development, countries with high water supply coverage had higher life expectancy, thus pointing to the contribution of socio-economic aspects to the health benefits of potable water and sanitation.

Several other factors such as; improved local economies, nutrition and education have been pointed out by many authors who have drawn attention to the factors which play a significant role in the health benefits that stem from investment in potable water supply and sanitation (Cvjetanovic, 1986).

A broad conceptual framework, concerning the direct and indirect impacts of investment in potable water supply and sanitation scheme on rural health is schematically illustrated in fig 6.3.

The impact of potable water supply and sanitation on health depends on the quality and quantity of the piped water supply and sanitation, the proportion of population covered, and the utilization of the water and sanitation facilities by the population (Cvjetanovic, 1986).

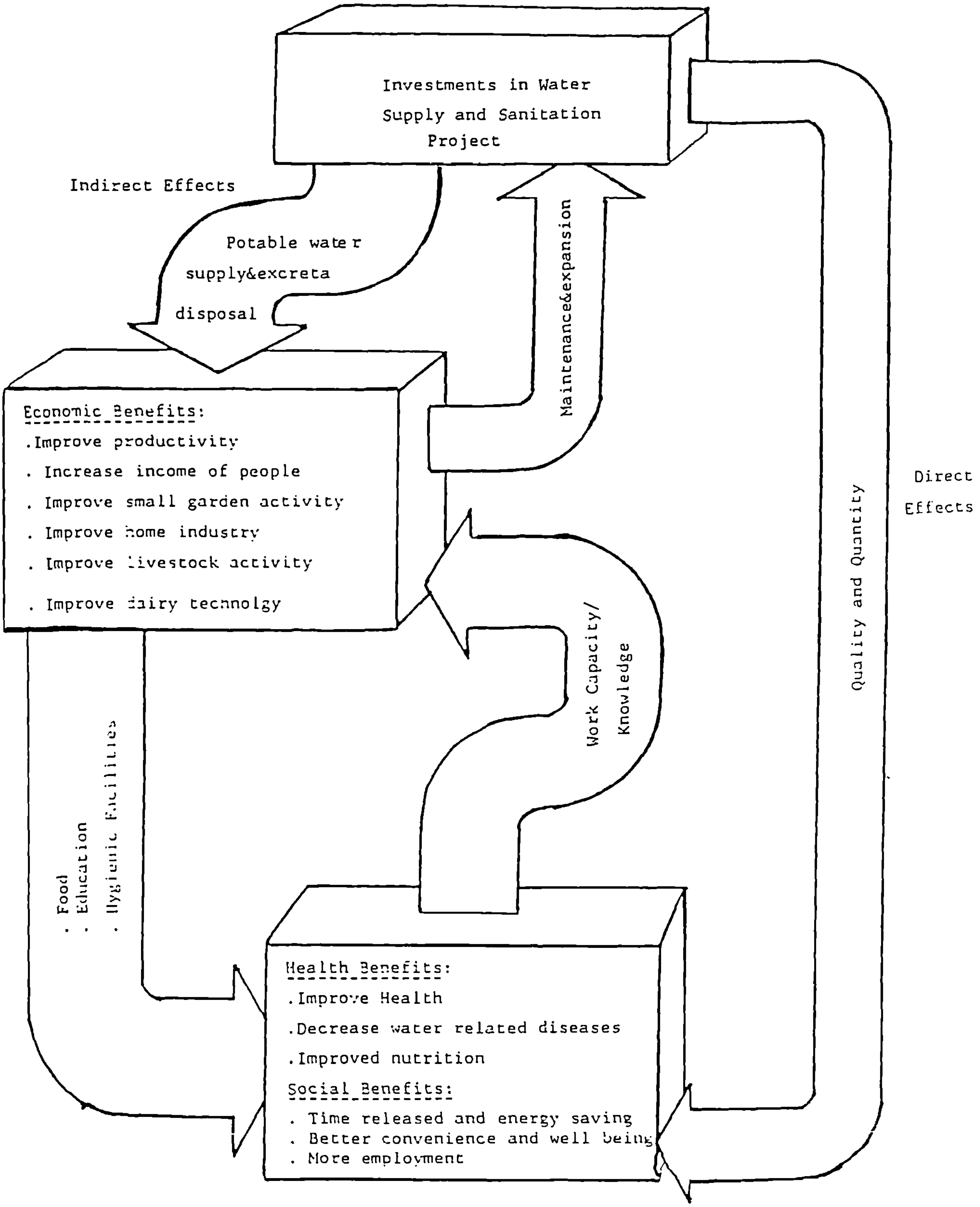



Figure 6.3 Direct and Indirect effects of investment in water supply and sanitation

Source: Taken and adapted from Cvjetanovic(1986)

As can be seen from the above figure, a primary input in the improvement of potable water supply and sanitation creates "direct" health and social benefits by preventing the prevalence of water related diseases and developing nutritional status. The resulting reduction in illness allows more time for productive work and educational activities which in turn increase the general well being of the people concerned and creates "indirect" health benefits. The provision of potable water supply may create various indirect economic benefits, such as improved productivity, increased income for people, improved small garden activity and improved dairy technology which will be dealt with in economic benefits.

Direct health benefits can be produced by increasing the quantity and improving the quality of potable water supply to rural people (Bradley, 1974). The result of a survey which was carried out by Warner (1973) in Tanzania showed that, the following health benefits:

1. Increased consumption of water
2. Greater frequency of bathing
4. improved quality of water
5. Reduced incidence of diarrhoea

may arise from the provision of potable water supplies and that these in turn have significant positive impacts on improved health. It would appear that water quality and quantity are the significant aspects from the health impact of view.

**6.2.6: The quantity of water used**

Depending on work load and climate, the human body needs between 3-10 litres of water per day for normal functioning. Part of this water is obtained from food (Hofkes et al·1986).

The term consumption is defined as the amount of water used by the members of a household for domestic purposes at household site (Warner,1973). Water used and consumption data are frequently expressed in litres per capita (head) per day (L.C.D), and it is used for making rough estimates of a community's water demand (Hofkes et al·1986).

There are many activities that account for water consumption. According to Cairncross (1987) these activities include drinking and cooking, washing dishes, bathing, washing clothes, watering animals and gardens. Moreover, Saunders and Wardford in 1976 pointed out that, there are wide variations in the amount of water people want to, or are able to use. For instance; Table 6.4 illustrates the average daily consumption figures in litres per capita per day for rural areas of developing countries.

Table 6.4 Daily consumption of water (LCD) For rural areas of developing countries

| Developing countries | Minimum | Maximum |
|---|---|---|
| Africa | 15 | 35 |
| Southeast Asia | 30 | 70 |
| Western Pacific | 30 | 95 |
| Eastern Mediterranean | 40 | 85 |
| Algeria,Morocco,Turkey | 20 | 65 |
| Latin America and Caribbean | 70 | 190 |
| World average for developing countries | 35 | 90 |

Source: Saunders and Wardford ( 1976)

Saunders and Wardford (1976) also pointed out that individual country data showed a minimum use of about 5 lcd for 7 countries, 20 lcd for 24 countries; and 40 lcd for 45 countries. Consumption which falls to as low 5 lcd is probably near the minimum demanded to sustain human life.

The provision of a potable water supply may increase the consumption of water. Research carried out by Warner (1973) in 9 Tanzania's villages before and after the installation of piped water supply found that at the time of the first survey, villages means ranged from 4.7 to 17.4 litres per person per day, while daily average for the second survey were 4.7 to 19.1 litres per capita. He also concluded that, all of the villages which received improved water supplies by the time of the second survey showed a significant increase in the consumption of water.

A study was carried out by Teller in 1963 in the unimproved areas of Tarija Valley, Bolivia, and concluded that the mean daily use per capita was 10.6 litres. The mean daily family consumption was 63.9 litres.

In a study of 14 communities with merely installed piped water supplies and without alternative supplies in North east Thailand, Feachem et al;(1977) found that the range of consumptive figures used for design purposes to be 50- 80 litres per capita daily. Actual use he found to vary from 9.6 - 36.8 lpcd at standpipes, and 24.4- 65.2 litres per capita daily for house connection.

The distance of water source from households may affect the consumption of water in unimproved villages. In this respect, White et al. (1972) found that household water use only decreased when the water source was at least a mile away. According to Feachem, et al (1977) it is likely that for households having a journey to a water source of over 30 minutes, will lead to or the volume collected of water being decreased. Conversely, if taps were placed inside house or even in the house yards that water use dramatically increases. White, et al (1972) also found that providing household water connection may increase water use two-fold or three fold.

## 6.2.7: Effects of chemical quality of water on Health

As noted in chapter 4 (page 145) drinking water in rural areas may be contaminated by various chemical substances. There are many chemical compounds whose presence in water may have harmful or even fatal effects.

According to Hinnawi and Hashmi(1982);and Tebbutt in 1983, some chemical compounds are very toxic since their effects are very acute with immediate symptoms in water users. Many others may have accumulative effects in the human body. Many chemical compounds can lead to the degradation quality of water and ultimately may be hazardous to rural people's health including:

**(a): Health effects of Nitrate:** Comprehensive studies concerning the adverse impacts of nitrate on health have been carried out by Feachem (1977); White et al.(1972); Tebbutt(1983); Bitton and Gerba (1984) and Goudie (1981). The results showed that drinking water with more than 10-22 mg/l of nitrate- nitrogen can be hazardous to human health, especially for bottle fed infants. It gives rise to methaemoglobinaemia or infant cyanosis (blue-baby disease). It can also produce carcinogenic nitrosamines in the stomach, leading to stomach carcinomas (Bastemeyer and Lee, 1992).

According to Tebbutt in 1983, The main reason why this disease occurs in infants up to 6 month age is that, they do not have the normal bacterial flora in their intestines and are unable to deal with the nitrite produced by reduction of nitrate in the stomach. Since, nitrite absorbed in the blood can prevent oxygen transport, the result is death. Changes in infant feeding practice such as breast feeding and health education to mothers to use a safe source of water in high nitrate regions may be useful in the reduction of this illness.

**(b) Health effects of flouride:**

As mentioned in chapter four(page 142) flouride is a natural constituent of some ground water supply in rural regions. Excessive flouride is a problem in tropical areas(White, et al; 1972).

A study carried out in Africa by Warner in 1973, showed that many water sources in North-central Tanzania contain excessive flouride, with concentration often exceeding one hundred times the allowable limits for human usage. Allowable flouride limits are based on maximum daily air temperatures, which correlate closely with average quantity of water consumed.

High concentrations of flouride content in water supply may have potentially detrimental impacts on health especially for children. For example concentrations of flouride more than 1.6 mg/l have adverse effects on children's teeth, and leads to mottled enamel (White, et al; 1972; Bitton and Gerba, 1984).

Skeletal fluorosis has been seen with usage of water contain more than 3 mg/l. The effects of flouride in the long terms in amounts greater than 20-40 mg/l ~~and~~ may result in crippling arthritis (Bitton and Gerba, 1984).

Small concentrations of flouride in drinking water may however,have beneficial effects on prevention of tooth decay especially among children (Tebbutt, 1983).

**(c) Health effects of other minerals**

Many other substances such as sulphates, sodium, and magnesium salts may exist in ground water supply. The mineral content of water not only has influence on water taste but it may have adverse impacts on health (Carruthers, 1973 ).

An excess of mineral sulphates gives water a purgative effect on users and rural people may prefer not to use it (White et al;1972; Warner, 1973). Most waters with harmful concentration of salts are so unpalatable as not to cause a health risk as they are not used (Bradley, 1977).

Many ground waters in rural areas may have hardness property and causes to complaints by consumers. Tebbutt in 1983, found that hardness in water may have an effect in decreasing certain types of heart diseases and hence, a harmful health effect may have arise from the softening water. This may be related to the exchange the sodium ions with calcium in boiled water used by some consumers. He also reported that some softening processes increase the sodium content of the water and this may have an unfavourable impact on some complaints including kidney and heart diseases.

Howe in 1976 and earlier works stated that goitre may be frequently endemic among communities which depend on their water and food on local supplies deficient in iodine.

**I: Health effects of Heavy metals**

As pointed out in chapter 4 (page 166) pollution of drinking water with heavy metals such as lead, cadmium, mercury, arsenic and many others can create great concern from the health point of view. Table 6.5 shows the effects of heavy metals pollutants on health and living resources.

Table 6.5 Effects of heavy metals on health and living resources

| Heavy metals | Hazards to human health | Harm to living resources |
|---|---|---|
| Lead | + | + |
| Mercury | +++ | ++ |
| copper | + | + |
| Zinc | + | + |
| Chromium | + | + |
| Cadmium | ++ | + |
| Arsenic | +++ | + |

Source: taken and adapted from Gesamp (1971)

+++ = Very important

Key: symbols: ++ = Significant

\+ = slight

As the above Table shows the impact of lead on human health is significant. A major problem with lead pollution is that the element is a cumulative poison (World Bank, 1974). The major negative health effects of water with high concentration of lead more than 0.05 mg/l,including; ischaemic heart diseases, renal insufficiency, gout and hypertension (Tebbutt,1983).

According to Hinnawi and Hashmi in 1982, exposures to lead have occurred in circumscribed areas of the world for 3000 years or more and were high among the Roman upper classes. The use of lead pipes in soft- water areas has lead to sporadic episodes of lead poisoning for communities who were drinking these waters.

In 1982 Holdgate, et al; reported that in countries where lead water tanks and pipes were employed to carry acid (plumbosolvent) water, the metal was found to reach concentrations of up 2000- 3000 g/l at tap, and pose a potential health hazard.

Mercury is very toxic metal and has crucial fatal effect on human. For instance, a disastrous effect of mercury on health has been reported by Southwick in 1972. This phenomenon was the cause of the well known outbreaks of poisoning at Minamata and Nigata in Japan and the major adverse impact on people's health was crippling diseases and resulted in death through the accumulation of methyl mercury in fish.

Cadmium like other heavy metals can have harmful impact on human health through food and water. In 1974 World Bank stated that cadmium toxicity has been implicated in serious cardiovascular diseases in Man. Moreover, it was known as itai-itai diseases in Japan, when rice paddy was irrigated with river water containing cadmium ( Holdgate, et al; 1982).

## 6.3: Social Impact of potable water supply and sanitation projects

### 6.3.1: Introduction

The provision of potable water supplies and sanitation systems may have positive or negative effects on the development process in various sector of the village economy and society (Falkenmark, 1982).

The social consequences of improving water supply are the most difficult to assess, as they depend so much on the subjective views of the assessor (Farrar, 1974).

This section, first, presents the direct and indirect impacts of time released and availability of water on rural people. Secondly, the impact of water supply project on community participation and migration of rural people will be considered.

### 6.3.2: Primary identification of social benefits

During the period of project design or early implementation, it is essential to visit project sites in order to make technical surveys. This time can also be used to obtain information on the social structure of villages. The possible benefits as well as social structural and organizational factors, may be identified through discussion with rural community (Falkenmark, 1982).

The direct effects of time released, energy saving and decreasing distance, may create indirect impacts such as greater convenience, and well being of the population living in the project area, particularly via productivity and income. These effects are discussed below:-

## 6.3.3: Positive primary impact of the provision of potable water supply

### (I): Time released and reducion of the distance travelled

In relation to the provision of potable water supply, time savings are the most immediate and easily measured benefits, and frequently the most appreciated by the rural people. Their magnitude will depend on conditions prevailing before installing the new piped potable water supply (Cairncorss and Feachem, 1983).

The time and energy expended on obtaining water is at least partly a function of the distance travelled, yet other factors may be important, such as the nature of the journey, the conditions at the water source, and activities, such as queuing and talking whilst collecting water (Carruthers, 1973).

Time released and energy savings are the initial and major benefit which may arise from the provision of the piped potable water supply in rural areas. In 1971, Jakobsen et al., pointed out that the time released for those who are engaged in fetching water sometimes from long distances, becomes available for application to other pursuits. According to Carruthers and Browne (1977) wherever time and energy savings are achieved, the supply will have a genuine amenity value and the relief from fetching water is a real social benefit. The WHO in 1983 reported that, convenience is a benefit that should be readily identified and assessed by the beneficiaries. The time saving associated with convenience, together with the elimination of the back, bending labour associated with the carriage of water over long distance, will increase the quality of life.

Fetching water is one of the most arduous of tasks in rural areas of developing countries. This task is usually carried out by women and children (Dufaut, 1988). For example, Warner(1970a) estimated 85% of the total time spent in carrying water in rural Tanzania was that of women and/or children.

Men may participate in fetching water , for instance in 1974 Farrar reported that in Swaziland, it was observed that men play a bigger part, using Ox-drawn sledges or carts to carry nearly 200 litre drums of water. Oxen belong to the Man's sphere of activity in the community, and hence they undertake this work, but men never normally carry the buckets by which most families are supplied, and indeed, they usually never learn to balance buckets on their heads as the women do. For these reasons it is the life of women which is likely to be most immediately affected by changes.

According to White (1977) water fetching does much to determine the structure of the day for women. In many rural areas, they usually have to go and fetch water in the early morning and again during the day.

Women may spend four hours or more for a single journey to fetch water. Therefore, the bringing of water to rural communities can in some cases fundamentally alter the existing division of labour between men and women ( Falkenmark, 1982).

A survey carried out by Warner in 1973 in East Africa showed that in two-thirds of the households domestic water regularly was carried by wives, in one-half of the households by daughters, and in only one-fifth of the households by males on a regular basis. In fact, two or more women fetched water in most households.

According to Feachem, et al; (1977) an investigation in Lesotho located in South Africa illustrated that, women are the main water fetchers and the mean time saving following supply improvement was 30 minutes per day for an adult women. However, in one-third of the low land villages observed the saving in time spent by the average adult women fetching water has been over one hour per day.

An extensive survey of water fetching in East Africa was carried out by White et al; in 1972, who found that those water fetching in rural areas spend a mean time of 46 minutes per day collecting water. But, a further study in some areas showed that many women spend 264 minutes per day for fetching water from a long distance (White,et al,1972). It would however, appear that the time spent for fetching water is related to distance of water source. Thus under the traditional regime, in many rural areas there is a significant difference between the distance travelled in the wet and in the dry season (Carruthers, 1973). For example; in 1977 White reported that in some areas households at the extreme limits of distance from a water source as in the Dongore area of Ethiopia where people in the dry season have to go 5 or more kilometres to the only accessible water source.

A study done in Tanzania villages by Warner in 1969a and 1969b measured the distance to the water sources, the time to make the trip and the number of adult trips for fetching water per day. The average round trip ranged from 1.0 to 5.6 miles and took between 40 minutes and 3.5 hours.

Furthermore, with more than one trip per day some households spent as much as 7 hours a day fetching water.

White in 1977 reported a case study from Tanzania and found that the distance of water source and time for fetching water has been reduced after the installation of a piped potable water supply.

**6.3.4:Positive secondary impact of time released**

Time released from fetching water in rural areas, opens up many alternative ways of employing that time. Different people are likely to spend their released time in different ways (Jakobsen et al 1971).

Researchers such as; Cairncross (1987); Warner(1973); Saunders and Wardford (1976); Carruthers (1973); White et al· (1972); Farrar (1974); Biswas ( 1981) amongst others have discussed the activities which may occur using time released by rural women. These activities including:-

**1- Household welfare**

Many women spend a portion of their newly acquired free time on domestic works such as; washing clothes, cleaning, sweeping, scrubbing and insofar as these promote hygiene they bring added health benefits. Moreover, better cooking may lead to health benefits (Cairncross, 1987).

A survey in the Philippines showed that children whose mothers had little time to cook ate less nutritious meals and suffered from eye disorders caused by vitamin A deficiency (Cairncross, 1987).

Some women may use their released time to look after their babies and husbands (Jakobsen et al;1971; Falkenmark,1982). It seems, in this case, children particularly under five years old gained more health benefits from time released by their mothers. This was certainly the main direct benefit of the Zania projet in Kenya (Jakobsen et al; 1971)

In many rural areas, women and girls may spend some of their released time on simply relaxing with their families or friends. Nevertheless, however, they spend it, it is a benefit in itself; a significant improvement in the quality of their lives (Cairncross, 1987).

**2- Formal and informal social participation**

Like people all over the world who place a high value on leisure, it may be expected that many people may use the time released, entirely for leisure and rest (Jakobsen, et al; 1971).

Some people may employ their time released on some undemanding activities in visiting friends and neighbours, listening to the radio (Jakobsen et al; 1971). Many other people may feel willing to employ their free time by participation in formal social organization such as self help activities, co - operative societies, and church meetings (Falkenmark, 1982).

**3. Productive activities**

Time released from fetching water for women and increased consumption of water may create productive activity, and this will be dealt with in the later section of economic impacts.

**4-Educational activities**

The implementation of a piped potable water supply and sanitation project may have educational benefits to rural people. According to Warner in 1973, there are two routes by which educational provision may be enhanced; (a) direct and (b) indirect role.

**(a) Direct role educational activities,** include: Participation of rural people in the project during the construction phase and can play a direct role in the fulfilling of rural educational policies by the creation of new technical job training on water schemes.

According to the WHO in 1983, water supply and sanitation projects which include a substantial amount of community involvement can provide a powerful learning experience for the rural people. For instance; Warner(1973) reported that, opportunities for increasing the supply of trained manpower occur almost every time a new development project is undertaken in East Africa. Most water supply and sanitation projects are built through the labour of local residents who are directed by a small cadre of sub-professional or supervisory personnel from outside the village.

Community participation can also have a great impact on the effectiveness and sustainability of water supply and sanitation programs. It can also help to minimize many of the potential negative environmental impacts associated with them (United Nations, 1987).

Participation of rural people associated with water supply and sanitation project may occur in all stages of a project. Table 6.6 illustrate the steps of involvement of rural community in the water supply and sanitation project.

Table 6.6 Steps of community participation in the project

| Design and implementation cycle | Possible involvement of people |
| --- | --- |
| - Identification | - Request for project |
| - Design preparation | - Site selection, |
| - Implementation and construction | - Provision of local materials, capital and labour (supervisory and workers) |
| - Finance | - Collection of water rates<br>- Initial capital contributions |
| - Operation and maintenance | - Water users organization |

Source; Miller ( 1979)

As the above Table shows, community participation in all steps of a project can be very fruitful. For example(), the identification of a project represents a high commitment and reveal felt need. Participation in design may lead to a more technically appropriate system for rural people.

The construction component of a water project may also provide opportunities for the acquisition of new skills such as plumbing, mechanical fitting, stone and wood working, and surveying. In most large villages masons and carpenters can be found, and many villager may help in water and sanitation projects as labours (Warner, 1973).

The United Nations in 1987 noted that, *in many cases*, proper installation, use and maintenance of wells, hand pumps and latrines depends on the community understanding how they work and viewing them as their property and, hence, responsibility. For this to occur, the community must participate in the planning, site selection, design, construction, and monitoring of the various facilities. To achieve this level of community participation, adequate training in the proper construction, operation and maintenance of the various facilities must be provided.

**(b) Indirect role of educational activities**

Women in rural areas may spend part of their increased time to take part in adult education classes. According to Warner( 1973) adult education is one of the most potentially beneficial activities that can indirectly result from improved potable water supply schemes. These adult education classes including; cooking, sewing, adult literacy, public health, baby care and family planning.

In the case of time released for children, more time becomes available for going to school, doing their homework and playing (Jakobsen, et al; 1971).

Another way in which piped potable water supply may indirectly persuade greater participation in educational activities is through the increased enrolment and attendance of children in primary schools (Warner, 1973).

However, Farrar in 1974 pointed out that the overall problem in rural community development is "education" in its widest sense that is, helping rural people to become aware of their abilities and showing them how realize their potential. It would appear that, the provision of piped potable water supply can have indirect impact on the improved education of women and children in rural areas of developing countries.

### 6.3.5: Impacts of water supply and sanitation projects on migration

In many developing countries migration of rural people to the cities has occurred. According to Saunders (1973) the migration of rural people to urban region has two significant aspects including: (a) the rapid migration of population in developing countries from rural to urban areas causes large quantities of scarce resources to be used simply to sustain the large unemployed segment of the urban population and (b) if rural to urban migration were slowed, these scarce resources could be better used as investment goods that would stimulate increase in the countries' long run economic out put. Otherwise, migration of population has potential negative impact on the socio - economic overheads of urban regions.

Several factors may be significant in causing this migration of population. The most important are; job availability, higher incomes, and educational opportunities in urban areas (Saunders and Wardford, 1976). Hence, the provision of potable water supply and sanitation facilities in rural areas may have beneficial impact by the creation of jobs and education and through making small industrial and institutions activities possible.

According to Hofkes, et al. (1986) and Carruthers in 1973, water supply and sanitation projects may encourage clustered settlement round a water point. But they concluded that the water supply and sanitation schemes are not the main aspect in determining the location of settlements.

Glennie in 1983 pointed out that one of the water projects in Malawi was part of an integrated agricultural development project. The area was fertile, but parts were under- populated due to the lack of domestic potable water supply. Over the years some villagers had been abandoned because of the deteriorating water situation, and the inhabitants had migrated to the few remaining water sources, putting extra pressure on the surrounding land. The water supply enabled people to return to their original villages and thereby increase the area of land under cultivation.

In short, it seems that to prevent migration of rural people to urban regions, many other supplementary facilities such as employment and education opportunities should follow the water supply and sanitation project. Thus, the provision of potable water supply and sanitation may only have a limited positive beneficial impact on the prevention of migration.

## 6.3.6: Negative impact of improved water supply on rural communities

As pointed out in chapter three (page 64) the provision of potable water supply may be positive as well as negative. Some adverse and deleterious impacts on rural population are as follows:-

**1- Negative impacts on water haulers:** In many rural areas of developing countries due to the great distance to traditional water source water, fetching water in done by haulers. The term of hauler is defined by Jakobsen,et al.(1971), "Hauler employers", that is, those who employ others to fetch water for them".

Nevertheless, by the introduction of piped potable water supply project to a rural, those people previously engaged in fetching water for others as a paid occupation, are thrown out of their job. Warner in 1973 reported that in a study in Zania, in almost all cases the paid water carriers were women. However, these groups of people who has lost their job with improved water supply in a village may be employed as a labourer in agricultural work.

**2: Break down:** If the water supply does not belong to the villagers. its maintenance is considered to be a government responsibility. It may break down frequently and if not repaired, the government will lose credibility. It will also be more difficult for the rural community to believe in the benefits of new technology, and in development in general (Falkenmark, 1982).

**3: Connection fee:** As is the case with most water supply schemes, every body has to pay for it, either by way of payment of the loan which enable the project to be built, or by way of fees to contribute to maintenance and operations(Jakobsen,et al; 1971). The connection fees and annual rates can be seen as an adverse impact on rural people ( Carruthers, 1973).

**4: Population growth:** As mentioned earlier (page 222), investment in potable water supply and sanitation in rural areas can have positive beneficial impact on improved public health. But improved public health can cause death rates to drop. In developing countries when death rates have been lowered the birth rate is increased and ultimately leads to increase population (Saunders and Warford, 1976). Furthermore, increasing population may create major economic, social and environmental problems (Tayler, et al; 1967) such as; shortage of living facilities, food, water, land and contamination of environment.

## 6.4 Economic impacts of potable water supply

### 6.4.1: Introduction:

As mentioned earlier (page 222) the provision of potable water supply and sanitation has positive beneficial impact on health and ultimately directly and indirectly on productive and economic benefits. Furthermore, investment in potable water supply and sanitation projects in rural areas where it is part of the local infrastructure may indirectly create additional future economic activities (Saunders and Wardford, 1976).

In rural areas, the major changes brought about by water projects have been economic benefits perceived by the villagers as deriving from the quality of water delivered, directly and reliably to their homes or to nearby. This convenience has resulted in considerable time saving and increase water use (Dworkin and Pillsbury, 1980). Hence, the direct impacts of water quality and time savings become a major factor directly effecting economically productive activities.

In this section the author deals with the potential secondary indirect positive economic benefits which may arise from the provision of a potable water supply and sanitation projects including:-

1- The beneficial impact of piped water supply on livestock activities.

2- The positive impact of piped water supply on the use of small gardens.

3- The positive impact of potable water supply on expansion of small scale industry.

4- The positive impact of potable water supply on savings in the cost of medical treatment.

## I: The beneficial impact of piped water supply on livestock activities

The provision of water for livestock is the main way in which water supplies could improve agricultural production and may arise particularly in major livestock producing areas. A permanent water source near or on the farm will permit an increase in cattle and improve the production of milk and beef for an existing herd (Bos, 1969).

Those farmers who previously felt water to be a crucial constraint, preventing them from keeping such livestock as grade cows and pigs, or expanding their activities in this regard, may find it feasible to do so (Jakobsen et al., 1971).

According to Cairncross and Feachem in 1983, when domestic water supplies are used for cattle watering, careful planning is required to avoid overgrazing around water points. In dry regions where rural people depend on cattle, water supplies may provide a real benefit in keeping cattle alive if water is more limited than grazing. Nevertheless, in other areas, the impact of water supplies for cattle may be slight unless individual connections are installed (Carruthers and Browne, 1977).

In Kenya, it was found that one of the major benefits of the Zania potable water supply scheme for rural people was the increase over a four year period, in the number of cattle, pigs, sheep, goat and poultry in the regions where there was access to watering troughs the year round (Saunders and Wardford, 1976). Furthermore, Carruthers in 1970 reported that milk sales from a dairy cooperation also increased.

According to the WHO in 1982, the raising of small animals, either for family use or for sale, is a readily evident benefit and this may have an additional health benefit in the form of improved nutrition together with the economic benefits.

In summary, it appears that the provision of potable water supply may have positive beneficial impacts on improved livestock activities in rural areas.

## II: The positive impact of piped water supply on the use of small gardens

The provision of piped potable water supply may have positive beneficial impact on the irrigation of small scale gardens. Saunders and Wardford(1976) and Carruthers in 1973 pointed out that a piped potable water supply project is designed and constructed primarily for domestic use or other (such as flood control) purposes but that there is often excess water available and it can be used for irrigation of small scale garden plots near each household or tap. It may, therefore, have positive beneficial *impacts* on increasing agricultural productivity and perhaps also improving nutrition status.

Some easily available water may help villagers to employ water for mixing with the preventive chemicals as a pesticide against disease. Moreover, small scale irrigation of vegetable gardens, especially around the water point, now becomes possible throughout the whole of the year (Jakobsen, et al; 1971).

A policy allowing the watering of small scale gardens tends to produce most benefits in regions which have acceptable soils but also in areas with at least one very dry and hot season where the shortage of water can be a constraining factor on the use of small gardens (Saunders and Wardford, 1976).

According to Feachem et al; (1977) communal gardens in Lesotho are one of greatest impacts or productivity. because, time released and ample water supply may create facilities for irrigation and so increased the garden's potentials. Moreover, the results of his survey indicated that the villagers sell fresh vegetables to the market and this is a direct economic beneficial for them.

In many rural areas, women may use extra time released for non domestic activities such as productivities. Saunders and Wardford in 1976 pointed out that after the introduction of a piped potable water supply, women are able to spend that time formerly used in fetching water in more directly productive activities. These activities in rural areas may be different. But in general women spend the bulk of their increased time on farming, handicrafts, marketing of crops, or processing of cash crops (Warner, 1973).

In a study of nine Tanzanian villages where agricultural work occupied the largest share of time of a majority of married women, when asked what they would do if they had more time available, less than half said they would spend it on agricultural activities ( Saunders and Wardford, 1976). They also added that in another study in Ghana women asked how they would employ their time if a new piped potable water supply system saved 12 hours per week for them. Their responses were illustrated in Table 6.7

Table 6.7: percentage of productive and non productive activities

| Activity | Hours | Percent |
|---|---|---|
| Household duties | 4.2 | 35 |
| Leisure | 0.9 | 8 |
| Productivity work | 6.8 | 57 |
| Total | 11.9 | 100 |

Source: Saunders and Wardford (1976)

It seems reasonable to assume that about half the time saving would be put to productive work. But since labour is often the greatest restraint on agricultural production during key periods, there will be occasions in the year when perhaps all the time released will be put into farming, and the subsequent economic impacts may be significant.

## **III: The positive impact of piped water supply on expansion of small scale industry**

The ample and availability of piped potable water supply in rural areas of developing countries may lead to improvements in the small scale industrial development and increased production. Warner in 1973 stated that water consuming industries in rural regions are usually small and at the level of individual households. He also investigated these activities in Tanzania, where activities including the brewing of beer from corn, brick-making with sun dried or baked earth and coffee pulping to remove the meaty coating from coffee beans.

**IV:The positive impact of potable water supply on saving in the cost of medical treatment**

As noted earlier(page 222) the provision of potable water supply and sanitation may lead to improved health of rural population. In 1976 Saunders and Wardford reported that if a rural water supply and sanitation project brings about lower water related diseases rate and thus a healthier population, it may be feasible for the country at least to reduce the rate of growth of some of the expenditures currently made for health and medical services.

The WHO in 1983 found a clear saving in the cost of medical treatment, especially with respect to some diseases such as cholera, typhoid and diarrhoea, *can be determined* from the annual reduction of disease episodes and the unit cost of treatment for each episode. In principal, the same approach may be used for the other diseases and disease episodes that are related to water supply and sanitation.

According to Carruthers in 1970, saving money may be possible on health expenditure. in particular saving on staff and drugs providing that preventable disease are in fact avoided.

Saunders and Wardford in 1976 reported that fewer funds may be necessary for vaccination programmes ( typhoid and cholera) hospital and health centre facilities and equipment, physicians and staffs, drugs and medicines, and transportation for health purposes.

To sum up all economic benefits, it seems that, small garden irrigation, livestock watering and small scale industry efforts may all create additional direct economic benefits to a rural community in a relatively short term by the increasing income and output of local people. In addition to all these productive activities, the reduction of medical treatment expenditures is of long term benefits to central government.

### 6.5: Summary

In this chapter I have outlined the wider implications of potable water supply and sanitation projects in rural areas of developing countries. Investment in the provision of potable water supply and sanitation projects may result in several direct and indirect effects on the status of health, social and the economic welfare of rural people. I have summarized these impacts in Table 6.8. Improved quality and increased the quantity of water and time released are the major cause of direct and indirect benefits of potable water supplies. The direct effects of water supply and sanitation on water related diseases are only one of the components of health benefits measured by a decrease incidence of these diseases. Another frequently more important effect is the indirect impact of water supply and sanitation through socio-economic, educational and other improvements on the health status(including nutrition) of the people.

Time and energy saving are the initial and main social benefits which directly may release a great number of women and children from fetching water. This time released in turn may create indirect social and economic benefits such as household welfare, formal and informal social participation, participation of women in adult eduction classes and attendance of children at school.

Increasing the quantity of water may create various indirect economic benefits such as; increased income of people, improved small garden activity, improved productivity, improved home industry,improved dairy technology and improved livestock activity.

Improved water supply may also has some negative impacts such as; unemployment of haulers, connection fee, annual rates and population growth.

Table 6.8 Summary of health, social and economic benefits of potable water supply

| Benefits | Significant factor | Direct positive impact | Indirect positive impact | Negative impact |
|---|---|---|---|---|
| 1.Health | Improved quality of water | -Better health<br>-Reduced water and excreta related diseases | -Long term improvement in family planning<br>-Improved sense of well being<br>-Improved hygiene<br>-Lower medical expenditure and family health costs<br>-Long term improvement in family planning through reduction of infant mortality | .Population growth<br><br>.Connection fee<br><br>.Annual rates |
| 2.Social | Time released and energy saving | -Saving on the water collection journey for the each household(women and children)<br>-Released labour | -Household welfare<br>-Formal and informal social participation<br>-Participation of women in adult education classes<br>-Attendance of children at school<br>-Domestic and agricultural activities<br>-More leisure<br>-More employment | Unemployment of haulers |
| 3.Economic | Increased quantity of water | -Reduced water washed diseases<br>-Better health<br>-Increased water activities | -Higher crop yields<br>-Lower production costs<br>-More high value crops<br>-Improved animal production<br>-Improved diary technology and higher quality of milk<br>-Improved small garden activity<br>-Improved home industry<br>-Improved livestock activity | |

# CHAPTER 7

# CASE STUDY

## 7.1: Introduction

The present case study was carried out at the University of Salford and in the rural areas in the North West and the Central part of Iran.

The first phase of the case study was done in the four villages of Urmia City located in the North West of Iran from 15/July/90 to 20/Aug/90. The second stage of the case study was carried out in the four villages located in the Yazd City Central (desert areas) of Iran from 1/Aug/91 to 15/Aug/91. The studies were carried out in the following ways:-

1- By applying questionnaires.

2- By visiting local state institutions.

3- By visiting and interviewing households.

4- By direct observation and taking photographs and slides of the sources of traditional and improved water supply; of fetching water by women and children and of pit latrines, unsanitary disposal of animal and human excreta by the villagers, and of the environmental contamination.

This chapter is divided into two main parts;(a) general description and (b) survey findings. In this chapter the following points will be discussed:-

1- The objectives of case study, methodology and data collection and sampling method.
2- Information about Iran and EIA of base line studies in the sample villages.
3- Survey findings regarding positive and negative environmental, socio-economic and health impacts of the improved potable water supply and sanitation projects in the sample villages.

## 7.2: Objectives of case study

The present study seeks to determine some major positive, beneficial, and negative, deleterious, effects of potable water supply and sanitation projects in eight villages which are located in two different zones of Iran.

To identify the positive and negative impacts of potable water supply and sanitation in improved areas, I included two villages with water supply and sanitation facilities and two without in each area. In each location the four villages were situated in areas of similar in ecology, farming pattern, social structure,and adminstration. Thus it was possible to compare development in these two matched areas and conclude with some confidence the differences between the areas in those respects likely to be affected by the presence of potable water supply and sanitation. All identified impacts in the sample villages will be assessed by an EIA methodology in the next chapter.

## 7.3: Methodology of data collection and survey

The development and use of indicators to measure the impact of safe piped water supply and sanitation facilities on socio-economic and health and health promotion call for the systematic collection, compilation and processing of data. For my work a questionnaire was prepared in order to collect relevant information. The basic questionnaire is attached in Appendix A.

The main purpose of the questionnaire was to identify and assess the perception of villagers concerning the changes which may occur in the village by introducing improved potable water supply and sanitation projects.

In the present case study four basic sources of data were used:- verbal, measured, observed and recorded. Verbal data provide the bulk of the information and was obtained from the questionnaire administered to housewives in the villages. Measured data consisted of the walking distances between households and their sources of water by foot. Observation data, on the other hand, included information obtained by direct observation.

The author spent eight weeks from 8 o'clock in the morning until 4 o'clock in the afternoon in the rural areas of both cities. These observation including direct observation of water carrying tasks and water reuse practice, the use of pit latrines, environmental pollution, human and animal waste disposal and the use of traditional water sources. Also included was data collected by the heads of environmental health departments and myself. Such data related to the rainfall, the population of the areas, the number of sanitary pit latrines and the health status of population.

## 7.3.1: The Sampling Method

### i: Village Selection

The characteristics of the case study villages were obtained by the author from the environmental health offices of the regions. The villages included were chosen from those in the planned or on going water improvement projects whose completion conveniently coincided with the time available for the surveys.

The conditions that cause some villages to attract piped water supply and sanitation projects may also strongly influence the appearance of benefits, otherwise attributable to water and sanitation. The inclusion of control villages in the investigation helps to identify the occurrence of developmental changes unrelated to water supply and sanitation improvements but does not account for the influence of conditions of this type as they may be unique to the project villages.

A total of eight villages located in the two different cities areas are included in the overall research. Table 7.1 illustrates the names, dates and places of the sample villages which have been studied in this research.

Table 7.1 Characteristics of the sample villages

| Zone | City | Name of the villages | Situation of water supply and sanitation projet | Time of survey |
|---|---|---|---|---|
| Northwest of Iran | Urmia | Tolatapeh<br>Emamzadeh<br>Hashmabad<br>Klanic | X<br>X<br>+<br>+ | 1/7/90<br>7/7/90<br>15/8/90<br>20/8/9 |
| Central part of Iran | Yazd | Moradabad<br>Khrang<br>Dehbala<br>Hamaneh | X<br>X<br>+<br>+ | 1/8/91<br>5/8/91<br>9/8/91<br>15/8/91 |

Key: X = With water supply and sanitation facilities
+ = Without water supply and sanitation facilities

In the present study the following abbreviations were used to show the name of the sample villages:

| | | | |
|---|---|---|---|
| Tolatapaeh | = A | Moradabad | = A1 |
| Emamzadeh | = B | Khrang | = B1 |
| Hashmabad | = C | Dehbala | = C1 |
| Klanic | = D | Hamaneh | = D1 |

**ii: Household selection**

Household selection within a given village was made at the beginning of the survey in each village. The environmental health officer, who accompanied me, first presented his letter of introduction to the main village officials and then addressed a meeting of the leaders of each village regarding my research and intended interviews.

The author was careful to point out that, our presence in the village was unrelated to the immediate implementation of new water supply schemes but that the cooperation of the rural community on the research and interview would assist the environmental health authority to better understand the problems of water supply and sanitation in the villages.

The number of the all households had been written on a paper by the environmental health officer and then I put them in a bag and drew out the number of 35 households based on a random sample. Two hundred and eighty (8 x 35) households were selected from four villages in the Urmia areas and four villages from the Yazd City regions.

Upon completion of the household selections, I drew up an interviewing schedule for the village concerned giving the day and approximate time that the households would be interviewed.

## 7.4: Background about Iran and Impacts of climate and physical features on water sources

### 7.4.1: Introduction

This section, deals first with the location and the natural environment, physical features and geographical situation of Iran and includes information on the climate, and its impacts on water resources and on the development and types of water sources. Secondly, the situation and problems of water supply and sanitation projects in the rural areas of Iran are considered. Thus, the object of this section is to describe the climate situation in Iran in order to demonstrate the importance of water and its effects on environment and rural communities.

### 7.4.2: Location and the natural environment of Iran

Iran is located in west central Asia and lies between 44° and 63° East longitude. The Southern Iranian boundary is at 25° and the Northern is at 39° 50′ Northern latitude, so that it is in the Northern Temperature zone (Honari, 1979).

Khosravi in 1987 stated that Iran lies between the temperate Caspian Sea and the warm, subtropical Persian Gulf, with its great mountain ranges, vast steppes and barren desert; fertile plains and vast wetlands, shows within its boundaries a great variety of environmental conditions caused by a great diversity of temperature, humidity, geology and topography. For instance; elevations range from over five thousand meters to below sea level.

The neighbours of Iran include; Russia in the North; Afghanistan and Pakistan in the East and the western neighbours are Iraq and Turkey. Figure 7.1 shows the topography, location of Iran and the case study areas are highlighted by stars on the map.

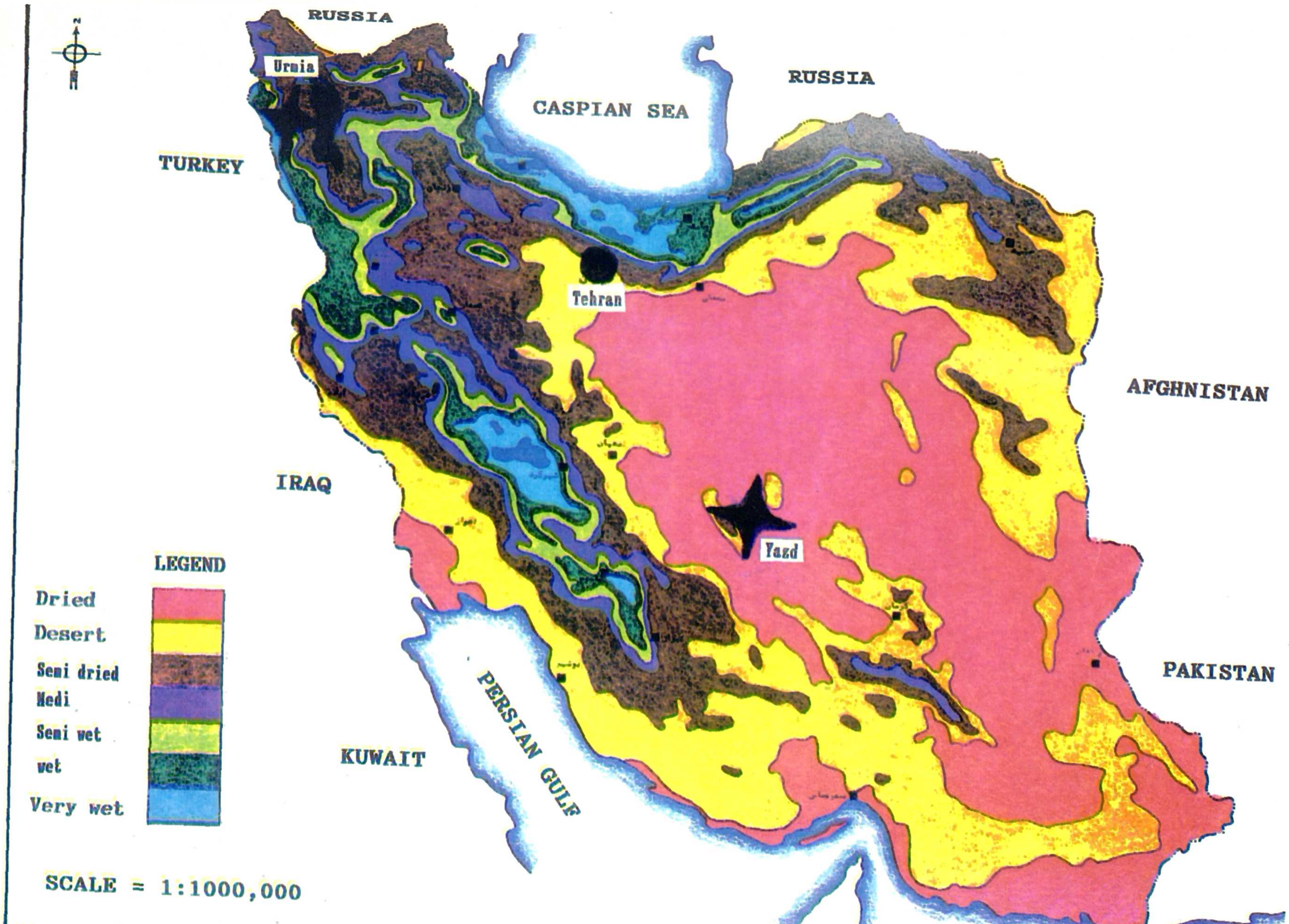



Figure 7.1 The topography of Iran and case study areas

Source: Statistical year book of Iran(1990)

Iran is one of the largest countries in the region. It has an area of 1648000 square kilometres. It is second in area only to Saudi Arabia (Frederiksen and Erickson, 1976). The size of the country is equal to the total area of Great Britain, France, Germany, Italy, Belgium, and Denmark. In other words, it is three times the size of France, five times that of Italy, and seven times that of Great Britain .

## 7.4.3: Physical features

As the above figure shows, Iran is shaped roughly like a triangle. The area outside the triangle is composed of highlands. Those enclosing the rim of the triangle are the Talish Hills and Alburz Mountains. The Western rim, oriented from North West to South West is the Zagros range. The Eastern rim is a series of lower ranges. The Alburz and Zagros ranges are high, with the peaks of each exceeding 4000, metres.

Iran's highest peak is that of Mount Damavand at 5678, which lies in the centre of the chain which is about 60 km North-East of Teheran. The slopes of the Alburz range are very steep; the Northern slope rises directly from the coast of the Caspian Sea, but the Southern slope drops less precipitously to the desert area or Kavir (Honari, 1979).

The Central basins, though lower, are not true lowlands, they are part of the Iranian plateau. The lowest lands lie outside the high rim of the triangle. The Caspian littoral plain lies North of the rim; the plains of Mesopotamia, on the East, merge into the coastal plains of the Gulfs of Persia and Oman in the South East and South (Khosravi, 1987).

These physical features have a beneficial impact on the climate of North and North west of Iran but an adverse impact on the climate of Central and Southern areas of the country. For instance, the Northern slopes experience heavy rainfall without a dry season. While, in the South and Central part of Iran rainfall is less and there is a dry season.

According to Khosravi precipitation may range annually from 2000 millimetres or more in the Caspian Coastal area to practically none in the vast expanses of the Central desert areas. The absolute minimum of temperature has been recorded as -35°C in Hamadan located in the North West and the absolute maximum of temperature has been recorded as 54°C in Ahvaz, located in the South of Iran.

**7.4.4: Adverse Effects of the Natural Conditions on the Development of Water Resources**

Iran is an oil rich country which enjoys the unique position of being rich in history, culture, population, resources and wealth, but one faced with the problems of water shortage and the need for better water management (Freisen and Moorer, 1972).

As stated earlier, the Country's geographical position is such that, despite abundant vegetation in the Northern provinces, Iran is basically *arid or semi arid*(see figure 7.1). Thus, water resources are a major economic growth limiting factor.

According to Mobasheri (1974) the average annual precipitation in Iran is only about 230 millimetres which is equivalent, without losses, to 368 billion cubic metres. This low rainfall is combined with other natural adverse factors including:-

1. Lack of precipitation during the growing season for most crops.
2. Non-uniform distribution of precipitation. For instance:- while 95% of land receives more than 500 millimetres of annual precipitation, for the Central plateau which covers about 50% of land the average annual precipitation is only about 130 millimetres.
3. High level of evapotranspiration which is caused by

high temperature, low level of humidity and in many regions prolonged seasonal winds.

4. Steep mountain slopes and vegetation coverage of most water sheds.
5. Extensive limestone formation which causes large amount of infiltration.

Due to the above factors, only about 20% of annual precipitation becomes available as surface runoff, of which a significant portion is in the flood seasonal. Thus, the Country suffers from a lack of sufficient surface flow. Most of the permanent rivers in Iran flow in the North, North West and West. The rivers in the rest of the Country apart from a few exceptions are seasonal and flow in late winter and early spring. They are thus not very useful for a rural water supply.

Nevertheless, Iranians facing these adverse natural conditions have tried, over the centuries, to exploit as much as possible from the available water resources of the country including:-

**i: Qanat waters**: Qanats are undoubtedly the most extraordinary works of ancient man for collecting ground water. The extensive qanat systems have been constructed over centuries for the use of underground water resources of the country (Mobasheri, 1974).

The origin of qanat building is not actually known, but it was certainly a Persian invention (Muse, 1961). In 1951 Fisher pointed out that qanats were developed in Iran nearly 4000 years ago.

According to Honari (1979) the qanat was invented and developed in the Iranian plateau, and has spread through out the world. The main reason is that the Iranian plateau is suitable for qanat digging; as sloping plains extended from the foothills to lower lands and deserts and throughout the plateau, settlements are located mostly on foothill plains. Furthermore, there is a lack of surface waters such as rivers and there is low rainfall. The most significant sources of water is underground which because of its sloping nature can be brought to the surface by qanat systems.

Merchant and Ronaghy in 1976 reported that the ancient system of water preservation and utilization is still used extensively in many parts of both rural and urban Iran.

There are many qanats in Iran. Honari (1979) stated that the total number of operating qanats was 18280. The total amount of water supplied by qanats was 7.5 billion cubic metres in 1977 which was 30.5% of the water withdrawn from underground sources.

The distribution of qanat water sources in Iran is not uniform due to the differences in climate and geology. For instance; 28.3% of the total number of qanats are located in the desert areas of Iran. Moreover, the qanats in this area are lengthy and deep and the average rate of water flow is relatively high, with respect to low precipitation. Only 9% of qanats are located in the Urmia region. The qanats in this area have a low water flow and as these areas are mountainous, the depth of qanats are low and the length short.

However, the qanat water systems have a significant role in the majority of Iranians'lives especially in rural communities. They are usually used for drinking and other domestic purposes such as; washing clothes, washing dishes, bathing, and watering animals. They are also extensively employed for irrigation and water as a source of power in water mills.

**ii. Spring Waters** : Springs as a source of potable water supply have been used in many rural areas since early Man established his settlements in Iran. Most of the springs are located in the North, North West and Western part of Iran due to there being more rainfall in these regions at present. The majority of the rural population use spring water with or without protection for drinking and for other domestic purposes. According to Honari (1979) the estimated number of springs in Iran was 8069 with the total water supply of 5379 million cubic meters and an average of 21 litres per second water flow. Twenty one percent of the water withdrawn from the groundwater sources flows from springs.

**iii. Rain Water:** Rainfall is used directly as a source of water supply in many villages in the South of Iran. To store the water for drinking, thousands of cisterns have been made in villages and towns, as well as near to roads and tracks in the deserts regions of the country. They store flood water after rainfall for the inhabitants of the villages especially where water from qanats or springs is brackish. The villages which get their drinking water from precipitation in the area below the 300 millimetres rainfall line. To improvement the quality of water in cisterns, it is disinfected by chlorine.

**IV. Wells**: In many rural areas of Iran where there is no spring, wells are considered. In Iran wells can be classified into three types; shallow wells, semi deep wells and deep wells. Shallow wells are dug by hand and their depth usually is less than 20m. The water is drawn up by a wooden windlass in plastic or leather buckets.

In the Southern parts of Iran water is drawn by ox power, but in recent years hand pumps and electric or small diesel pumps have begun to be used for raising water. The water is usually used for drinking and other domestic purposes and on a small scale for irrigation.

The digging of semi and deep wells in Iran began during the Second World War in the early 1940s, and since 1960 has spread rapidly on the whole country. The *depth* of semi deep wells varies from 10 to 50, and deep wells from 100 to 250 m respectively (Honari, 1979).

In Iran the deep well system of water supply has improved and extended due to fuel becoming cheaper and readily available(Muse, 1961). In 1977 the total number of deep wells was 16940 with an annual discharge of 7567 million cubic metres. The total discharge from wells is about 11797 million cubic metres which supplies 47.8% of the water withdrawn from underground sources (Honari, 1979).

Nevertheless, changes in water management technology are bringing about changes in the rural environment. From the 1960s onwards, as the number of deep wells increased, more qanats dried up and the amount of water flow dropped as a result of the drop in the water table and ignorance of the qanat system. The replacement of qanats by deep and semi deep wells in many rural areas of Iran is due to more demands on water resources owing for easier availability, at the shift of many villages to the centre of the plains.

## 7.4.5. The Situation and Problems of Water Supply and Sanitation Projects in Iran

In addition to the adverse natural conditions and water shortage problems mentioned above, another important problem that Iran is already facing is that of increasing population. Table 7.2 shows the trends of population increase from 1966 to 1986.

Table 7.2 The situation of population in Iran from 1956 to 1986

| Population<br>Year | Total population million (000) | Urban million (000) | % | Rural million (000) | % |
|---|---|---|---|---|---|
| 1956 | 18,944 | 5,684 | 30 | 13,260 | 70 |
| 1966 | 25,781 | 9,794 | 38 | 15,994 | 62 |
| 1976 | 33,708 | 15,8540 | 47 | 17,854 | 53 |
| 1986 | 49,445 | 26,844 | 54 | 22,349 | 46 |

Source:Taken and adapted from: Statistical year Book of Iran(1977)

As Table 7.2 shows at the time of 1956 census the population of the country was 18 million. Of that 70% were in rural areas. The last census in 1986 also indicated that the population of the country had increased and 46% of people were in rural regions. Iran is still predominately a rural country. Most of population live in the North, North West, North East and West while in the central and south of Iran the population is less.

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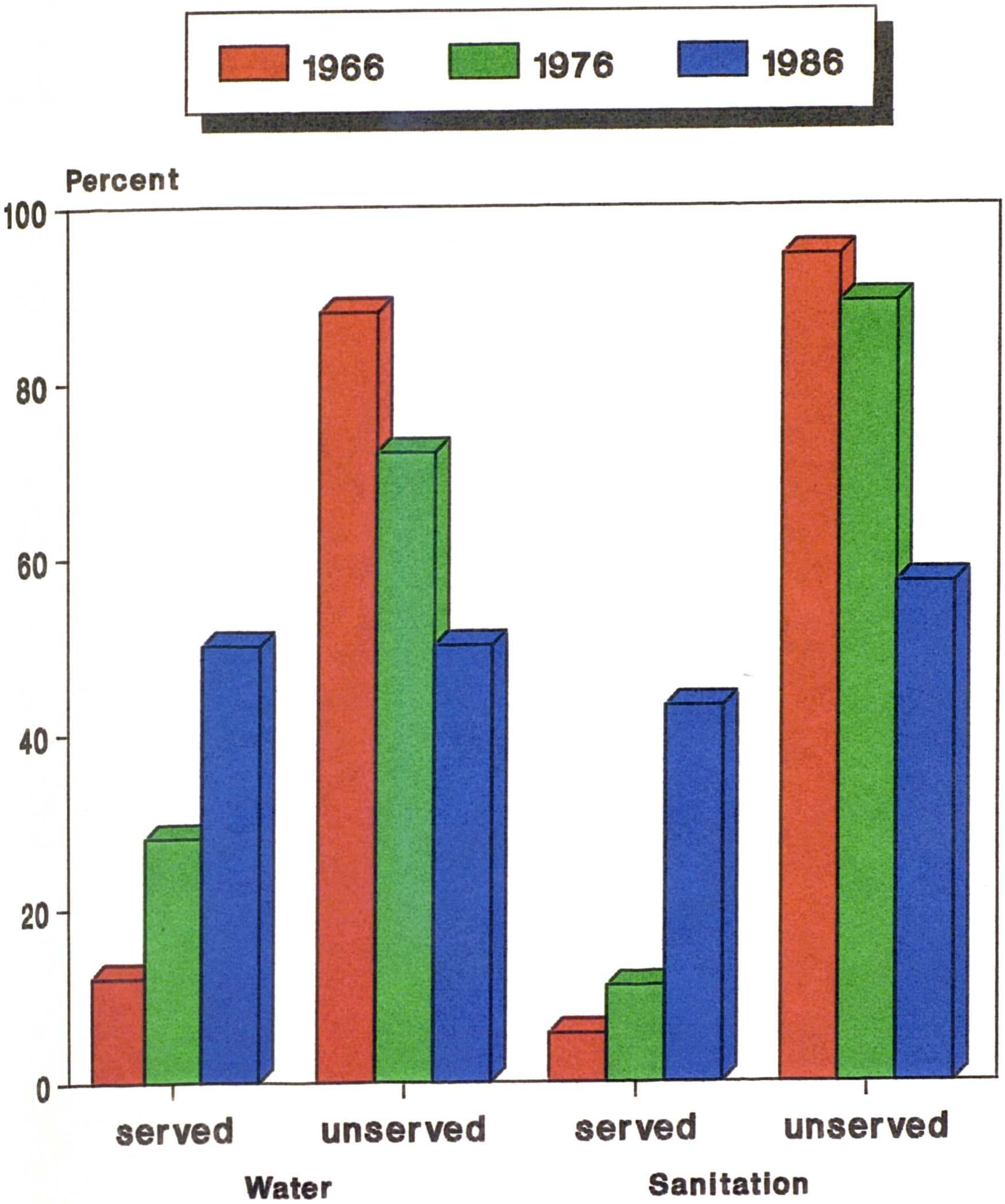
Table 7.3 Estimated coverage of rural water supply and sanitation facilities in Iran from 1966-1986

| Year | 1966 | | | | 1976 | | | | 1986 | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Population 15,994000 million | | | | Population 17,850,000 million | | | | Population 22,340,000 | | | | |
| Facility | Served | % | UnServed | % | Served | % | UnServed | % | Served | % | UnServed | % | |
| Water supply | 2,000.000 | 12 | 13,994.000 | 88 | 5,000.000 | 28 | 12,854.000 | 72 | 11,174.000 | 50 | 11,1746.000 | 50 | 100 |
| Sanitation | 895,000 | 5.6 | 15,000.000 | 94.4 | 1,963.000 | 11 | 15,800.000 | 89 | 9,610.000 | 43 | 12,739.000 | 57 | 100 |

Source: Taken and adapted from World Resources (1987)

# SITUATION OF RURAL WATER SUPPLY AND SANITATION IN IRAN




Fgure 7.2

As Table 7.3 and figure 7.2 show, in 1966 only 12% of population was served with water supplies but by the 1976 the figure was 28%. In the 1960,s after 10 years of intensive efforts, only 50% of rural communities were served with potable water supplies. In the case of sanitation, the situation was worse than that of water supply, only 43% of the population in the 1986 having sanitation facilities.

The lack of potable water supply and sanitation facilities, in many rural areas, may be considered as the main cause of the high prevalence of disease infection. In most rural areas of the country, human and animal wastes are collected and used as fertilizer, this procedure causing a high transmission of infection (Arfaa, 1972 ).

All these problems have caused the mortality rate of children in rural areas of Iran to increase. According to Merchant and Ronaghy (1976) of the infectious diseases in the country, diarrhoea was the most frequently occurring during the year 1972- 1973. Typhoid and hepatitis were among the most common infections. Table 7.4 shows the mortality rate of children less than 5 years old in rural areas of Iran.

Table 7.4 the mortality rate of children less than 5 years old in rural areas of Iran from 1960 to 1990

| Year | Death of children < 5 in 1000 birth rate |
|---|---|
| 1960 | 254 |
| 1970 | 150 |
| 1980 | 115 |
| 1990 | 107 |

Source: Taken and adapted from World Resources (1987) and the United Nations (1990)

As the above Table shows the mortality rate of children less than 5 years was highest rate in 1960, but after 30 years of effort and in the supply of water and sanitation facilities it is still too high in 1990 with 107 death per 1000 births.

However, in addition to the above problems, the other problems in relation to piped water supply and sanitation projects in rural areas of Iran based on experiences of the author including:-

1. Lack of sufficient finance resources
2. Lack of management
3. Lack of maintenance of water supply and sanitation facilities
4. Lack of the participation of rural people in projects
5. Problems of the scattering of small villages

## 7.4.6: Physical features of North-West (First case study areas)

This region includes the whole of Azerbijan and it is divided into two parts, East and West Azerbijan. A salt Lake is located between them known as Lake Urmia. On the west of the Lake there is a range of mountains which is nearby 140 km long from the South and average of 50km wide. The salt concentration in the Lake is so high that no fish can live there and swimmers cannot sink. Urmia Lake is the largest Lake in the Country; it is about 130 kilometres long and 60 kilometres wide (Khosravi, 1987). This brine Lake has significant adverse impact on the majority of lands around the Lake.

This research has been carried out in West Azerbijan and Urmia City is the centre of *this province*. *The* population of the Urmia Province (Ostan) based on the census in 1986 was 1,971,677. Of those 1,068,512 people or 54.2 % of population lived in rural areas.

The climate of the Urmia Region is basically one of hot and dry summers and cold damp winters with snow fall occurring mainly during the winter and early spring.

Winter temperature is often below zero for long periods of time and this constitutes a serious problem especially in rural areas in terms of communication. In a bad and cold winter road access to the mountain villages and indeed to many of the foothills can be blocked for several months a fact which has a significant effect on transport activity and the lives of the rural people.

The maximum and minimum temperature in summer and winter are 36°C and -25°C respectively. The average rainfall is almost 450 millimetres per year. Hence, the major part of Urmia villages is subject to heavy continental rains in spring and is relatively well watered. This aspect has a positive beneficial impact on increasing ground and surface water sources for the purpose of rural water supply.

There are three main rivers and many small streams of which some are dried in summer. The Urmia basin, mainly depends on underground water resources and nearly 853 million cubic metres are withdrawn annually, 42.3% from qanats, 37.3% from wells and 20.4% from springs (Honari, 1979).

Finally, the basin of Urmia is an example of an active densely populated region. One of the main features of this area is the high density of small villages. There are only a few large villages throughout the whole area. Figure 7.3 illustrates the location of Urmia City and the location of the sample villages.

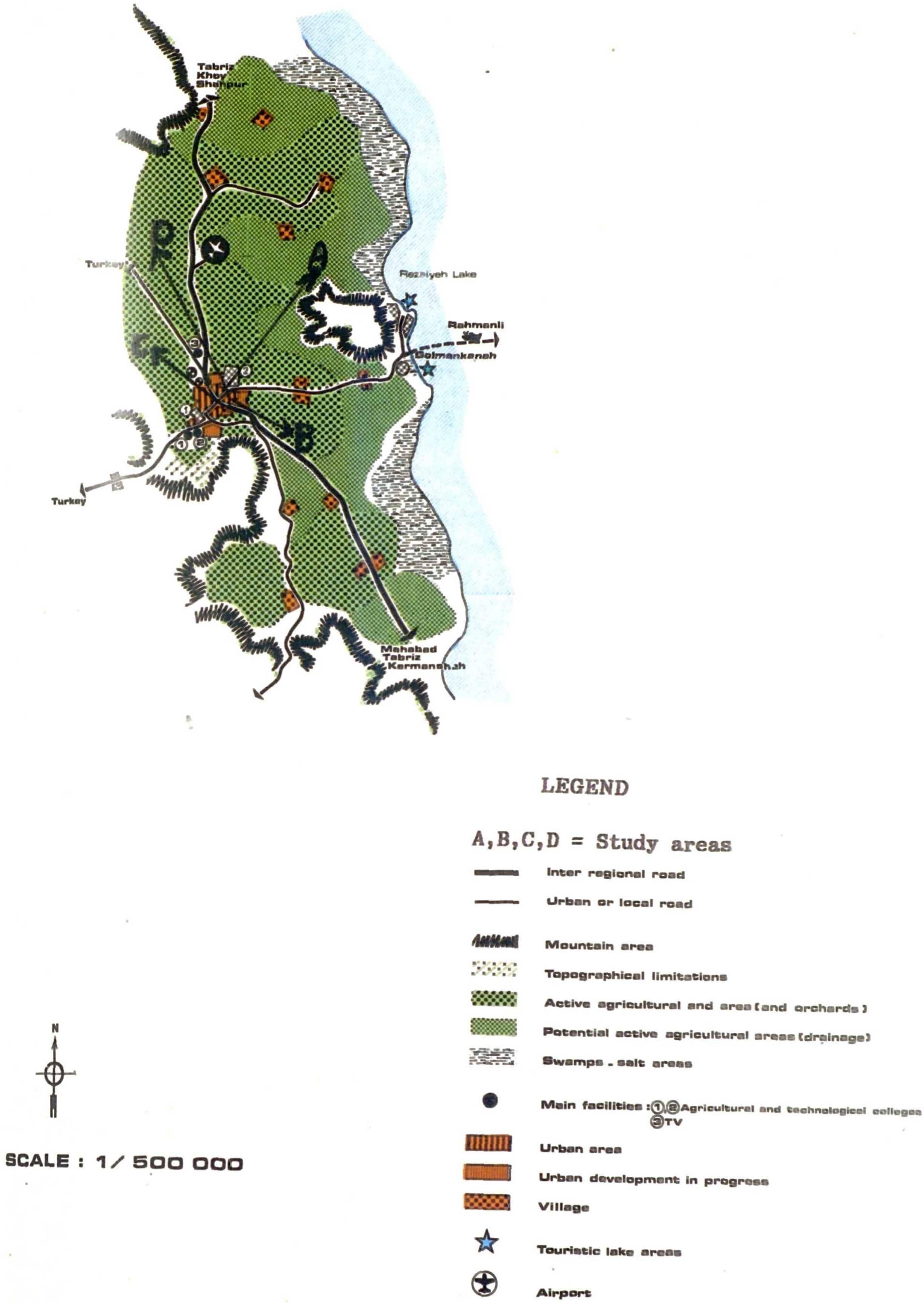



Figure 7.3 Urmia City and the location of the study areas

Source: Statistical year book of Iran(1990)

## 7.4.7: Physical features of Yazd City (Second phase case study areas)

The second phase case study was carried out in four villages of Yazd City. The Yazd province is located in the Central desert areas of Iran and has an area of 56000 km. It is bounded in the West and the South-west by the Central Range of mountains and from the North and South by the desert (kavir). The highest peak in this region is "Sir-Kuh" to the South-West of Yazd. The altitude above the Sea level is 1,234 meters.

Yazd like the other places around the desert has an extreme climate. The summer is hot and the maximum shade temperature is + 45°C and the minimum temperature in winter is - 6°C.

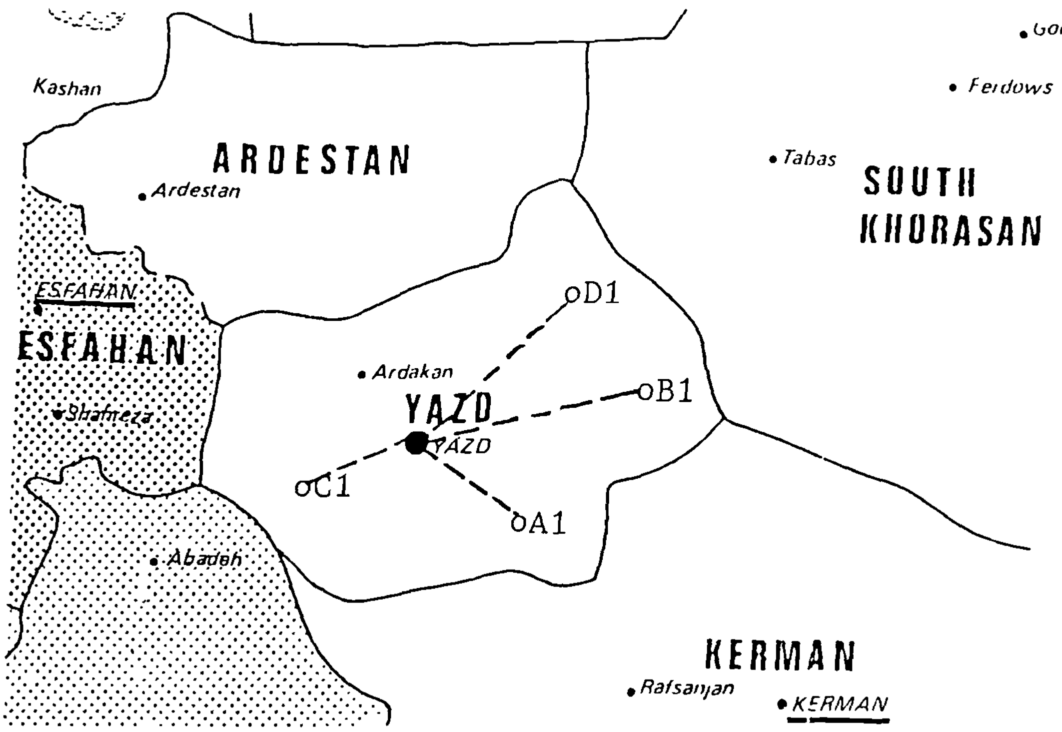
Annual precipitation in Yazd is almost 58mm. Sometimes, the rainfall in one day may reach 24mm which is about half the annual precipitation. There is little snow on the plain; but on the high mountains snow stays longer and as it melts during late winter and early spring it feeds the underground water resources. This water thus flows from the South to the North and feeds the qanats ( Honari, 1979).

The percentage of population growth in this City in 1966 was 44.3% it reached to 67% in 1986 (Golriz, 1958).

Hence Yazd City had the fastest growing urban population in Iran. The average growth rate population of Yazd province is 5.6%, of those which 67.4% live in City and the remaining 32.6% live in rural areas (Statistical Year Book of Iran, 1990).

Based on this information one can say that, the population rise in the City will have a potentially significant adverse impact on water sources, because it leads to destruction of the qanats, and then the villagers, and subsequently to immigration of the villagers to the City.

The major economic activity is carpet weaving, and agriculture is the chief element of the traditional life. The agricultural crops produced are: pomegranates, wheat, barely, pistachios. Figure 7.4 show the Yazd City and the location of the sample villages.




Key: ● Yazd City
O Sample villages

Figure 7.4 Yazd City and the location of the sample villages

## 7.4.8: Water supply problems in the Yazd area

The main source of water in the Yazd area is qanat water and there is no surface water. The people of the Yazd plain depend almost exclusively on the qanat system for their water supply.

The Yazd area has long been well known for its qanats. Whenever Yazd is mentioned, qanats would also be mentioned, and vice versa. The longest qanat in Iran is in Yazd province and located in Ardakan city and is called the Sadr- Abad. It is nearly 48 km. The number of qanats recorded for the all province is 980 (Honari, 1979).

Another water source in this region is tube wells with depths between 100-200m. Most of these are dug around the City, located on the South of the plain, where the water table begins. The fast increasing of population on one hand and rapid drilling and more excessive usage of wells on the other has caused a rapid drop in the water table. In some regions the water table has dropped nearly 40m in the past years. As a result, these have been negative and deleterious impacts on the environment. The majority of qanats feeding from the water table dried up very rapidly, and the people who could afford to do, started to dig new tube wells.

Many people are now faced with a shortage of water during the summer. The Government decided to prevent the digging of tube wells by requiring permission to be obtained from the Water Supply Authority of Yazd. As a result, some of the people who had dug a tube well over used it, because there was no control on how much water they could raise. The majority of people started to dig shallow wells in their gardens as these did not require special permission. The digging of deep tube wells also continued illegally (Honari, 1979).

Digging tube wells still continues and the water table in many areas is still decreasing. The environmental consequences of these will be depletion and degradation of ground water, and the drying up and destroying of qanat water sources, which will in turn lead to the destruction of flora and fauna and damage to agricultural crops of villagers.

## 7.5: Baseline studies in the sample villages

### 7.5.1: Introduction:

As stated earlier in chapter two the baseline study of a project is the foundation of an EIA process. In this section EIA baseline studies of four villages with a piped water supply and sanitation facilities during the operation and four villages without having such facilities during the construction phase in two different zones of Iran will be considered.

Data were obtained in two ways. Firstly, by visiting and observation and survey from the fields; concerning the main problems associated with water supply and sanitation facilities, and environmental pollution. Secondly, the data about the environmental impacts of water supply and sanitation project was obtained through interviews and questionnaires with the households and local people in each village.

## 7.5.1:Urmia Villages

### I: Tolatapahe Village (A)

Tolatapahe village is located in the East of Urmia City and its distance from the City is 40 kilometres. It is accessible by an asphalt road with the exception of about 2 kilometres.

They are approximately 233 households in the village and the population is approximately 1035. The number of males is 452 females is 379 and children under five years old is 204.

Homes are usually of two to three rooms and are adobe -brick structures with one or two windows and the roofs are usually thatched. The village has a health centre and it includes primary health care and environmental health sections. It has also a school with a primary and secondary class and a public bath. There are three hand brick makers in this village. The chief agricultural crops are; grape, wheat, tobacco, and bean.

The water supply system was installed in 1985. The main source of potable water supply is a borehole with an electro pump and includes an elevated tank with volume of 50m3. Before installation of the piped potable water supply the source of water for the community was tubes wells in the yards of villagers.

A committee of five persons in the Village is responsible for following up the problems related to the water supply and sanitation. They also supervise the water supply facilities and take responsibility for the operation and maintenance of the supply and sanitation facilities. The annual water rate is collected by the committee from the households and they spend this money for the maintenance and operation of water supply system.

According to a worker in the Health Centre Office almost 98.8% of people have access to sanitary latrines. (The difference of sanitary and unsanitary latrines will be dealt with in sanitation section).

My survey and observation shows that all villagers use the benefits of improved potable water supply, but the environmental health situation of village was not good due to the unhygienic disposal of animal waste and waste water by the villagers. This aspect thus has a potential adverse impact on environment and ultimately on people's health.

However, The major problems in this village are:-

(1) The cutting off of electricity for between 6-8 hours per week due to the lack of adequate power station in Urmia City which has adverse effect on the availability of water supply for rural people, and

also damages to the electric pump.

(2) the lack of drainage systems in the majority of households causes pollution of the environment.

(3) the raising of water table

(4) the vicinity of the majority of villagers' lands to Urmia Lake.

The high level of the water table especially in the wet season causes a big problem with the evacuation of latrines and also the likely pollution of shallow wells near to pit latrines.

Moreover, the raising of the water table has adverse impact on agricultural lands and productivity due to the salinity of Earth. The proximity of this village to Urmia Lake is another significant adverse impact on the villager's lands because of the intrusion of salt water from the Lake.

**II: Emamzadeh Village (B)**

This village is situated in the South of Urmia and its distance from City is 15 kilometres. The road is completely asphalt and the communication status of the Village due to being near to the City is good and the level of education of the people is also of good quality. There are of 150 households and containing 716 persons who include 321 females, 249 males and 146 children under five years old.

The quality of homes is better than Tolatapahe village and they are often made of brick and stone. The village has facilities such as a public bath, primary and secondary school and a health centre which includes family planning and environmental health sections. There are two technicians in the environmental health division and they always supervise the water supply and sanitation facilities.

The provision of piped potable water supply was carried out in 1987 and it includes an elevated reservoir and an electro pump. The main problems in this village are:-

(a) the break down of the electric pump due to the cutting off of electricity
(b) the pollution of the environment by animal and human excreta,
(c) the lack of drainage system in the households.

According to environmental health office 97% of households have sanitary pit latrines and situation regarding environmental health of the Village is not good.

The main agricultural products are grapes, apples, wheat, beans and tobacco. There are two hand brick making facilities in the village.

**III: Hashmabad Village (c)**

Hashmabad is a large village of about 215 households in and is situated on a mountainous area. It is located to the South - west of Urmia and is 60 kilometres from it.

Villagers use water in summer from a number of springs which issues in the wet season and which are at the most 150 metres from any households. In winter a single perennial spring is all that is available and people must walk between 100 and 500 metres to reach it. Another water source is a river which it is located one kilometres from the village.

The climate of this village in summer is chilly but in winter temperature is nearly -20°C for more than 6 month with high snowfall due to the location in the mountain. Thus the villagers have serious problems in winter due to roads being blocked with snow. During the author's investigation in August 1990, the villagers were obtaining most of their water from an unprotected traditional spring and shallow wells in their yards (see photograph 7.2 page 326).

The major problem in this village was (a) lack of potable water supply and sanitation facilities, and (b) possibly contamination of environment and unprotected water sources with animal and human waste.

Since 1987, to provide a potable water supply, villagers have been requesting the environmental health authority to build a gravity fed piped water supply and public bath facilities.

During my visit, water was carried by the women and children in plastic pots. The quality of the houses is not good and includes one-two room adobe brick structures with one or no windows. All the roofs are thatched.

The village has only a primary school but no health centre, and villagers usually go to the another village to use the health services. The mortality and morbidity of children less than five years old are high because of lack potable water supply and sanitation facilities and pollution of environment. The mortality rate among children less than five years old in 1990 was 12 per thousand birth rate of children.

The main agricultural crops are wheats, beans, and tobacco.

<u>IV: Kalanic Village (D)</u>

Kalanic Village is made up of 115 households along a ridge about 1500 metres above sea level. All of the people earn their livelihood from cultivation of wheat and bean. It is located in the North of Urmia and 70 kilometres from the City and in the mountain area.

The majority of households drew water from either unprotected shallow wells or in the wet season a river from close to the Village. In summer the river is dry and some dug wells with high mineral content and a small stream is about 300 metres from the average household serve as the village water supply.

The main problem of this village is a lack of potable water supply and sanitation facilities. My observation of and survey of pit latrines showed that the majority of households' pit latrines were blocked with human excreta due to a lack of adequate water for their cleaning. Water is scarce during the dry season from July to October. Many people fetch water from a small stream very far from their houses for both drinking and other domestic purposes.

This village is very poor and lacks public facilities such as health centre, public bath, and a school. Thus people have to go to other local villages to use these facilities.

## 7.5.3: Yazd Villages

### I: Moradabad Village (A1)

This village is located in the east of Yazd and it is 70 kilometres from the City. The total population of the village is almost 1000. There are public facilities such as a public bath, a health centre and primary and secondary schools.

The present piped water supply system was completed in 1979 and includes a borehole with an electro motor pump and an elevated storage tank with volume of 30 m3.

The environmental health officer and the majority of villagers stated that the quality of piped water supply due to the high mineral and salt is unpalatable. Hence rural people use it neither for drinking nor for irrigation and washing clothes and other domestic purposes. For this reason, the environmental health authority has found another borehole with better quality.

The new project will include a borehole with depth of more than 80 metres, a floated electro pump and a ground reservoir with volume of 250 m3. The distance of these facilities is almost 5 kilometres from village and a potable water supply will be distributed to the Village through a Iranite pipeline after three months.

When the author was visiting the Village people fetched water for drinking from the new water source by a car. According to the environmental health officer 98% of households have access to the sanitary latrines. Moreover, villagers have arranged to dispose of their solid waste and animal excreta out of the village area.

The major economic and productive activities associated with water supply are brick making and carpet weaving. Agricultural products include, radish, pistachios, wheat and barely.

The chief problem in this Village is the excessive usage of ground water by the villagers due to shortage of water during dry season which leads to lowered ground water table.

**II: Khranag Village (B1)**

Khranag village is located in the North East of Yazd, and its distance from the City is 75 kilometres. The population of village is 897. The public facilities include primary and secondary schools, a public bath and a health centre.

The piped water supply system was installed in 1982 and it includes an elevated storage tank with a volume of 30m3 and a borehole with floated electro pump.

All villagers have a private tap in their yards but the majority of them stated that they use this water only for washing utensils, clothes and watering the garden due to the unprotected, high mineral and salt content of the water.

The main source of potable water is a cistern which has been constructed 10 meters underground. The villagers used to collect rain water in the cistern, but due to pollution of water, they carry potable water by a car from a long distance and collected it in the cistern. This water then is disinfected by the technician of environmental health.

The agricultural production includes wheat, oats and Pomegranates. The economic activities are carpet weaving, brick making and masonry.

According to a health centre report, more than 60 percent of the people are infected by the parasitic diseases particularly giardiasis which is widespread among children.

The main problem in this village is carrying water from a long way as housewives have to use time and energy to fetch water from the cistern.

**III: Dehbalah Village (C1)**

Dehbalah village is situated high up among valleys to the west of Yazd. Its distance from Yazd is almost 50 kilometres. The climate of this village in summer is chilly and many of Yazd people go on holiday during the summer every year.

The population of the Village is 618 in 135 households. The main sources of potable water are qanats and one of them is protected and located 8 metres underground with 30 access stairs. Moreover, there are four unprotected qanat supplies and the whole Village use it for washing clothes, utensils, and watering gardens.

The public facilities in the village are:- a public bath, a primary school and a health centre. According to an environmental health officer the public bath is not useful and many people take a bath at their houses. My observations and survey showed that the quality of latrines and environmental health of village is not good due to disposal of solid waste and animal waste to the open environment.

The major problem is a lack of potable water supply and sanitation facilities. Pollution of environment by solid waste and animal wastes. The situation has caused mortality and morbidity in children due to diarrhoea.

According to health centre the mortality rate of children less than five years old in 1991 was 6 in a thousand.

**IV: Hamaneh Village (D1)**

Hamaneh Village is located 80 kilometres to the North of Yazd. The elevation of the Village varies between 1300 -1500 metres.

This Village is situated in the mountain region and the average rainfall is almost 65 mm and is more than Yazd City. The population of the village is 750 and it includes 467 females,235 males and 48 children under five years old.

The major source of potable water is a protected spring. The volume of this water is so great that villagers use it both for drinking and for other domestic purposes. The average distance of the spring from the households is almost 250 metres. Hence, the majority of housewives and children spend time fetching water from spring. In addition to the spring, many households have access to tube wells in their yards but the quality of water is not good because of its high mineral and salt content.

The situation of the latrines and conditions of the general environment was not healthy because many households throw their solid waste and waste water out of their yard into the streets.

The Village has public facilities such as, a public bath and a primary school and a health centre. My observations and survey showed that the majority of villagers have conflicts with each other over the use of the spring water, because many of them use this water for irrigation and they disagree over a potable water supply. This is a significant problem for villagers.

## 7.6: Survey Findings

### 7.6.1: Introduction

In this section I will present the information which I obtained through my observation, interviews and questionnaires. The questions were asked by the author from households in an open-ended manner and the answers were matched with a pre-coded list of answers. All data were processed and analyzed at the University of Salford, Computer Centre, with the aid of the SPSS/PC+ package.

### 7.6.2:Characteristics of the population(Question 1)

The first question asked households was about the number of households members. The total population number, average size of population per household, total population of children less than 5 years in both Urmia and Yazd villages are shown in Table B.1 (Appendix B).

The data shows that the population of the two areas are broadly similar. Total population in the sample in the improved and unimproved villages of Urmia city are ; 231, 196, 238 and 143 in villages A,B,C,D respectively. The average household size in villages A&B are 6.6, 5.6 and 6.8 & 4.1 in the villages C&D respectively.

In the improved A1&B1 and unimproved C1&D1 of the Yazd villages the population are 224, 203, 157 and 206 respectively. The average household size are 6.4 & 5.8 and 4.5 & 5.9 respectively.

## 7.6.3: Characteristics of interviewed persons(Question 2)

Question 2 asked households about the characteristics of people who were interviewed. For instance; when the housewife was not available the next available relative such as her husband (head of house),a son, or daughter was interviewed. Table B.2 (Appendix B) and figure 7.5 illustrate the characteristics of housewives and others who were interviewed in villages.

As can be seen from figure 7.5 the percentage of persons interviewed in the improved villages of Urmia A&B were 68.5% & 62.8% housewives, 20% & 22.8% head of house, 8.7% & 11.6% daughter, and 2.8% & 2.8% son. In the unimproved villages C&D 71.4% & 79.7% housewives, 17.3% & 11.6% head of house, and 11.6% & 8.7% daughter respectively.

In the improved villages of Yazd A&B the percentage of persons interviewed were; 85.6% & 82.6% housewives, 8.7% & 14.2% head of house, 5.7% & 2.8% daughter. In the unimproved villages C&D; 85.6% & 91.3% housewives, 8.7% & 8.7% head of house and 5.8% son respectively.

My findings showed that the overall, 78.4 % of the interviewed persons were housewives, 14 % head of house(man), 6.1% daughter and 1.5% son respectively (see figure 7.5).

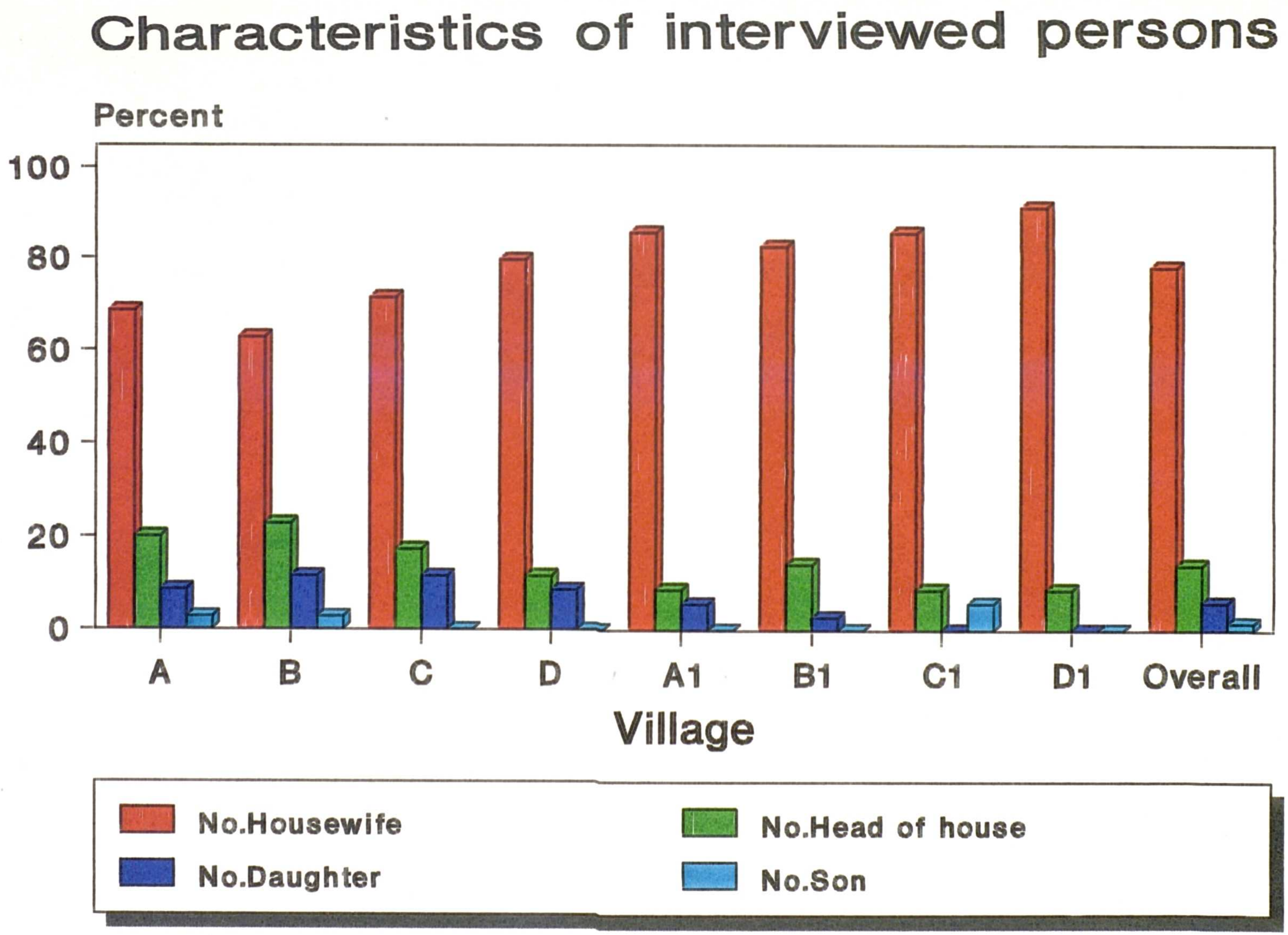

Characteristics of interviewed persons
Percent
100
80
60
40
20
0
A
B
C
D
A1
B1
C1
D1
Overall
Village
No.Housewife
No.Head of house
No.Daughter
No.Son

Figure 7.5

## 7.6.4: Survey of the environmental effects of more use of groundwater

### (I) Introduction:

I believe that, the installation of a piped potable water supply may result in changed environment. In this section the perception of households about the potential adverse effects of more use of groundwater on environment is examined.

### (II) Environmental effects (Question 3):

Question number 3 asked villagers about the effects of more use of ground water. Table B.3 (Appendix B) and diagram 7.6 compares the environmental effects of the greater use of ground water. All information was obtained through questionnaire, reports of the environmental health officer and my observation from the field.

As can be seen from diagram 7.6 the majority 57.1% and 65% of households in the improved villages of Urmia (A&B) stated that the improved piped potable water supply and more excessive usage of groundwater may lead to a drop water table and 37.2% and 31.4% of households answered that they do not know. The remainder 5.7% and 2.8% of them replied that greater use may lead to decrease pressure of aquifer. While in unimproved villages C & D, 34.2% and 40%

of households stated a drop of water table and the remainder 65.7% & 60% of them answered that they did not know.

In the improved Yazd villages A1&B1, the response of households were 71.4% and 77.1% a drop in water table,25.7% and 22.8% a decrease pressure of the aquifer and only 2.8% of households in village A1 answered do not know. Whilst in the unimproved villages C1 & D1, 48.5% and 42.8% a drop of water table, 8.5% and 5.8% a decrease pressure of aquifer and finally, 42.8% and 51.4% do not know.

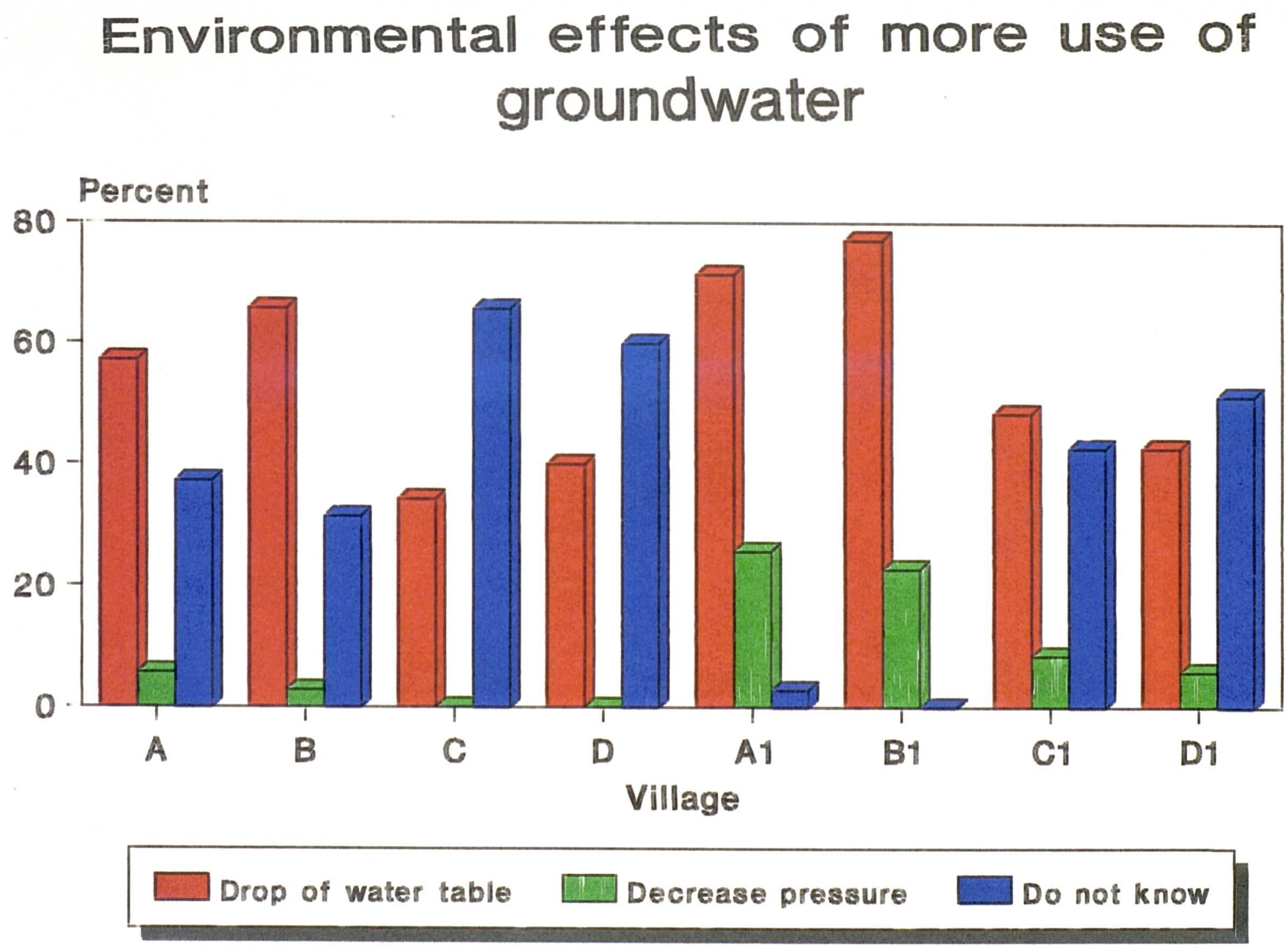

Environmental effects of more use of groundwater
Percent
80
60
40
20
0
A
B
C
D
A1
B1
C1
D1
Village
Drop of water table
Decrease pressure
Do not know

Figure 7.6

My findings showed that many environmental aspects are different in the two regions and these are listed as follows:-

1. Based on reports from households in the Urmia villages the environmental impacts of the provision of potable water supply and more usage of water are not important due to moderate climate and adequate rainfall.

2. In the Yazd villages the perception of the majority of villagers was that adverse and deleterious impacts of piped water supply and more usage of water on environment is higher. At the present they are faced with these environmental problems, the most important of which are:

(a) the quality of ground water in many villages is poor due to the excessive use of water for irrigation and water supply leading to mineralisation.

(b) in many villages the water table has dropped by at least 80 metres.

(c) the pressure of aquifer in this area has decreased.

My observations also showed that, another major adverse environmental impacts of piped water supply projets in the improved villages is related to the flowing of water from taps and sanitary waste from the households to the streets. This will be dealt with in the sanitation section see (page 351).

## 7.6.5: Survey of water collection and use

### I: Introduction

This section presents the amount of water consumed for each household and the following activities of water usage, water carrying and also the type of water containers which may be used in the sample villages. To identify the benefits of potable water supply, comparison of water used between the improved and unimproved villages is considered. Questions 4 to 6 are related to this section.

### II: Quantity of water used(Question 4)

As stated before (page 226) the quantity of water to be provided is usually expressed in terms of litres per capita per day (L/C/D) in the project area. In my survey measuring water consumption in the sample villages only water carried to or obtained at the household site is considered. It does not include activities such as; washing clothes, animal watering and garden watering. The measurement of water consumption involves determining the average daily quantity of water consumed by persons in a village.

The daily per capita consumption is the most direct measure of water usage in a village. Thus it is measured on the basis of the total volume of water used by a group of families/person divided by the number of families/ persons present on that day. By determining water consumption on a per capita basis, comparisons among the sample villages can be made. Question 4 asked households about the daily amount of water used per person and per family. Table B.4 (Appendix B) and diagram 7.7 illustrate the mean water consumption (per capita and per family) in the improved and unimproved villages.

# Comparison of mean water consumption (per capita and per family)

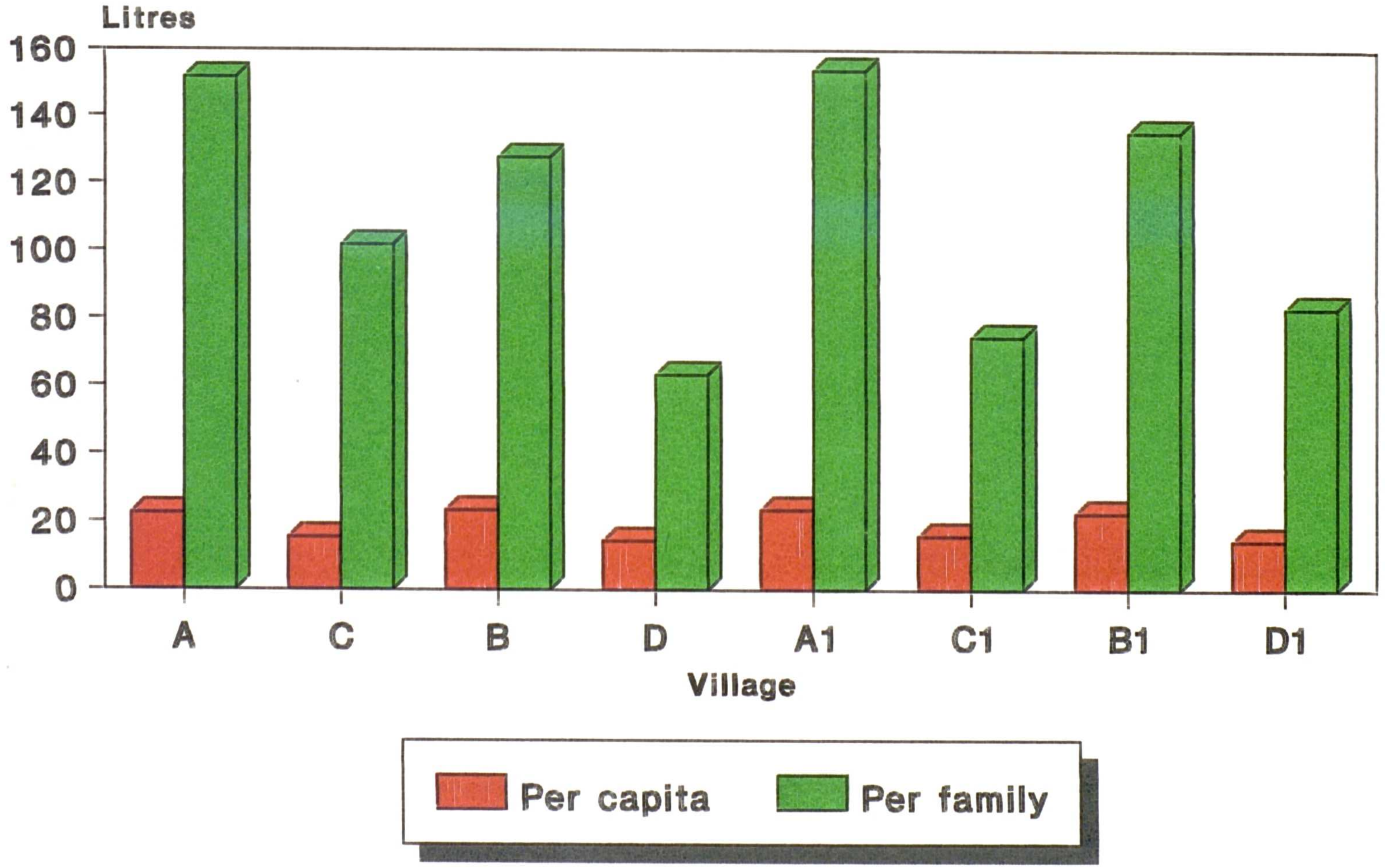



Figure 7.7

As can be seen from the above figure, the mean consumption of water per capita and per family in the improved villages A & B and A1 & B1 is more than unimproved villages C & D and C1 & D1. The difference of the means of the per capita and per family consumption of water was tested by t-test. The result of t-test of difference between means indicates that there is a statistically significant increase in consumption per capita occurred in the villages A & B and A1 & B1 compared with the village C & D and C1 & D1 respectively with a probability level ($p =< 0.001$). For more details see Table B.4 (Appendix B).

However, my findings indicated that, the amount of water used in the improved villages is more than in the unimproved areas. The possible reason is that the quantity and reliability of water in the improved villages are high but in the unimproved ones the reliability supplies are less. Another important reason is the distance of water sources to households (see page 328).

**III: Activities of water used(Question 5&6)**

Question 5 and 6 asked households about the activities of water and the most amount of water used at house. In both the Urmia and the Yazd villages a majority of households in each village reported that cooking, drinking, washing utensils and personal washing are the activities that consumes the most water.

The next greatest use of water varies among villages. Table 7.5 illustrates the activities of water consumption in the improved and unimproved villages of Urmia and Yazd.

Table 7.5 Comparison of water activities

| village / Activity | Urmia | | | | Yazd | | | |
|---|---|---|---|---|---|---|---|---|
| | Improved | | Unimprov | | Improved | | unimprov | |
| | A | B | C | D | A1 | B1 | C1 | D1 |
| Drinking | D | D | D | D | D | D | D | D |
| Cooking | D | D | D | D | D | D | D | D |
| Personal washing | D | D | D | D | D | D | D | D |
| Washing utensils | D | D | D | D | D | D | D | D |
| Bathing adults and children | D | D | IR | IR | D | D | IR | IR |
| Washing clothes | D | D | IR | IR | D | D | IR | IR |

Key: D= Activity occur daily
IR= Activity occur irregularly

As Table 7.5 shows, the activities such as; drinking, cooking, washing utensils, personal washing which occur in the improved and unimproved villages. Other activities for instance, washing clothes, bathing adult & children and babies, as occurred daily in the improved villages while irregularly in the unimproved villages. These activities are more related to the availability and quantity of water and its distance.

**IV: Water carrying and types of containers**

**(a): Water carriers (Question 7)**

My observations and survey indicated that in the eight villages water carrying is definitely considered to be a women task. A majority of households in each village stated that either women alone or women and children together are the water carries (see photograph 7.2 & 7.3, pages 326 and 327). Question number 7 asked households about water carriers. Table B.5 (Appendix B) and diagram 7.8 compare the water carriers in villages.

It can be seen that, of women and women and children are the usual the main carrier of water in all the improved and unimproved villages. But in the villages C&D, 14.3% and 17.2% of men and in the villages B1, and C1&D1, 8.7%, 20% and 14.4% of men, in addition to these women and children carry water, because of the great distance of the water source to households.

It can be concluded that, in the improved villages A&B and A1 due to water carriers having access to water in their yards, the task of fetching of water is not difficult and only women and children carry water. But in the villages C&D, C1&D1 and B1 the women, children and men carry water bodily because of the long distance.

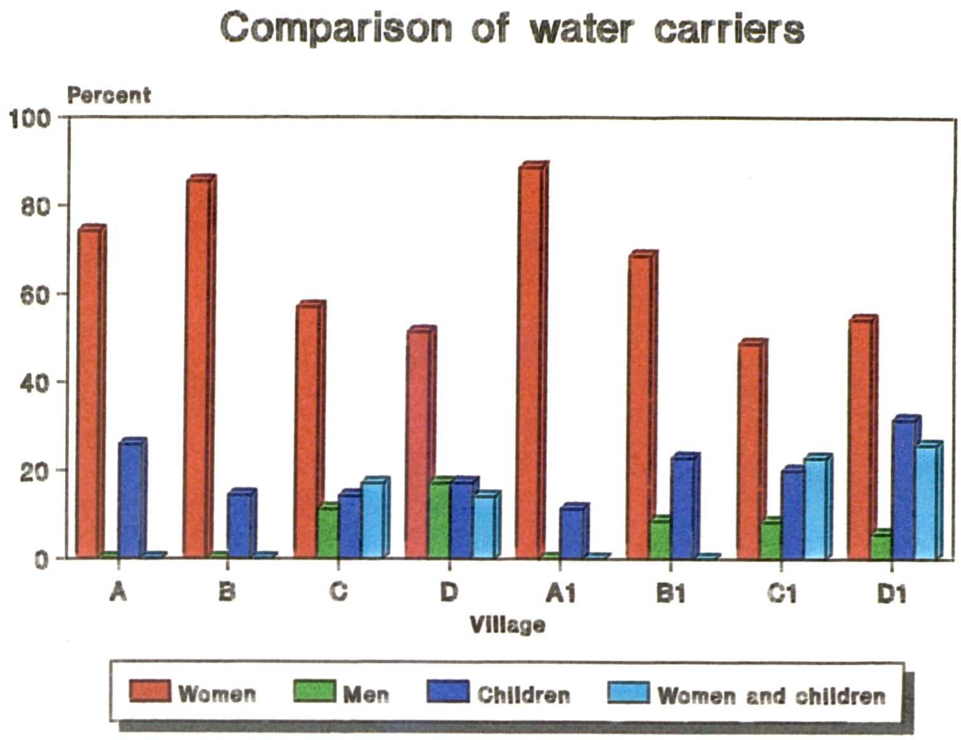



Figure7.8

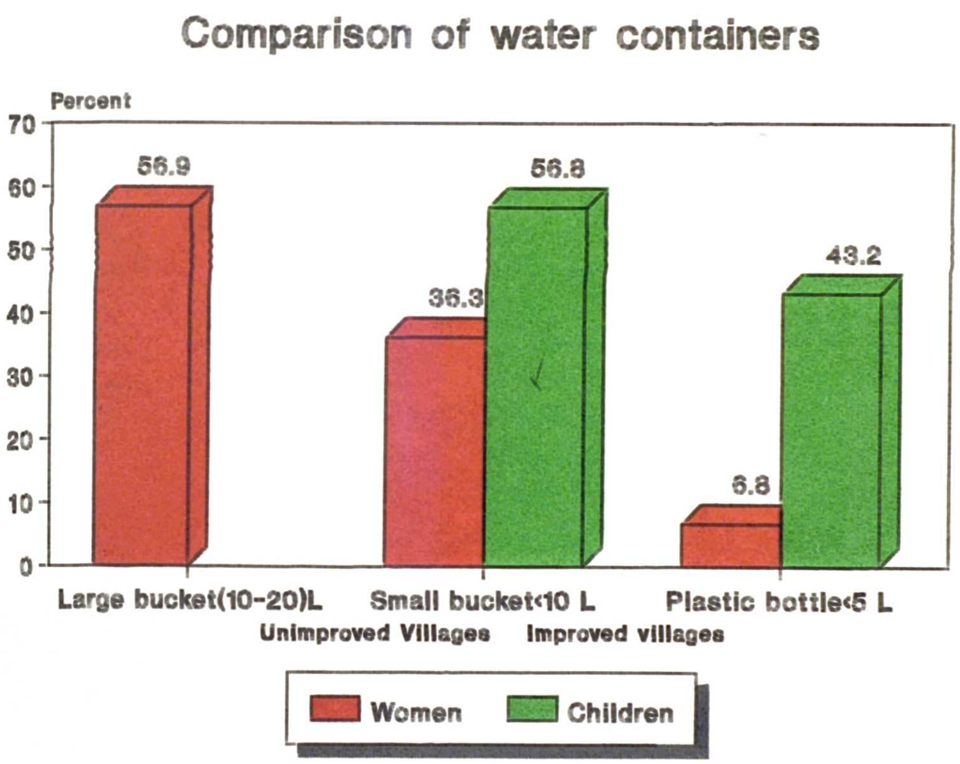



Figure 7.9

**(b): Types of water containers (Question 8&9)**

In almost all samples a wide selection of containers is used by adults and children. Questions 8 and 9 asked households about the water containers. Table B6 and B6.1 (Appendix B) and figure 7.9 shows types containers which may be used to carry water. My survey and observation showed that in the unimproved villages of Urmia and Yazd, 56.9% of adults use large buckets between (10-20) litres. Where as, in the improved villages 36.3% of them use small buckets <10 litres and 6.8% of adults use a plastic bottle 5 litres(see photograph 7.2 and 7.3 pages 326 and 327).

The containers which are used by the children vary with district. 56.8% of children usually use a small container of <10 litres in the unimproved regions whilst, 43.2% of them use plastic bottle approximately 5 litres comparing in the improved villages of both regions (see photograph 7.2 page 326).

In conclusion it can be said that, households that have access to a piped potable water supply usually use small container over the short distance but in the villages without a piped water supply women and children use a big container to fetch water over a long distance.

## 7.6.6: Survey of types of water sources

### I: Introduction

This section deals with types of water sources which may be used in the sample villages and assessment of their quality.

### II: Types of water sources(Question 10)

My survey and observation showed that, the types of water sources which are used by villagers for drinking and other domestic puposes are different. Question 10 asked households about the types of water sources used. Table 7.6 compares the types of water sources in the sample villages. Data was obtained through direct observation from water sources and interview from housewives.

Table 7.6: Comparison of types of water sources

| Village | | URMIA | | | | Yazd | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Impro | | Unimpr | | Improv | | Unimpro | |
| Source | | A | B | C | D | A1 | B1 | C1 | D1 |
| Protecteed spring | S1 | - | - | - | - | - | - | - | x |
| Unprotected spring | S2 | - | - | x | x | - | - | x | - |
| Protected qanat | S3 | - | - | - | - | - | - | - | - |
| Unprotected qanat | S4 | - | - | - | - | x | x | x | x |
| Protected cistern | S5 | - | - | - | - | - | x | - | - |
| Protected tube wells | S6 | - | - | - | - | - | - | - | - |
| Unprotected tube " | S7 | x | x | x | x | - | - | - | - |
| Protected boreholes | S8 | x | x | - | - | x | x | - | - |
| river water | S9 | - | - | x | x | - | - | - | - |
| Stream water | S10 | - | - | - | x | - | - | - | - |

Key: X = Access to water source
- = Without access to water source

As Table 7.6 shows in the improved villages of Urmia all households consume piped water for drinking and other domestic purposes. There are also a few unprotected sources such as S7 in these villages and some villagers use these sources for watering of garden and animals. In the unimproved villages, households have access to unprotected sources such as; S2, S7, S9 and S10.

The water source S9 is only available in the unimproved villages C&D in the wet season but during the hot season it dries and people use from the sources S7 and S2 and S10 for drinking and other domestic purposes.

III: Assessment of water quality (Question 11 and 12)

My observations showed that there are different water sources with different types of water quality in the sample villages.

Springs are perceived as the cleanest of the unimproved supplies and so are used particularly for water intended for drinking, cooking or food washing. All people in the unimproved village C use their domestic water from an unprotected spring (see photograph 7.2), whilst the majority of people in village D1 use water from a protected spring source for all domestic purposes and watering garden.

Qanat water sources are the main source in both the improved and unimproved villages of Yazd. But many of them have been destroyed and the quality of water has been decreased due to the excessive usage of ground water by villagers and by pollution from industry (see photo 7.4).

Other differences between the villages are summarized as follows:

**1.** Sufficient rainfall in the Urmia *region* allows villagers to access ground water of good quality and surface water as well. In the Yazd village because there is less rainfall the ground water level is too low and the quality due to the high mineral and salt content is not good.

**2.** The existence of hot and dry weather over a long period in the Yazd villages causes increased evaporation, leading to a loss of both surface and ground water.

The assessment of water quality should based on the recommended standards of the World Health Organization. The author due to lack of both time and laboratory facilities could not obtain information concerning physical, chemical and bacteriological examination of water quality. But, direct observation of the water sources and questionnaire data obtained on household water treatment and on information from the environmental *health technician* and local views as to the quality of their potable water supply was undertaken. Question 11 asked households about the quality of water. Table B.7 (Appendix B) and diagram 7.10 illustrate the perception of households about water quality.

As can be seen from Figure 7.10, the majority of households in the improved villages of Urmia (A and B), stated that the quality of piped potable water supply is good. In the villages (C&D), 77.1% & 8.6% of households reported that the quality of drinking water from spring source is good and 5.7% & 25.7% of them stated that the quality of water is average. The remainder 17.2% and 65.7% of households answered that the quality is bad, because, they used as their main water source a traditional unprotected spring and small stream, river water with a few unprotected shallow wells. The quality of these sources can be changed by human and animal pollution due to unprotected water source.

During the dry season stream flow is low and water quality tends to be poorer than at high flow periods. Therefore, this has significant deleterious impact on water quality and ultimately to the health of villagers.

Question 12 asked households about the methods of treatment of water used at home. Table B7(Appendix B) illustrates the perception of households about the water treatment method. In the improved villages A&B all households answered that they do not need to treat water, because of high quality of potable water supply. Whilst, in the unimproved villages C&D, 22.8%,48.5% and ,17.2% 77.1% of households replied that they use chlorine and boiling method for the treatment of water at home respectively. The remainder 28.7% and 5.7% of them answered that, they do not use any of the disinfection methods.

In the Yazd villages, 100% of housewives in the improved village A1 answered that the quality of piped water supply is good but in the village B1 all households replied that the quality of piped water is bad and unpleasant due to high mineral and salt content and that they use water from a cistern water source for drinking and that its quality is good (see photograph 7.3).

As figure 7.10 shows in the unimproved villages C1 the majority 74.2% of households reported that the quality of drinking water from protected qanat water is average, and the remainder 25.8% of them answered that the quality is bad. Moreover, over 74.2% and 11.5% of housewives replied that they employ chlorine,boiling for treating water respectively. The remainder 14.2% of households stated that they do not use the treatment method. The majority of 100% of housewives in the village D1 stated that the quality of protected spring water source is good but that it is faraway.

In conclusion, it can be said that the provision of piped potable water supply in the villages A & B and A1 and protected spring water source in the village D1 and cistern water in village B1 result in improving water quality and does not need any treatment facilities. Thus, this may have beneficial effect on the villager's health.

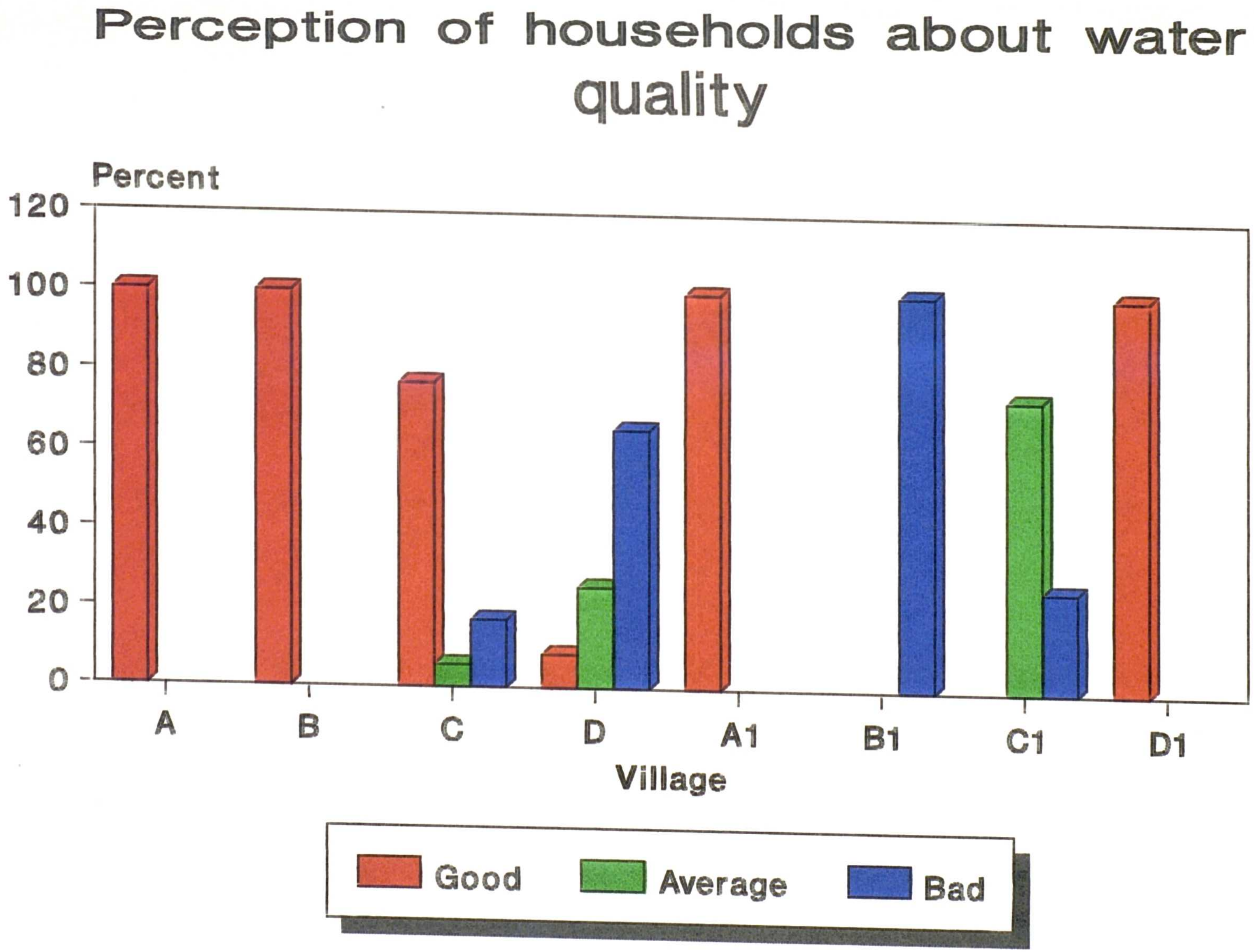
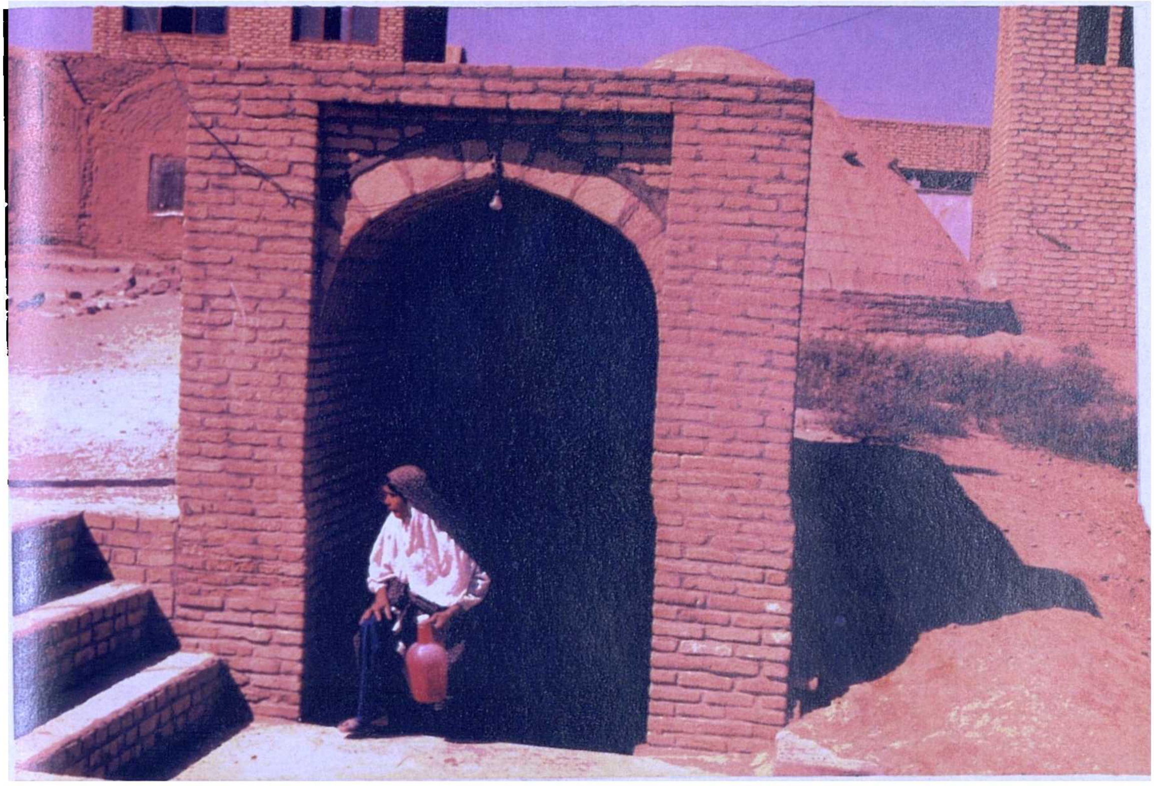

Perception of households about water quality
Percent
120
100
80
60
40
20
0
A
B
C
D
A1
B1
C1
D1
Village
Good
Average
Bad

Figure 7.10

Photograph 7.1 Small stream water source in Village D
in dry season

Phothgraph 7.2 Spring water source in village C



Photograph 7.3 Cistern water source in Village B1

Photograph 7.4 Qanat water source in village C1

## 7.6.7: Distance and time spent in water carrying

### I: Introduction

This section first deals with the major direct positive impact of the provision of a piped water supply on decreasing the distance of water source from households and time saving, and then the indirect secondary effects of time released is considered.

### II: Decreasing the distance of water source(Question 13)

My observations and survey from the sample villages indicated that, residents of rural communities in the improved and unimproved areas obtain drinking water from different distances of water sources.

Great variations in distance to water fetching exist between the improved water supply and the comparison areas. Question 13 asked households about the one way distance of the water source to the household. Table B.8(Appendix B) and diagrams 7.11 illustrate the distance travelled for fetching water in the improved and unimproved villages of the Urmia and Yazd City.

## Comparison of mean distance between households and source of water

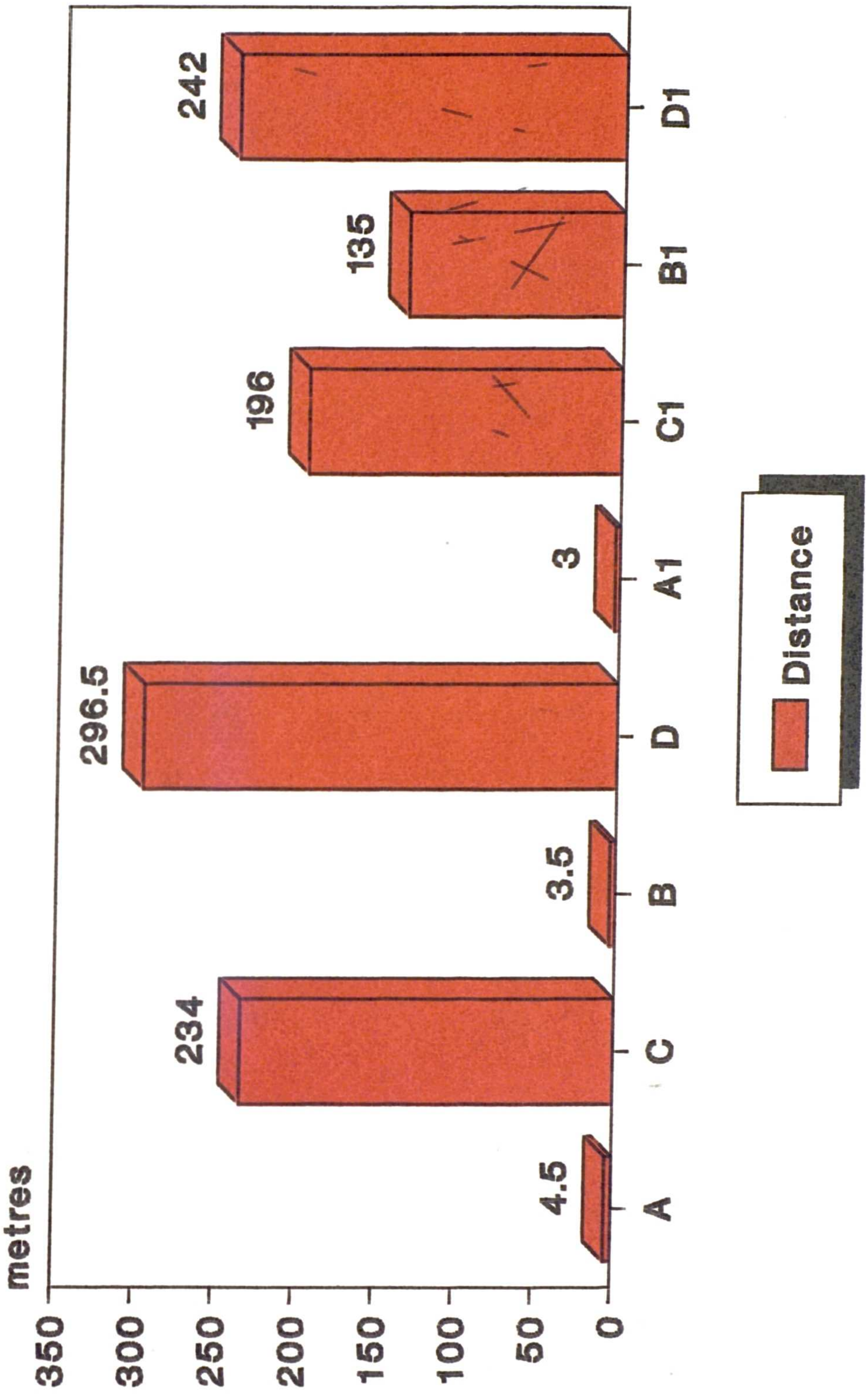



Figure 7.11

As can be seen from diagram 7.11, households in the improved villages A&B fetch water from a tap in their yard over a short mean distance of 4.5 metres and 3.5 metres. While in the unimproved villages C&D villagers carry water from a spring over a mean distance of 234 metres and 296.5 metres respectively.

In the Yazd villages households in improved areas only village A1 fetched water from a tap over a short average distance of 3 meters. Whilst households in B1 village despite having piped *water supply fetched water for* drinking from a cistern over an average distance of 135 meters. But households in the unimproved villages C1&D1 carried water from spring and qanat from a long an average distance of 196 metres and 242 metres respectively.

However, there is a significant difference between the improved and unimproved villages. T-test of difference between means of distance indicates that a statistically significant reduce of the distance by providing of a potable water supply in the villages A & B and A1&B1. Table B.8 (Appendix B) contains the results of means, standard deviation and a t- test, of the difference between the distance of improved and unimproved villages with a probability level $P<0.001$ as a significant level.

My findings also show that there is a significant negative correlation between the distance of water source from households and the quantity of water used at household with a probability (p=0.001) as a level of significance. The reason is that with increasing the distance of water source in the unimproved villages the amount of water used is reduced. For more details see Table B.9 ( Appendix B).

It can therefore, be concluded that, an improved piped potable water supply in the improved villages reduces the distance over which water is carried and that as a result there is the possibility of a positive social and economic impact on water carriers in villages.

## III:Round trip(travelled time) in fetching water(Question 14)

My above findings indicated that, the installation of a piped potable water supply in the improved villages can result in decreasing the distance travelled and it may lead to a decrease in the round trip travelled time. Question 14 asked households about the time spent for the round trip to get water. Table B.10 (Appendix B) and diagram 7.12 compare the mean round trip travelled time in the improved and unimproved villages.

## Comparison of mean round trip travelled time between water source and household

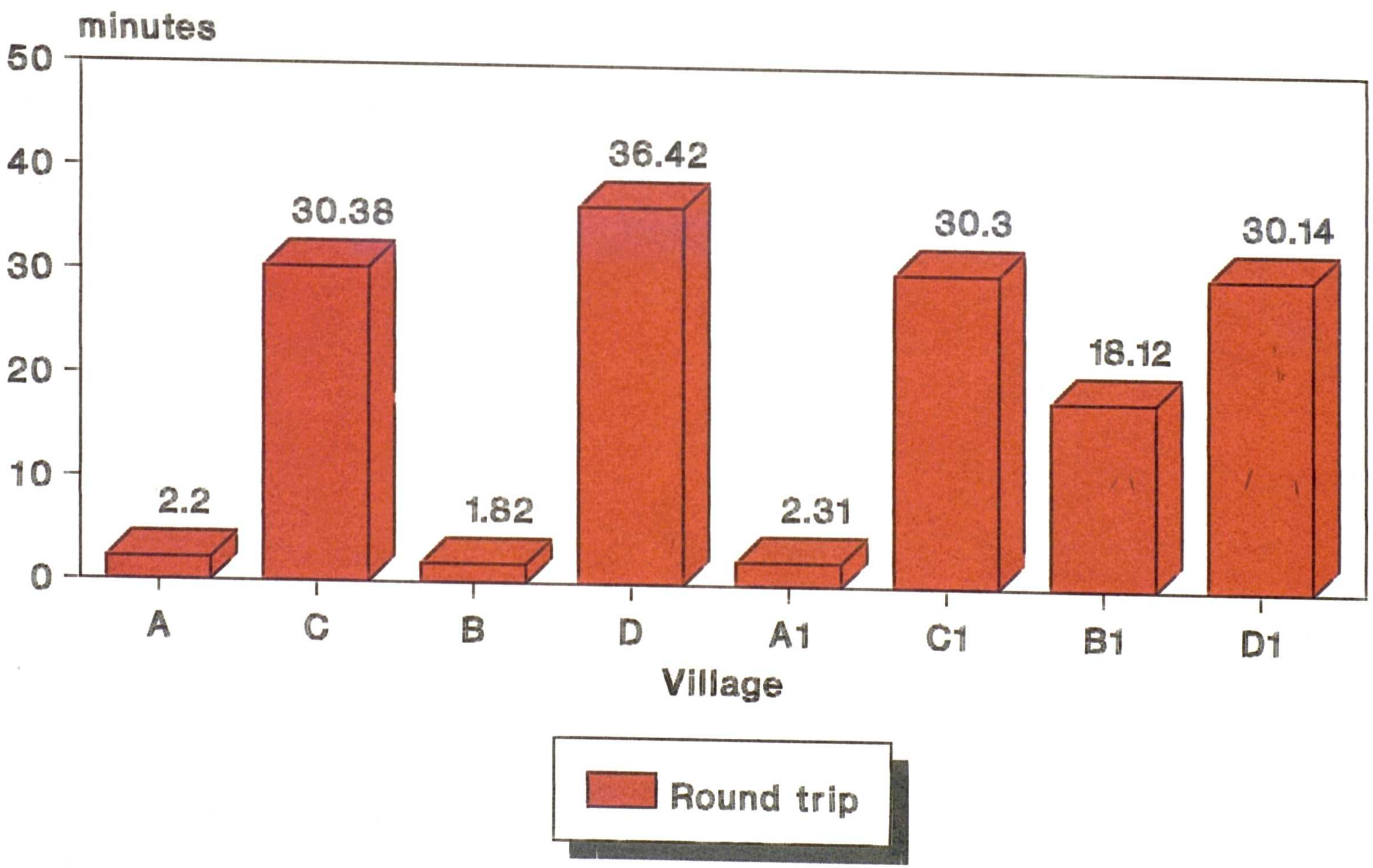



Figure 7.12

As the above figure shows, the mean round trip to get water in the improved villages of Urmia A&B is 2.20 and 1.82 minutes, while in the unimproved areas C&D is 39.42 and 36.42 minutes respectively.

In the Yazd villages, the mean round trip travel is 2.31 minutes in the improved villages A1 and 18.12 minutes in the village B1 while,in the unimproved villages C1&D1 the mean round trip are 30.38 and 30.14 respectively.

There is *significant* difference between *the means of* round trip travelling time fetching water in the improved and unimproved villages. T-test of difference between the means shows a statistically significance reduce in the time spent for round trip in the improved villages with a probability level (P<0.001). For more details see table B.10 (Appendix B).

My findings also showed that there is a positive significant correlation between the mean distance of water source and round trip travelled time for fetching water in the improved and unimproved villages with a probability level P=<0.001. The main reason is that, with increasing ~~the~~ distance of water source the round trip travelled time is increased see Table B.9 (Appendix B ).

## IV: Total daily time spent for fetching water (Question 15 to 17)

My observation and survey in the unimproved villages showed that the majority of women, children and sometimes men spent their time fetching water. Questions 15 to 17 asked households about the total daily time spent fetching water. Table B.11 to B.13 (Appendix B) and figure 7.13 illustrate the total daily time spent by women, children and men.

As the figure 7.13 shows, the total daily mean time spent in the improved villages A&B for *women and children* are 20.5&14.5 and 11.5&10.5 minutes, while in the unimproved villages are 157 & 175 and 124 & 153 minutes respectively.

In the improved Yazd villages A1&B1 the total time spent for women and children are 13 & 60 and 10 & 50 minutes, where as in the unimproved villages C1&D1 are 108 & 120 and 95.50 & 105 minutes respectively.

My findings also showed that in the unimproved villages usually men fetch water due to the great distance to the water source. The total daily mean time spent by men in villages C & D was 62.5 & 82.5 minutes. While in the unimproved villages C1 & D1 it was 30 & 24 minutes respectively.

However, there is significant difference between the daily mean times spent for fetching water by women and children in the improved and unimproved areas. The difference between the means was tested by t-test and indicated that, there is a statistically significant decrease in daily time spent for fetching water in the improved villages for women and children with a probability level (P=<0.001). But there is no significant difference between the mean time spent by men in the villages B1 and D1. For more details see Tables B12 to B13 (Appendix B).

In conclusion, it can be said the provision of a piped potable water supply in the improved villages A & B and A1 & B1 results in time saving for the women, children and men. This time released is of some considerable value either to the family as a welfare benefit or to the farm as an economic benefit. These aspects are dealt with in the following section.

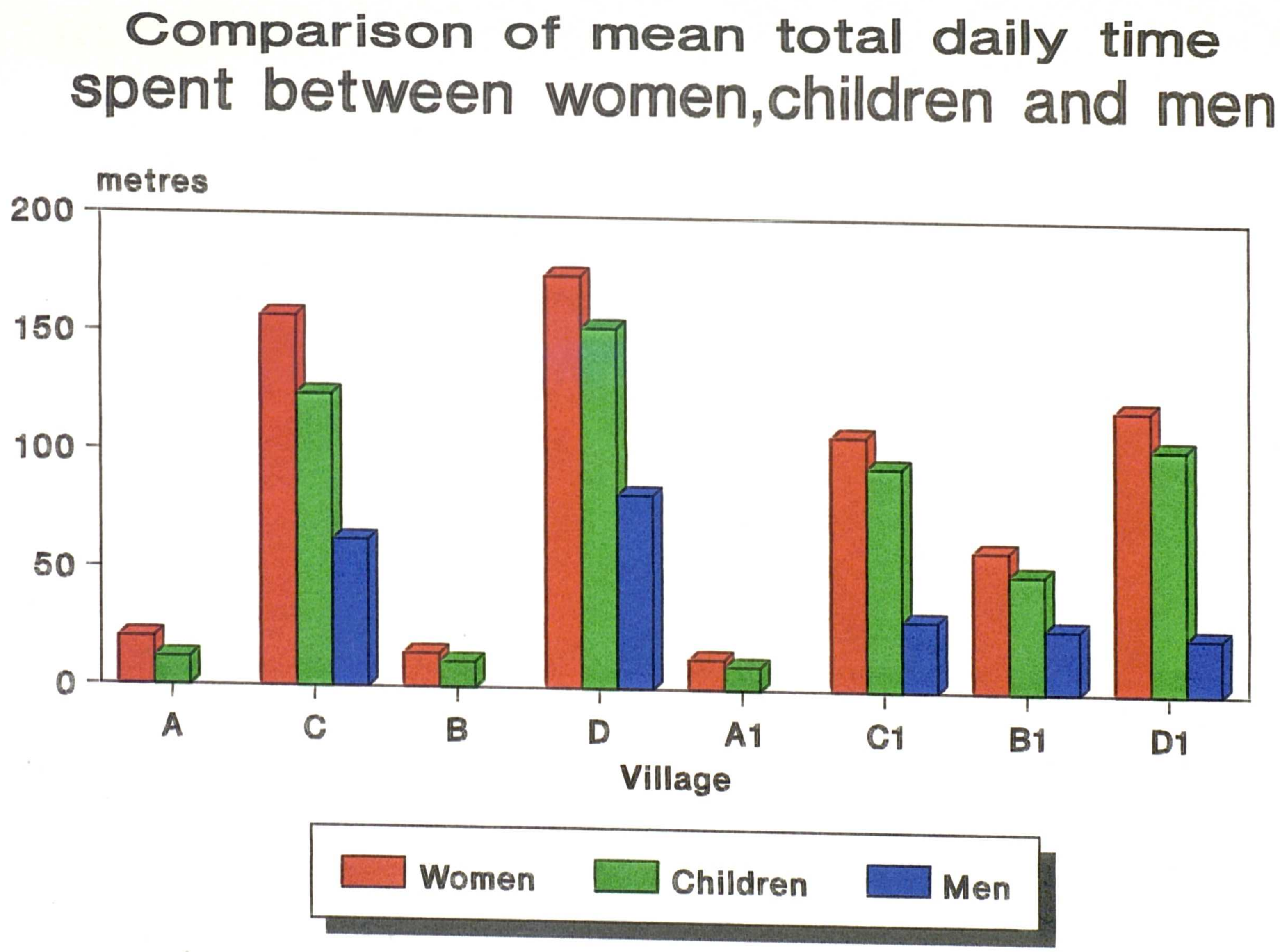

Comparison of mean total daily time
spent between women,children and men
metres
200
150
100
50
0
A
C
B
D
A1
C1
B1
D1
Village
Women
Children
Men

Figure 7.13

## V: Impacts of time saving on women and children (Question 18-19)

My investigation indicated that several activities may be possible using time released for housewives and their children. Questions 18 and 19 asked housewives about the available extra time from fetching water. Table B.14 (Appendix B) and diagram (7.14-7.15) illustrate the impacts of time saving on women and children.

As diagram 7.14 (Page 339) shows. in the improved villages A & B the majority of 48.5% and 42.8% of housewives stated that they spend their extra available time for housework and for agricultural work such as weeding and the irrigation of small garden in their house. 17.1% and 25.7% of them stated that they are interested in participation in the adult education classes. The remainder 34.2% and 31.5% of housewives answered that they spend their extra time on housework such as cleaning the house, cooking, washing dishes and clothes and baby care.

Of the children who were responsible for fetching water in the households, the majority 85.7% and 91.5% of them in the villages A&B reported that they have more time for studying and playing. The remainder 14.3% and 8.5% of the children stated that they more time to do agricultural work and to help their parents (see Figure 7.15 page 339).

In the improved villages A1 & B1, 54.2% and 48.5% of housewives stated that they usually spend their time on carpet making. 25.7% and 20% of them answered that they spend their time for the housework and baby care. 8.5% and 14.5% of housewives replied that they spend their time participating in adult education classes. The remainder 11.6% and 17.1% of them answered that they spend their extra time on housework and agricultural work.

Among the children, the majority 62.8% and 51.4% in the villages A1 & B1 stated that they spend their extra available time on carpet making and 31.4% and 45.7% answered that they spend on time in studying and playing. However, the remainder 5.7% and 2.9% stated that they do agricultural work and help their parents.

In conclusion, it can be said that, the provision of piped water supply in the improved villages of the Urmia and Yazd City leads to saved time and this in turn creates opportunities for participation in the adult education classes, domestic activities such as house work and baby care and on economically productive activities such as carpet making and agricultural work. Furthermore, the children in the Urmia villages took the opportunity for study and playing and for children in the Yazd villages for economically productive activity such as rug making.

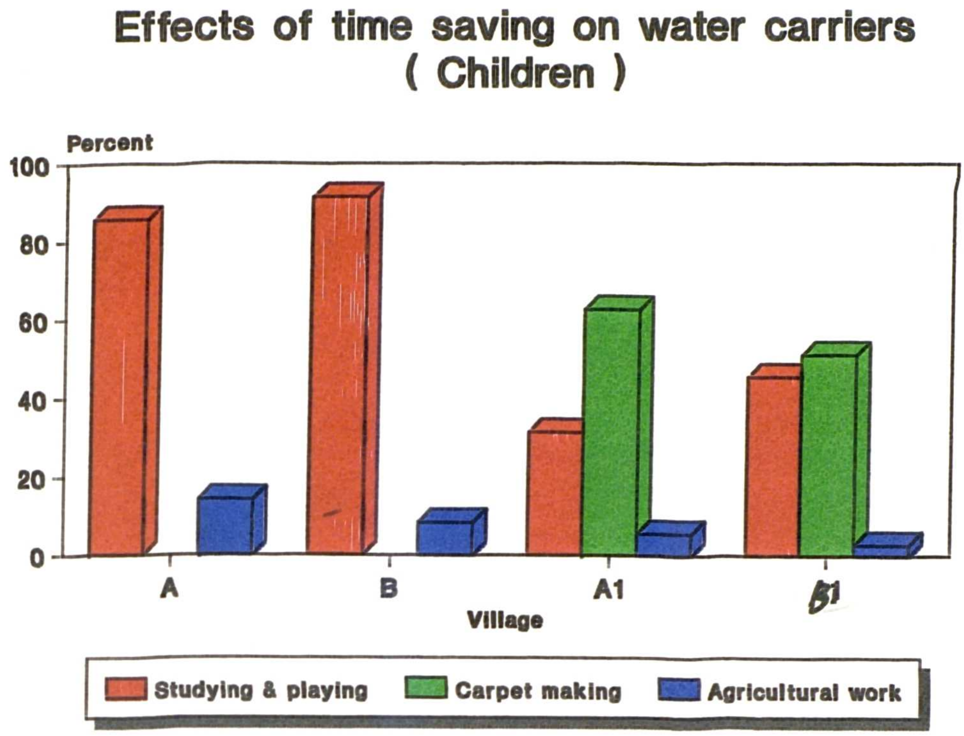



Figure 7.15

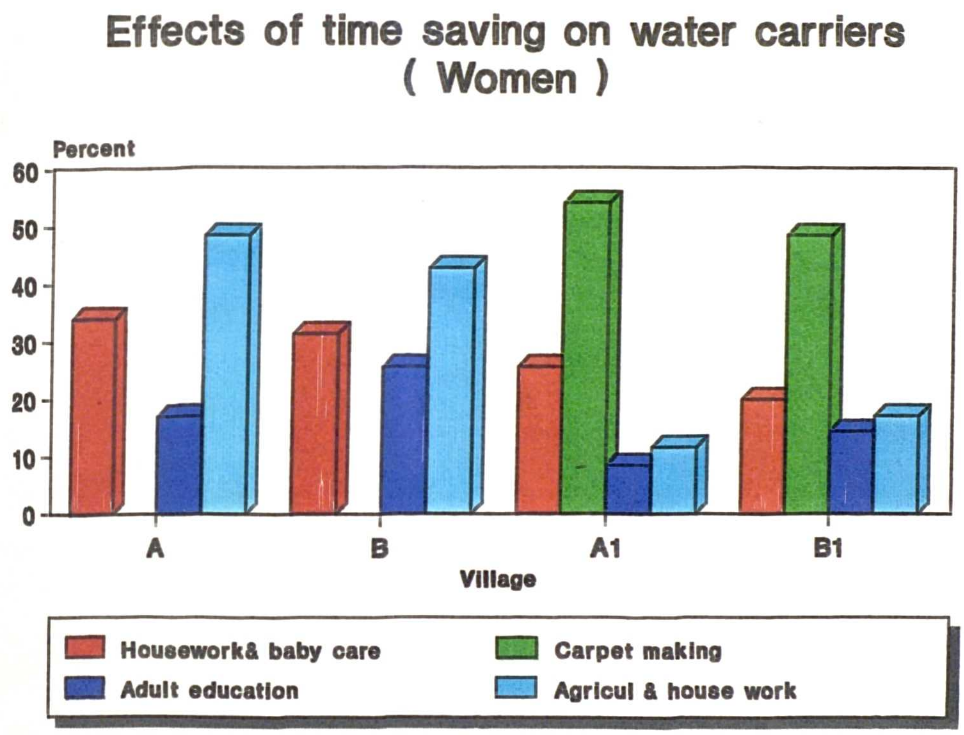



Figure 7.14

## 7.6.8: Survey of the economic effects of piped potable water supply in the sample villages

### I: Introduction

I believe that the provision of a piped potable water supply to rural areas may have secondary productivity impacts such as: water quantity and time released for water collection have the greatest economic implications for increased productivity. In this section three aspects of these activities are considered. They are:-

**1**: the positive impact of a potable water supply on livestock activities.

**2**: the positive impact of a potable water supply on small scale industrial production.

**3**: the positive impact of a potable water supply on the use of small gardens.

### II:Livestock Activities(Question 20-21)

My observations showed that livestock activities in the Urmia and Yazd villages are sheep, goat, and cattle rearing. Livestock was found in all villages but the activities varied from village to village. Questions 20 and 21 asked households, about livestock activities.

My investigation revealed that in the villages A&B

60% and 51.4% and in the unimproved villages 45.7% and 40% of households had livestock activity. While in the improved (A1 & B1) and unimproved (C1 & D1) villages of Yazd 25.7% & 31.4% and 20% & 17.1% of households had livestock activities.

Table B.15 (Appendix B) illustrates the proportion, means of difference between the size (sheep and cattle) in the household, t-test and standard deviation in the villages. The provision of a piped water supply does not seem to have had any impact on the rate of keeping of livestock as the size of cattle, sheep.

My findings showed that the expectation greater water availability would result in the mean number of the livestock per household in the improved villages being significantly increased does not occur. Thus, there are no significance differences in mean numbers of sheep and cattle between the improved and unimproved areas.

My observations and survey support this suggestion as livestock does not usually benefit from village water supplies as animals are usually grazed away from the villages and able to use natural water sources that are found around the Urmia villages.

**III:Small scale industrial activities(Question 22-23)**

My survey and observation showed that there are a number of large industries in the sample villages but that they are small and are usually confined to individual households.

Water is used to produce items for which there is an immediate market. Typical activity include brick-making with sun dried earth.

This activity requires an adequate water supply and it was measured in terms of the average weekly water used. Questions 22 and 23 asked household about this activity. Table B.16 (Appendix B) and Figure 7.16 show the percentage of the households having a brick making activity and the mean of difference weekly water used and t-test and probability level in the improved and unimproved villages of Urmia and Yazd. My survey and observations showed that, brick making activities occurred in all villages but that it is greater in the improved villages.

My findings indicated that, in the improved (A&B) and unimproved (C&D) villages of the Urmia 22.8% & 17.1% and 5.7% & 8.8% of households had brick making activities and the mean amount of weekly water used were 731.250 & 714.285 and 165 & 96 litres respectively.

In the Improved A1&B1 and unimproved C1&D1 of the Yazd villages 20.5%&14.2% and 5.7%&11.4% of households had brick making activities and the mean amount of weekly water used were 433.5&400 and 110&92 litres respectively.

The changes which occurred in the mean weekly water usage among households engaging in brick making activities were tested for significant with t-test of the mean of the differences. Thus there is a significant difference between the mean of the weekly water used in the improved and unimproved villages with a probability level (P<0.001) for villages A & C, P=<0.002 for villages B & D, P=<0.006 for villages A1 & C1 and P=< 0.009 for villages (B1 & D1). For more details see Table B.16 (Appendix B).

A comparison of mean weekly water used between the improved villages Yazd and Urmia showed that the amount mean weekly water used in the Urmia villages is more than in the Yazd area. T-test of the difference between the means indicates that a statistically significant increase in brick making activity in the Urmia villages with a probability level P=<0.001. The main reason may be related to water shortage in the Yazd villages.

In conclusion, it can be said that, the improved villages A&B and A1&B1 which have access to piped water supply may get more benefit from brick making.

## Comparison of mean weekly water used for small garden activity

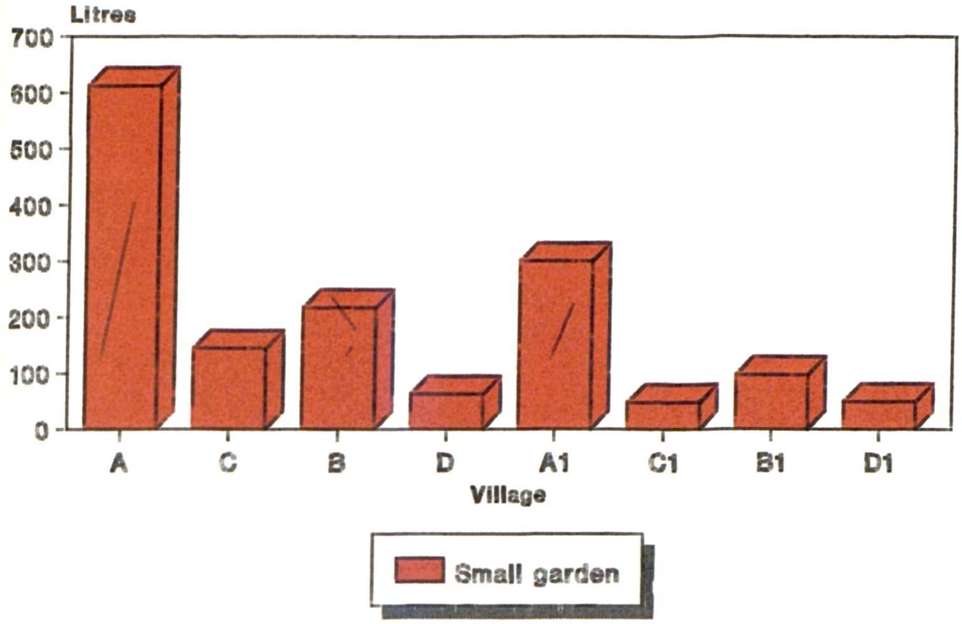



Figure 7.17

## Comparison of mean weekly water used for brick making activity

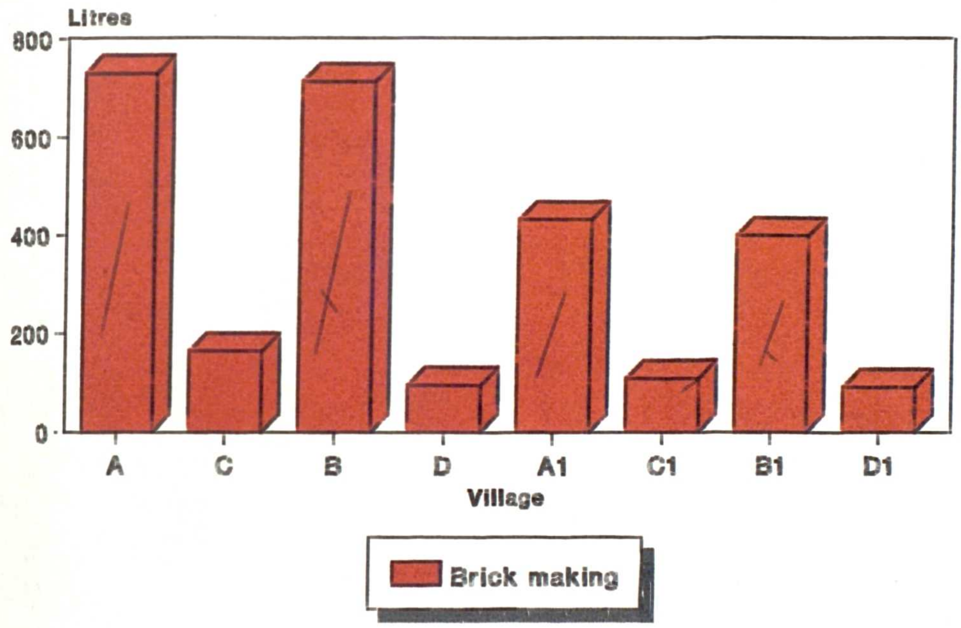



Figure 7.16

**IV: Small scale garden activities(Questions 24-25)**

I believed that, where an improved water supply is constructed primarily for domestic purposes there is often excess water available for none domestic use and it may be used for irrigation of the small scale garden.

I tested this view in my survey and my finding are as follows:-

1. The majority of households in the improved villages have a small vegetable garden in their yards.
2. The gardens which the author observed in the sample villages is usually cited within 5 and 25 m2 and have been planted with a few apple, grape trees and or with vegetables such as; lettuce, celery and carrot for use by the villagers and or selling at markets.

These gardens benefit directly by the availability of an adequate supply of water. Therefore, I obtained measurements of weekly water use for households irrigation. Questions 24 and 25 asked households about this activity. Table B.17 (Appendix B) and Figure 7.17 (page 344) illustrated the average weekly water used, t-test, and probability level in the improved and unimproved villages.

My findings showed that in the improved villages A&B, 68.5% and 65.7% and in the unimproved villages C1&D1, 20% and 17.1% of household had access to a small garden. While

In the Yazd villages A1&B1 and C1&D1 40% & 25.7%, 17.1% and 14.2% of household had small garden respectively.

As Figure 7.17 (page 344) shows the mean amount weekly water used for garden watering in the improved and unimproved villages of Urmia were 612.50 & 217.39 litres and 144.28 & 63.33 litres. Whilst, in the improved and unimproved villages of the Yazd it was 300 & 98 litres and 48.3 & 50 litres respectively.

My finding showed that, there is significant difference in mean weekly water used between the improved and unimproved villages of both regions. This difference was tested for significance with t-test of the mean of weekly water used in villages with probability level ($p < 0.001$).

A comparison of small scale garden activities in the Urmia and Yazd villages showed that a number of households have small garden activity and the amount of weekly water used in the Urmia villages is more than in the Yazd area. Thus there is a significant difference between the Urmia and Yazd villages. A t-test of the mean of the difference of weekly water used in the improved villages of both region indicated that increase this activity in Urmia villages with a probability level $p=<0.001$ as a significance level. The main reason may be due to the availability of water in the Urmia villages and lack and shortage of water in the Yazd villages.

In conclusion, it can be said that, the provision of a piped water supply has beneficial impacts on the improvement of small garden in the improved villages of Urmia. But in the improved villages of the Yazd some aspects of the desert climate leads the housewives to get less benefit from this activity.

## 7.6.9: Survey of Water and excreta related Disease

### I: Introduction:

This section deals with the survey of the water and excreta related diseases and health impacts of piped potable water supply and sanitation project in the sample villages.

### II: Water related diseases(Questions 27-28)

I believed that, direct measurements of health parameters in case studies normally demand highly trained personnel and with a fully equipped laboratory. Because, these resources were not available in the villages, I devised a series of indirect measures of health. I considered water related diseases particularly diarrhoea among children less than five years old.

To measure the incidence of diarrhoea, data were collected from the health centres in each village and interviews were undertaken with housewives. My survey showed that in all the villages there was some incidence of diarrhoea especially during the summer season. Question 26 asked housewives, how many children less than five years old frequently suffered from diarrhoea?. The information is summarised in Table B.19 (Appendix B).

The data showed that in the improved villages A&B 25.7% & 17.1% of their children less than five years old were frequently infected with diarrhoea, while, in the unimproved villages C&D were 77.1% & 74.2% respectively.

In the unimproved villages of Yazd A1&B1 25.7% & 20% of households responded that their children less than five years old were infected to diarrhoea, whilst in the unimproved villages C1&D1 were 74.2% & 71.4% respectively.

The difference of the mean number of children less than five years old per household between villages A&C, B&D, A1&C1 and B1&D1 was tested by t-test. My result showed that there is significant difference between the mean number of children less than five years old in villages A&C and A1&C1 with a probability level (P=<0.001). While there is no significant difference between the mean number of children in the villages B & D and B1 & D1 with a probability level (P=<0.087 & P=< 0.319).

In response of the question 27 what is the main cause of diarrhoea, my findings showed that 62.6% of housewives answered that the contaminated water is the main cause of diarrhoea and 31% of households replied that the polluted food and the remainder 6.4% of them responded that do not know. For more details see Table B.19 (Appendix B).

My survey showed that the incidence of diarrhoea in the unimproved villages is more than in the other villages. The possible reason might be related to the lack of availability of potable water supply in these villages.

**III: Excreta related diseases**

According to reports from the health centre in the villages B1 and C1 of Yazd, in addition to diarrhoea other diseases such as parasites especially giardiasis, are very prevalent among the children under five years old. Data obtained from the microbiology laboratory showed that, among 50 children were examined 65% had giardiasis, 29% has ascariasis and 6% were infected with oxyu re. The probable cause is the use of unprotected qanat water in village C1 and use by children of cistern water in village B1.

According to the health officers, parasite diseases in the Urmia villages are very prevalent but accurate real data was not available in the health centres of villages. Hence, the author obtained information from a survey which has been undertaken in 1992 by Shariety among 12 villages in the Urmia area. The results showed that of 6609 people who were examined, 3803 (57.5%) were infected to the parasite diseases.

Among the parasitic diseases, giardia with 31.1%, Oxyuire with 22.4% and ascariasis with 8.4% was the highest prevalence among children less than 5 years old. Ascariasis infects people at the age of 5 and upper. It is most prevalent between the age group 25-44 where more than 21% infection has been recorded. The next most susceptible group are the age of 5-14 with 16.1% infection. The probable cause is that in the majority of Urmia villages many people use animal and human waste for agriculture purposes (see photograph 7.10 and 7.11 page 359).

It is concluded that, the provision of potable water supply is only one important factor in rural area health improvement. Other significant aspects such as:- health education; sanitation of latrines; the correct disposal of human and animal excreta; changes in the belief and behaviour of rural people; the awareness of people to the need to protect the environment, all may have beneficial impacts on reducing excreta related disease in the improved and unimproved villages.

## 7.6.10: Survey of village sanitation

### I: Introduction

I believed that the implementation of a piped potable water supply projects in the Urmia and Yazd villages has not drastically benefited people without also improving the sanitation facilities. (To obtain the full benefit from the piped potable water supply projects there must also be improved environmental sanitation).

In this section I intend to discuss the survey of the existence problems of the environmental sanitation in the sample villages including; pit latrines, disposal of human and animal excreta, waste water disposal and their impacts on public health and environment. As previously data was obtained through my observations, from the field studies and questionnaires.

### II: Problems of pit latrines and human excreta disposal

My observations in the improved villages of Urmia showed that 91.5% of households have access to sanitary pit latrines, whilst in the unimproved villages only 30 percent of households use sanitary pit latrines.

In the Yazd villages 88.5% of households in the improved and 44% of households in the unimproved areas have access to sanitary pit latrines.

My own findings showed that, many unsanitary latrines occur in the unimproved villages C & D and C1 & D1. The latrines cause problems such as; the presence of flies and mosquitoes, bad smells, and difficulties of use for children under five years old.

My observations also indicated that, in all villages only one kind of simple pit latrine without *flushing of* water is used, but that some of them were sanitary and the remainder was insanitary. A sanitary pit latrine consist of three main parts; the dug pit, the superstructure, and the squatting plate, or slab floor, which is usually made of concrete. This type of pit latrine should be easy to clean, comfortable to use and control flies. Thus, if a latrine does not have these conditions, it is called an unsanitary pit latrine.

When people use a pit latrine they have to carry at least 10 litres water to wash themselves and to flush their excreta. In unimproved villages, where water is scarce, many of these pit latrines become clogged with human faeces and thus may lead to pollution of the environment and ultimately create health risks for householders and village.

The techniques use for the disposal of human excreta in villages are different. Question number 28 asked households about disposal of human waste. Table B.20 (Appendix B) shows the perception of households concerning the disposal of human waste. The majority 71.4% & 85.5% of households in the improved villages of Urmia A&B dispose of their human excreta through a car and then carry it out of village. The remainder 28.6% & 14.8% of them use it as a fertilizer. Whilst in the unimproved villages C&D, 62.8% & 68.5% of people, use human excreta, after drying it, as a fertilizer. The remainder 37.2% & 31.% of them leave it a deep hole.

When I was visiting these areas I found that a few households in the unimproved villages particularly in village C dispose of their pit latrines waste into a small stream next to the spring water. Photographs 7.5 and 7.6 illustrate the unsanitary pit latrines and unhealthy disposal of human excreta on the ground in the village C & D respectively.

In the improved villages A1 & B1 of Yazd, the majority 85.5% & 94.3% of households dispose of their human excreta into deep holes and a few only 11.4% & 5.7% of households use it as a fertilizer. Whilst, in the unimproved villages C1&D1, 77.1% & 60% of households leave it in a deep hole and the remainder 22.8% & 40% of them use it as a fertilizer.

Many aspects of human waste disposal are different between the Urmia and Yazd villages. They are:-

1. The water table level in the improved villages of Urmia is high, thus villagers have to empty human waste by a car twice a year. Otherwise many pit latrines clog with human excreta and cause bad smells and other difficulties for households. In the Yazd villages, however, the water table is low and they can leave it in a deep hole.

2. Agricultural activities in the Urmia villages making the use of human excreta as a fertilizer feasible.

Photo 7.5 Unsanitary pitlatrine and unhealthy disposal of human excreta into stream in village C

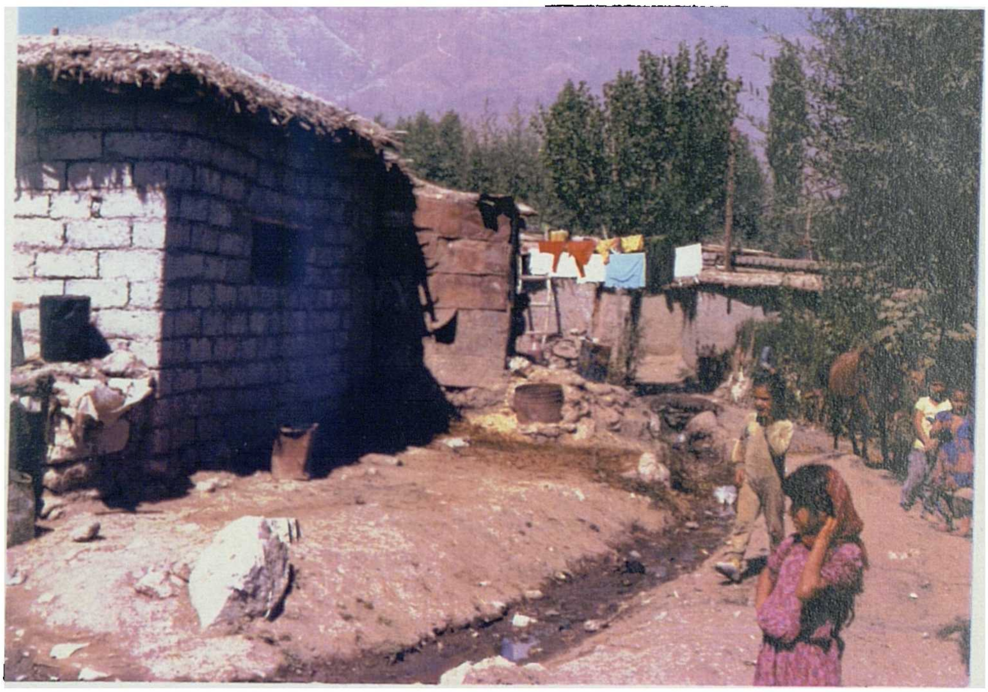


Photo 7.6 Unsanitary pitlatrine and disposal of human excreta to the street in Village D

**(III): Problems of waste waters, solid waste and animal waste disposal**

As pointed out, on page 310, many households in all villages especially in the improved and unimproved areas of Urmia dispose of the waste waters including; that for:- washing utensils, washing clothes, bathing adults and babies as well as sanitary waste water from taps to the streets, open canals or into the yard and small garden. Thus, the unsanitary disposal of these wastes has caused the general environment to become polluted. These problems are discussed in the following section.

When the author asked housewives why do you dispose of your waste water out of the house?. The majority replied the village has no sewerage system and this is the easiest way to dispose of waste waters. My further observations showed that, the pollution of environment by the waste waters in the Urmia villages is worse than Yazd ones. Photograph 7.8 and 7.9 illustrate the flowing of waste water from households to a open canal and street in the villages A & B respectively.

Similarly, solid waste are thrown out of houses by the majority of villagers. In the improved village A1, in the Yazd area, however, households have employed two persons, from the village, to collect and dispose of solid waste out of the village area.

Animal wastes like human excreta have harmful impacts on health and environment. Unhealthy disposal of animal waste occurred in many rural areas especially in the Urmia Villages A&B and C&D. Question 29 asked households about the dispose of animal waste. The methods which are used to dispose it are shown in Table B.21 (Appendix B) . The data shows the majority 68.5% & 62.8% of households in the villages A&B and 82.8% & 71.1% in the villages C&D in the Urmia area use unsanitary method to dispose of animal waste. My observations showed that, housewives collect the animal waste with their hands and then dump them close to their own houses for later use as a fuel or fertilizer. Photograph 7.9 and 7.10 show the collection and dumping animal waste in the Urmia villages.

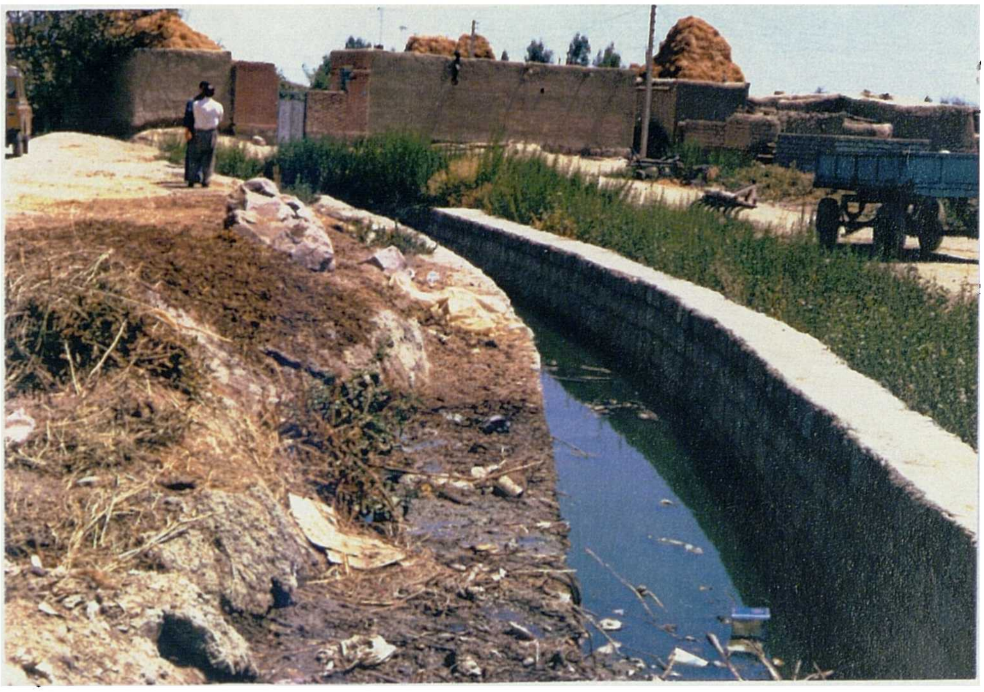


Photo 7.7 Flowing of waste water to open canal(village A)

Photo 7.8 Flowing of waste water to the street(villageB)

Photo 7.9 Dumping of animal waste (village A)

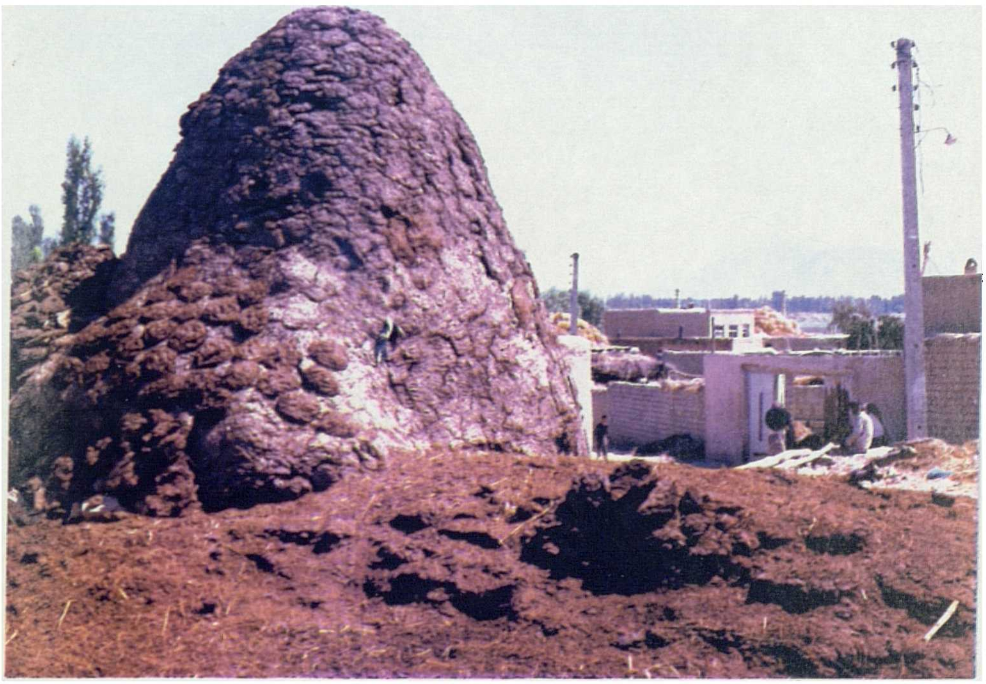


Photo 7.10 Dumping of animal waste (village B)

By contrast, in the improved and unimproved villages A1&B1 and C1&D1 of Yazd, the majority 51.4% & 45.7% and 40% & 34.8% of households respectively who had animals, collected and carried it out of the village and use it only for fertilizer not as a fuel.

It can be concluded that, animal waste disposal method in the Urmia and Yazd villages are different in many aspects, and it is possible to state that:-

**1.** animal waste disposal method in Yazd villages is relatively better than in the Urmia villages. Thus, health risks in the Urmia areas are greater than in the Yazd area.

**2.** The winter season in the Urmia area is more sever and longer than in the Yazd area and thus leads villagers to keep and use animal waste as a fuel.

**3.** As the above photographs show, contamination of environment by the animal wastes in the Urmia villages is greater than the Yazd villages.

**(IV): Impacts of unsanitary disposal of human and animal wastes on environment and public health**

It is evident from my previous section that the sanitary conditions in the sample villages except in the improved village of Yazd (A1) are very poor. Stagnant pools and open canals of water, sewage and with garbage carelessly strewn about, refuse freely littering the yards and streets, and ill-conceived and traditional insanitary habits of living all occur.

In the unimproved villages lack of a good water supply system on one hand and the unsanitary disposal of human and animal excreta on the other hand are public health risks.

Observations on the dumps of animal wastes indicated that a further adverse impact is that non insects such mosquitoes can be attracted by the waste as a food supply and a place of breeding for rats and mice. These pests cause health problems in their own right. Another significant adverse impact of this waste on public health is that large areas have a very bad smell.

The collection and flowing of waste water from households into open canals and also the gathering and dumping of animal excreta next to houses even in the improved villages of Urmia has a disgusting impact on the landscape of adjacent areas.

In addition, pathogens in both human and animal discharge to the land surface may penetrate to underground water sources causing diseases. Hence, this form of pollution also has health hazards to consumers of well water especially in the improved villages of Urmia due to high level of ground water.

### (V): Positive beneficial effects of gathering animal wastes

Further personal observations and surveys of households in the sample villages indicated that, in contrast to the several adverse impacts of animal wastes, there are also positive and beneficial impacts.

As previously concluded, the majority of households in the improved and unimproved villages of Urmia replied that they use the animal waste for cooking and heating during winter. They also use and sell it as a fertilizer thus generating financial income for households.

## 7.6.11: Summary of main findings

The identification and evaluation of beneficial and adverse impacts that might arise from a potable water supply and sanitation project in the Northwest and Centre of Iran was based on comparisons between the improved and unimproved villages in the Urmia and Yazd City. The main finding of this case study have been divided into two main groups; (a) beneficial impacts and (b) adverse impacts. Thus they are dealing with briefly in the following section.

### (a): Beneficial Impacts

The major beneficial impacts is divided into (i) direct and (ii) indirect effects including:

### i. Direct beneficial effects

**(1)** Significantly increased in the consumption of water (per capita and per family) occurred in the improved villages. My findings showed that the mean amount of per capita increased in the villages A&B by 7.4 and 8.9 litres. In the improved Yazd villages A1&B1 the mean amount of per capita increased by 7.7 and 8.1 litres. Increased quantity of water is caused by increment of water usage or activities such as; washing clothes, washing utensils, watering gardens, bathing adults and children.

**(2)** significantly decreased in the distance of water source to households. My investigation indicated that the distance decreased in the villages A & C 229.5 metres(C-A=234-4.5), and for villages B & D, 292 metres (D-B=296.5-3.5). While in the Yazd villages A1 & C1, 193 metres (C1-A1= 196-3) and 107 metres (D1-B1= 242-135) for the villages B1 & D1.

**(3)** Significantly decreased the round trip travelled time for fetching water. My result showed that the round trip travelled time in comparison with the villages A & C was 37 minutes(C-A= 39.5-2.5), for villages B & D was 34.5 minutes (D-B= 36.5-2), for villages A1 & C1 28 minutes (C1-A1=30.5-2.5), and 12 minutes (D1-B1=30-18) for villages B1 & D1.

**(4)** Significantly decreased the total daily time spent for women and children in fetching water. In this respect, my finding revealed that in villages (A&C) the time saving for women was 136.5 minutes(157-20.5), for children 112.5 minutes(124-11.5), for villages B & D was 160.5 minutes (175-14.5), for women and 85.5 minutes (153-10.5) for children. In the Yazd villages, A1&C1 the time saving for the women was 95 minutes(108-13), and 142.5 minutes (95.5-10) for children. In the villages B1 & D1 for the women was 60 minutes(120-60), and 55 minutes (105-50) for children.

**(5)** Diarrhoea disease decreased. My results showed that the proportion of children less than five years old in the improved villages is more than, unimproved ones. Moreover, t-test of the mean between villages A&C and A1&C1 showed that diarrhoea significantly decreased in the villages A & A1. My findings also showed that parasitic diseases such as giardiasis,ascariasis and oxyuire occurred in all villages particularly in the Urmia villages.

**(6)** The quality of water improved. My findings showed that the quality of water in the improved villages is better than in unimproved villages, the exception being village B1.

**(ii). Indirect beneficial impacts**

Indirect positive impacts also stemmed from the availability of potable water supply including:-

**I. Addition domestic activities:** including; extra baby care, food cooking, and house cleaning became possible.

**II.** Participation of housewives in adult eduction classes and attendance of children in school became possible in general.

**IV. Economic activities** such as:-

(a) Increased livestock activities, impact did not occur, but there was an increase in home industrial activity such as brick making.

(b) Agricultural activities such as: irrigation of small gardens became possible in general.

**(b) Adverse effects**

The consequences of the adverse environmental impacts of a piped potable water supply and more usage of ground water occurred in the Yazd villages including:

1. Dropping of the water table
2. Depletion and degradation of ground water quality
3. Decrease pressure in the aquifer
4. Damage to or destruction of qanat waters in the Yazd areas

**(c) Village sanitation**

The results of my observation and survey from the village sanitation status showed that, there were some significant problems regarding environmental health in all villages except village A1 in the Yazd area. They are:

1. The flowing of waste water from households to the streets and to open canals.
2. The reuse of human and animal excreta as a long standing activity is practiced in all the sample villages but particularly in the Urmia areas.
3. There is the likelihood of pollution surface waters and ground waters by insanitary disposal of human and animal waste.

# CHAPTER 8

# Application of EIA in Water Supply and Sanitation Projects

## 8.1: Introduction

As stated earlier, in chapter 2 (page 26), to assess the beneficial and adverse impacts of a project it is desirable to use an EIA technique. In this chapter, different methods of EIA are first briefly described and illustrated, then a suitable technique of EIA will be selected to assess the impacts of a piped potable water supply and sanitation project in the rural areas of Iran. Secondly, the application of checklists and matrices in the water supply and sanitation projects in the sample villages and an EIA matrix presentation survey are described. Thirdly, comments on the most important environmental impacts( positive and negative) identified in the matrix are discussed. Finally, mitigation measures to minimize adverse environmental impacts and to maximize positive impacts, and the conclusion and main findings of the application of EIA to water supply and sanitation projects in the rural areas of Iran, will be considered.

**8.2: Methods of Assessment**

Several methods and techniques have been developed to meet the many requirements of environmental impact assessment even so, there is no single " best" methodology. Characteristics of a technique such as the types of impacts or projects covered and resources available might be virtues in one instance, vices in another. Thus, only the decision makers can determine which tools may be best appropriate to a particular task ( Warner, et al, 1974).

Information on the various methods of assessing environmental impacts of proposed activities are available in documents such as; Sammy (1982); WHO (1983); Mitchell (1989); Biswas and Geping ( 1987); Ahmad and Sammy (1985); Wathern (1988) and the United Nations ( 1985).

In 1990, Prusty reported that most authors who have reviewed the development of techniques, have adopted the following classification:

1. Ad hoc Method
2. Checklists including; simple, descriptive, scaling, and weighting and scaling.
3. Matrices including; simple, scaling, and stepped matrices.
4. Overlays
5. Networks
6. Evaluation techniques

7. Adaptive methods
8. Modelling

Each method has its own advantages and limitations. I have given initial consideration to those aspects relevant to the application of EIA in water supply and sanitation projects.

Of the various types of EIA, because they represent the most widely used methods, only checklists, matrices, networks, and overlays will be discussed in this chapter. In addition the use of techniques such as computer modelling are not suitable for use where expertise and computer facilities are not freely available.

**I: Checklist methods**

Checklists are lists of environmental parameters or impact indicators which the environmental analyst is encouraged to consider when identifying potential impacts. Such lists can be modified to reflect the nature of the development activity and the geography of the study area (United Nations,1985). They do not demand establishing cause-effect links to project activities and they also do not, may,or may not, include guidelines about how parameter data are to be measured and interpreted (Bisset, 1987 ).

According to the United Nations ( 1985); Sammy (1982) and Bisset, in 1987, checklists, are divided into four broad groups, which may defined as follows;

**(a) Simple checklists;** These consist of a list of environmental factors which *should be addressed in the* course of an assessment. Simple checklist do not provide information as to specific data needs and method of measurement; or impact prediction, quantification and evaluation.

**(b) Descriptive checklists;** these include an identification of environmental parameters and guidelines on how data on the parameters are to be measured .

**(c) Scaling checklists;** these are similar to descriptive checklists, but with additional information on the subjective scaling of these parameters.

**(d) Scaling - weighted checklist;** this technique is similar to the scaling checklists, but additional information is provided for the subjective evaluation of each parameters with respect to the other parameters.

According to Bisset in 1987, the simple checklist is still commonly used. The use of this method demands little technical and ecological data. Moreover, the WHO ( 1983) and United Nation in 1985 pointed out that, scaling and weighting checklist methods are more complicated and are not necessarily more useful.

The first and most efficient way of developing a checklist of impacts is by synthesis from other EIAs for similar projects (Ahmad and Sammy, 1985). The checklists are useful for structuring the initial assessment, but tend to be rigid and only direct impacts are considered.

**II: Advantages and disadvantages of checklists**

According to the United Nations in 1985, impact identification is the most fundamental function of an EIA and, in this respect, all types of checklists do well. But simple, descriptive checklists offer no more than just this. They merely identify the potential impacts without applying any sort of rating on their relative magnitudes.

A further advantage of checklists reported by Prusty in 1990, lies in its structure because it is designed to stimulate thoughts about possible consequences of proposed developed and to aid data gathering presentation.

**III: Matrix Approach**

Numerous matrices have been developed for environmental assessment work ( Mitchell, 1989). The most famous is the Leopold Matrix developed for the US Geological Survey (Leopold et al· 1971). Their matrix is ideally suited for impact identification and can be employed to illustrate the results of an assessment. Figure 8.1 shows an example of Leopold's matrix which can be used in an environmental assessment.

## Instructions

1. Identify all actions (*located across the top of the matrix*) that are part of the *proposed project*
2. Under each of the proposed actions, place a *slash* at the intersection with each item *on the side of the matrix* if an impact is possible
3. Having completed the matrix, in the upper *left-hand* corner of each box with a slash, place a number from 1 to 10 which indicates the MAGNITUDE of the possible impact; 10 represents the greatest magnitude of impact and 1, *the least*, (no zeros). Before each number place + (if the impact would be beneficial). In the lower right-hand *corner of the box place a number from* 1 to 10 which indicates the IMPORTANCE of the possible impact (e.g. *regional* vs. *local*); 10 *represents* the greatest *importance* and 1, the least (no zeros)
4. The text which accompanies the matrix should be a discussion of the significant *impacts, those columns and rows with* large numbers of boxes *marked and* individual boxes with the larger numbers

Sample matrix

| | a | b | c | d | e |
|---|---|---|---|---|---|
| a | | 8/1 | | | 1/6 |
| b | | 7/2 | 5/8 | 3/1 | 4/1 |

**Proposed actions** (across the top of the matrix)

**A. Modification of regime**
a. Exotic flora or fauna introduction
b. Biological controls
c. Modification of habitat
d. Alteration of ground cover
e. Alteration of ground water hydrology
f. Alteration of drainage
g. River control and flow modification
h. Canalization
i. Irrigation
j. Weather modification
k. Burning
l. Surface or paving
m. Noise and vibration

**B. Land transformation and construction**
a. Urbanization
b. Industrial sites and buildings
c. Airports
d. Highways and bridges
e. Roads and trails
f. Railroads
g. Cables and lifts
h. Transmission lines, pipelines and corridors
i. Barriers including fencing
j. Channel dredging and straightening
k. Channel revetments
l. Canals
m. Dams and impoundments
n. Piers, seawalls, marinas and sea terminals
o. Offshore structures
p. Recreational structures
q. Blasting and drilling
r. Cut and fill
s. Tunnels and underground structures

**C. Resource extraction**
a. Blasting and drilling
b. Surface excavation
c. Subsurface excavation and retorting
d. Well drilling and fluid removal
e. Dredging
f. Clear cutting and other lumbering
g. Commercial fishing and hunting

**CHEMICAL CHARACTERISTICS** (down the side of the matrix)

**1 Earth**
a. Mineral resources
b. Construction material
c. Soils
d. Land form
e. Force fields and background radiation
f. Unique physical features

**2 Water**
a. Surface
b. Ocean
c. Underground
d. Quality
e. Temperature
f. Recharge
g. Snow, ice and permafrost

Figure 8.1 Outline of a Leopold's Matrix Source: Leopold's et al.(1971)

According to Bisset in 1987, the matrix includes a horizontal list of project activities arranged against a vertical list of environmental parameters. The possible cause-and-effect relationship between particular activities and environmental variables can be identified by placing a mark in the similar intersecting cells. The United Nations in 1985 pointed out that, each cell in the Leopold matrix requires three operations including:

1. A slash is placed in each cell for which an action has a possible impact on any kinds of environmental characteristics, condition.

2. In the lower right - hand corner of each slashed cell, a number from 1 to 10 is inserted to indicate the "**IMPORTANCE**" ( sometimes referred to as significance ) of the possible impact. 10 representing the greatest importance and 1, the least (there is no zero value). Before each number place the symbol ( + ) if the impact would be beneficial, and the symbol (-) if the impact would be negative.

3. In the upper left hand corner of each slashed cell, a number from 1 to 10 is inserted to show the "**MAGNITUDE**" of the possible impact. Ten represents the greatest magnitude of the possible impact and 1, represents the least (no zero).

The magnitude of the effect is defined by Thomas in 1987 as " the degree, extensiveness or scale of an interaction", and it is assessed on the basis of the facts submitted. The magnitude of an effect depends on the magnitude of the action and magnitude of the environmental factors affected. A long road through a rain forest would have an effect with a large magnitude; where as an action of low magnitude acting on a small environmental factor would result in an effect of small magnitude.

Ahmad and Sammy in 1985 reported that "**MAGNITUDE**" refers to the quantum of change that will be experienced. A change of great magnitude would be, for instance: the doubling of a city's population.

Leopold et al; in 1971 defined "**IMPORTANCE**" of an effect as the weighting of the degree of importance of the particular action on the environment. So, it refers basically to the significance of the effect to the community. Short term importance may also be difference from long term importance (Thomas, 1987).

The assignment of a numerical value to the significance of an impact is based on the subjective judgement of an individual investigator or of an interdisciplinary team working on an environmental assessment study (Bisset, 1987). The importance of a impact depends on the effects of the change that may take place, and this has to be distinguished from the effect of the action.

The score for importance may, however, be different.

If a visual impact were to occur in an area of poor landscape quality then a score of only 2 or 3 may be marked instead of 7 or 8 in an area of high quality (Wathern, 1988).

The importance of an effect is difficult to evaluate, but it is necessary to attempt an estimate since, it will be essential to compare quantitative values of the magnitude and importance of many effects; such as comparing a large number of small adverse effects with a single large beneficial effects (Thomas, 1987).

Ahmad and Sammy in 1985 noted that the significance of an impact looks beyond the magnitude to the actual effects. Consider a species of fish which demands a minimum of 10 parts per million ( ppm) of oxygen in the water to survive. If the fish is an endangered species, or if it has economic or recreational *value, then a change* from 12 ppm to 9 ppm oxygen, though not great in magnitude, is absolutely significant.

According to Sammy in 1982, the construction phase of water resources project generally increases employment, wet season impoundment reduces seasonal flooding downstream of a dam, and supplying adequate quantities of water to be treated for domestic supply. In this context, importance addresses the significance to the area and population affected and magnitude indicates the degree *by which a* parameter changes. For example; the employment impacts are of varying magnitude, because during construction many jobs may be created thus the value of 7 can be assigned as to magnitude. While during the operation phase of a project only a few jobs may be created, thus the value of magnitude can be assigned as a low magnitude with value 2.

The health effects may be different in importance. The construction health effects are limited to the immediate area of the project. Thus, the importance of possible health effect is minor and the value 2 may be assigned. The provision of safe water to a majority of population during the dry season would be a benefit of great importance. Because, the demand of people for potable water is vital. Thus, the numeric value 6, in this case may be assigned as the significance of possible impact.

Bacterial ( cholera ) contamination of drinking water in a rural area can have negative impact on health. The significance of impact is considerable due to the health of people at risk and may kill them. Thus, the value of 7 may be assigned for the significance of the possible impact. If pollution of water become widespread on the whole area and all water sources become contaminated with cholera bacteria, the magnitude of possible impact can be noticeable. Thus the numeric value 9 may be marked as the magnitude of the possible effect of water contamination.

**IV: Advantages and disadvantages of Matrix**

Several advantages of the Matrix method have been reported by Wathern (1988); United Nations ( 1987); Abu - Zeid (1987); Mitchell *(1989) and Bisset in 1987 including:*

1. Matrices identify first - order interactions and represents a step ahead of checklists.
2. They are used in the identification of impacts by systematically checking each development activity against each environmental parameter to ascertain whether an impact is likely to occur.
3. By using the matrix method all interactions which are part of the proposed development can be identified.
4. By providing a visual display on a single diagram, the matrix may be effective in communicating results.

Despite the above advantages, there are several disadvantages including:

1. Immediate and long term impacts are not differentiated,although separate matrices may be prepared for different time periods.
2. The scoring of importance and magnitude is left to the judgement of an assessor and different individuals may produce different assessments.

**V: Overlays Mapping Method:** Mitchell in 1989 reported that, overlay mapping is as a useful technique for environmental impact assessment. It was used for the first time by McHarg in the 1968s. The application of this technique has a long history in environmental planning and is adequate for the consideration of spatial aspects of project assessment.

According to Warner, et al; (1974) and Abu - Zeid in 1987, overlays methods rely on a set of maps of environmental characteristics ( physical, social, ecological, and aesthetic) for a project area. These maps are overlaid to produce a composite characterization of the regional environment. Impacts are identified by noting the impacted environmental characteristics lying within the project boundaries.

The overlay approach involves various phases. During the first phase, categories of information are examined for their positive, negative or neutral effect on a prospective development or for the effect of the development upon them. Subsequently, values are then attributed to the categories and they are mapped on transparent overlays.

Categories assigned high value are given a dark shading, intermediate values are coloured in grey, and low value are lightly shaded or left clear. When the various overlays are superimposed, the cumulative affect of shading highlights those area where impact would be the least and the greatest (Mitchell, 1989).

According to the United Nations (1985); Abu - zeid (1987) Mitchell (1989) and Bisset in 1987, overlay techniques have both advantages and limitations. The chief advantages are: -

1. An overlay is simple and generates an effective visual display and shows the spatial dimension of impacts.
2. It is most useful in assessing alternative routes for linear developments, such as pipelines, highways and transmission lines.
3. The overlay method can be adapted for computer analysis, with weighting and mapping done by computer.

A number of disadvantages should, however be noted including:-

1. The overlay system can becoming confusing when large number of transparencies are super imposed and the combination of colour or the shading effect become a problem to recognize.

2. Overlays, do not consider characteristics such as probability, time and reversibility and are not adequate for the analysis of specific information.

3. The application of overlay mapping normally requires considerable information which way not always be readily available.

When the weakness and strengths are balanced, it appears that, the overlay method is useful as a "first cut" technique to identify major areas of concern, making it similar in value to checklists.

**IV: Network analysis**: Networks *use links and nodes* to depict the interrelationship between project activities and environmental impacts ( Sammy, 1982). The network is in the form of a tree, called a relevance of impact tree. It is used to relate and record secondary, tertiary and higher order impacts (United Nations, 1985).

Networks may be employed in the identification of the magnitude of impacts as a basis for determining their significance. They are an extension of matrices incorporating long - term impacts of the project activities where the environmental components are generally interconnected in the form of webs or networks (Santos, 1992).

Networks are also useful for displaying impact information and for organising the discussion of the anticipated impacts of a given project. These are useful for impact identification and impact display (Prusty, 1990).

The first EIA network was developed by Sorensen in 1971 (Bisset, 1987). Figure 8.2 shows a network analysis of dredging projects as utilized by Sorensen. This particular network analysis identifies various interrelationships, between the causal factors of dredging operations, such as removal of bottom material and production of material and the environmental items impacted by these operations. Secondary and tertiary effects associated with dredging are identified in this network.

According to Abu - Zeid in 1987 the major strengths of the network system are:- (a) its ability to identify pathways by which both direct and indirect environmental impacts are provided, and (b) it is useful in the consideration of mitigating measures during the early stages of project planning.

Besides these advantages, there are also some disadvantages associated with this method. To date, the need for network, techniques has been recognized but they have proved difficult to develop and use because of their size and complexity ( Santos, 1992). This technique does not provide a standard means of deciding on the relative importance of differing "cause - condition - effect" pathways (Prusty, 1990).

Prusty also noted that this method can cope partially with the problem of uncertainty, but risk, monitoring and the public dimension aspects are not identified by this technique. Although networks trace out high order effects, they can not identify all those which occur.

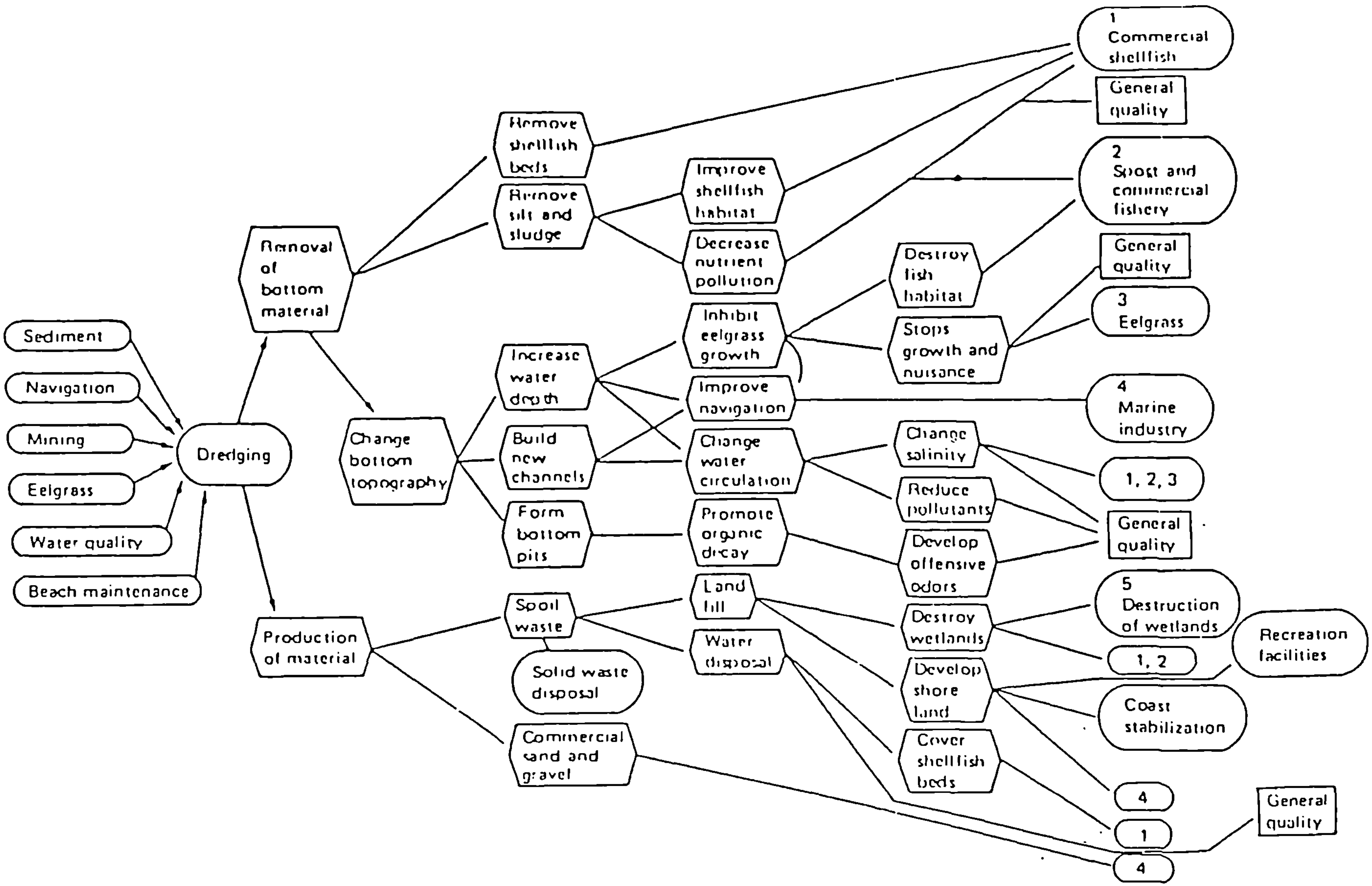



Figure 8.2 Network analysis of a dredging system Source: Thomas (1987)

## 8.3: Selection of an EIA technique appropriate for the assessment of a potable water supply and sanitation project

### 8.3.1: General considerations

The final phase of this study examines the assessment of the environmental impacts which may result from the provision of a potable water supply and sanitation scheme in the rural areas of Iran.

The identification and assessment of impacts demands the collection and manipulation of a great amount of information. A starting point for an EIA, is the collection of high quality, accurate data about the existing environment. In this study, most data concerning the environment were obtained by the author from: - field studies, documents of environmental health offices, reports of the health centre workers in each village and my observations and survey from the existing environment. All this information was explained previously in the baseline study of villages.

It should be noted that, due to the large number of Iranian people who live in rural areas, the provision of a piped potable water supply and sanitation facility in the rural areas of Iran is vital and has significant impacts on the improvement of health, socio - economic status of the rural communities and the surrounding country.

The provision of a piped potable water supply and sanitation project in rural areas may create: - both immediate impacts and also impacts which become distinct after a considerable period of time. In addition impacts may be both positive and negative. To assess these impacts, an appropriate EIA technique should be selected.

An appropriate choice of a technique for the assessment and for understanding the basis for the prediction of impacts is an important prerequisite of an EIA and help to overcome some of the difficulties involved in the undertaking of this process.

As Prusty in 1990 noted, it is true that no single method is universally applicable to all projects in all situation. A knowledge *of available techniques with their* strengths and weakness is useful in the selection of a suitable method. Many techniques lack explicit descriptions of particular impact assessment. Neither specific techniques nor other kinds of guidance to achieve assessment have been developed. For instance; the network methods and checklists do not specify the data needed before impact identification. Thus, decision on this matters are left to the assessor. Professional judgements should be employed both in the selection of an appropriate technique and its application.

Furthermore, the selection of a EIA technique for application depends on each professional's understanding and judgement and it differs in each case. The main reason for this difference is that each individual differs on the ideas on how best to approach a problem. In order to obtain the aims of the environmental assessment, usually parts or sections of more than one technique may be employed, alone or in combination with other parts.

The author believes that, in the specific case of a piped potable water supply and sanitation project, before the selection of any technique, it is essential to focus on some aspects of the EIA process and also some characteristics of the project activities in the both construction and operation phase. Furthermore, before starting an environmental assessment of a project, the relationship between impact causing factors should be considered.

Another significant aspect for consideration in the context of EIA of a piped water supply and sanitation project is the occurrence of direct impacts and their causes which may themselves create indirect impacts. For instance; as noted in chapter 6 on page 222 improved quality and quantity of water ( the cause ) may lead to reduction in the water related diseases and improve health (direct impact). Thus , this direct impact which in turn may lead to increase productivity (secondary impact).

The interactions mentioned above are very common in water supply and sanitation projects and it seems that their analysis is difficult to achieve. Nevertheless, they should not be overlooked.

I believe that, in the selection of an EIA method for the assessment of a project, its appropriateness is largely dependent on the characteristics of the project activity to be evaluated and the knowledge and ability of assessor.

However, based on the strengths and weaknesses of EIA techniques and the reasons mentioned above, and the known characteristics of the activities of water supply and sanitation project, the combination of checklists and matrices was selected by the author as the most appropriate methods for the assessment of environmental impacts of a potable water supply and sanitation scheme in the rural areas of Iran.

I chose the checklist approach due to its suitability for the identification of general impacts and to ensure that all important parameters are considered. Moreover, the checklists are also the base for many of the cause - effect matrices.

The Matrix method was also selected as it can give valuable guidance and give effective displays for assessors and does not demand high levels of particular professional expertise and or the availability of computer systems. As stated earlier, a matrix can also present the cause - effect relationships between the project activities and environmental parameters, since, this can be the most significant technique for the assessment of the water supply and sanitation project.

**8.3.2: Application of checklist and Leopold Matrix**

As described in chapter 7 (page 290), EIA baseline studies were undertaken in four villages with piped potable water supplies and sanitation facilities and four villages without such facilities, in two different regions of Iran.

A checklist of the environmental features that are expected to be affected by these activities including both the construction and operation phases of the project in the sample villages is provided and illustrated in Table 8.1 The features are identified in the context of their natural, social and economic dimensions. Data, were obtained from the baseline studies, my findings in the case study, literature review and the personal experience of the author.

Table 8.1 Checklist of environmental features

| Natural environment | Social environment | Economic environment |
|---|---|---|
| 1.Land use<br>2.Visual quality<br>3.Soil erosion<br>4.Flora and Fauna<br>5.Water table<br>6.Ground water-quality<br>7.Ground water-quantity<br>8.Land pollution<br>9.Insects e.g. flies problems<br>10.waste drainage problem<br>10.Decrease pressure of aquifer | 1.Employment<br>2.Adult education<br>3.Skill and new job<br>4.Better health<br>5.Water borne diseases<br>6.Parasite " "<br>7.Water use activities<br>8.School attendance<br>9.Convenience<br>10.Welfare of family<br>11.Participation of people<br>12.Domestic activities<br>13.Non domestic " | 1.Brick making<br>2.Rug making<br>3.Market for product<br>4.Income of people<br>5.Small garden activity<br>6.connection fee<br>7.Water rate |

I used a Leoplod matrix technique to evaluation the environmental impacts of the water supply and sanitation project in the rural areas of the Urmia and Yazd city.

The matrix is arranged into columns of project activities, and rows of environmental parameters. It should be noted that in the application of EIA in the improved villages only operational activities in the project were considered. The construction activities were not taken into consideration because the project had been in use for several years.

Eight main project activities ( operation phase) were identified. They are:-

1. Maintenance
2. Improved quality of water
3. Increased quantity of water
4. Availability of water flow from convenient taps
5. Waste disposal ( Sanitary and insanitary waste disposal )
6. Time released because of easier water availability
7. More use of ground water
8. Disinfection of water

In the unimproved villages, EIA was based on the construction and operation activities of the project because the project has not been implemented in these areas. Thus all possible impacts could be predicted through the use of an EIA technique and it is useful for rural people and environmental health officers to be aware of these impacts prior to starting water projects. The main construction activities of water supply and sanitation project in rural areas were identified. They are: -

1. Land requirements
2. Installation of taps ( private and public)
3. Labour requirements
4. Well drilling activities
5. Construction of sanitation facilities ( septic tank, pit latrine, sewerage system ).
6. Trench digging and pipe laying activities

7. storage tank and spring box construction
8. Drainage, apron and soakaway construction
9. Maintenance work
10. Training

The likely interaction between project activities and environmental parameters and causing positive or negative impacts are shown in figures 8.3 - 8.6.

In the following operations the environmental parameters are illustrated with their first words; Natural ( N), Social ( S), and Economic ( E ) system. The interaction of the project activities and environmental parameters represent the possible impacts. In each cell in the Leopold matrix, the following operations are considered ( see matrices 8.3 to 8.6):

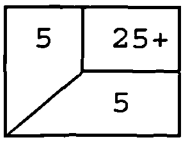
**1.** If an impact is identified, the sign positive ( + ) or negative ( - ) is given, if there is no impact a zero ( 0 ) is given.

**2.** In the identified impact cell, a /( diagonal slash) across the cell is given.

**3.** On the upper side of the slash, a number from 1 to 5 indicating the magnitude of identified impacts is shown. On the lower side of the slash a number from 1 to 5 indicating the importance of the identified impact.

**4.** On the upper left on the cell, the product of the multiplication of the magnitude (M) with importance (I) of the impact is shown as the assessment of the impact ( M x

I ). The minimal number is zero ( 0 ), indicating no impact at all. The maximum number given to an impact, where it is positive or negative, is 5 x 5 = 25, for instance(i):




Furthermore, the following criteria are considered for the scoring of likely impacts.

| | |
|---|---|
| Very small impact | 1 |
| Small impact | 2 |
| Important impact | 3 |
| Very important impact | 4 |
| Extremely important impact | 5 |

The weighting process adopted for the EIA of this study was based on the principles and guidances related to the Leopold's matrix and or the personal evaluation of the author. In order to reduce the degree of subjectiveness, generally attributed to the matrices, the personal assessment was made after careful consideration of available literature and my earlier baseline studies and findings in the sample villages.

To show the weighting process in the EIA of the water supply and sanitation project in the sample villages, some examples are given for each matrix including:-

1. The possible interaction between more use of ground

water and drop of water table in the matrix figure 8.4 ( villages A1 & B1 in dry areas ) has been marked with significance 5 and magnitude 5. The weighting of significance and magnitude in this case is the same as both relate to negative importance and magnitude on the natural environment. This is certainly due to the fact that, significance 5, because , in one hand the importance of water for people and also the problem of a drop of water table for each household, and the shortage of rain on the other (see chapter 7 and chapter 5).

Furthermore, the weighting of the magnitude 5 indicates that, the great majority of rural people at present are faced with this problem. Since, the magnitude of the possible impact of more use of ground water on environment will result in the dropping of water table in the whole areas it is considerable. The main reason of these rating is based on my finding in these villages ( see chapter 7 on page 288, and the literature review in chapter 3 on page 98). Therefore, the result of assessment is M X I = 5 X 5 = - 25.

In the wet area villages A & B, the possible interaction between more usage of ground water and a drop of water table has been marked with significance negative impact 2 and magnitude 1. The weighting of significance is bigger than magnitude, firstly because the drop of the water table in this village has a small negative impact on a drop of water table due to more rain (based on my observation from the wells and finding in chapter 7 page 310). Secondly, it is not a very great problems for both the environment and the people in that area. Otherwise the magnitude of the impact is very small in all area. Therefore, the result of assessment is; M XI=2 X 1= - 2.

**2.** The provision of potable water supply in the villages C & D and C1 & D1 where villagers fetch water from a far distant water source will have positive impact on people. Because of the distance decreased and time released for rural people particularly for women and children, a value 5 has been assigned as the significance of the possible impact (see matrix figure 8.6 and chapter 7). The magnitude of possible impact is considerable because the vast majority of people in the whole areas will be affected by the potable water supply and they can use the time released and energy saving for other activities ( see chapter 7 and 6). Thus, a value of 4 has been marked as the magnitude of possible impact of time released from the availability of water. Therefore, the result of assessment equals; M x I = 5 x 4 = + 20

**3.** As matrix figure 8.3 illustrates the availability of water may have negative impact on the natural environment. For instance; the possible interaction of availability of water from taps of households in the villages A & B with waste water disposal and drainage problems has been marked with significance 4 and magnitude 4. Significance 4, because the availability of flowing water from tap in the yard of household has significance impact in the pollution of environment ( see chapter 7 page 293 and my observation from the fields ). Magnitude 4 because, most of the environment in this village might be affected by water ~~from~~ the flowing from taps. However, the result of assessment equals I X M = 4 x 4 = -16

**4.** As matrix figure 8.5 shows the construction activities of water supply and sanitation *project in the villages C* & D and C1 & D1 may have positive impact on social environment. For instance; the possible interaction between the construction of sanitation facilities and participation of rural people has been marked with significance impact 3 and magnitude 3. With regard to the literature review in chapter 6 on page 244 the significance 3, indicates that, the construction of sanitation facilities such as pit latrine has a significant impact on the participation of rural people. The magnitude 3, shows that, the construction of sanitation facilities may affect on the majority of rural people to be interested to participate in the project. Thus, the result of the assessment is ; M x I = 3 x 3 = + 9.

**4.** In the matrix figure 8.3 in the villages A & B during the operation phase of projet, increased quantity of water may have indirect positive beneficial impacts on social and economic environment. For instance:- the interaction between the increased quantity of water and water used activities in the household has been weighted with significance 4 and magnitude 3. The significance 4, indicates that, increased water quantity has very important impact on the water use activities of each household such as washing clothes, bathing, watering animals and watering garden. The magnitude 3, shows that increased quantity of water may be considerable impact on the whole households. These weightings are based on literature review in chapter 6 on page 226 and my finding in chapter 7 (page 311). However, the result of the assessment equals I X M = 4 x 3 = + 12.

However, the application of EIA *matrix in the improved* villages (A&B and A1&B1) and in the unimproved ones (C&D and C1&D1) during operation and construction phase of project and mathematical operations for analyzing impacts are illustrated in figures 8.3 to 8.6 respectively.

Figure 8.3 Application of EIA matrix in the villages A & B during operation phase

| | Project activities / Environmental Parameters | Operation phase: Maintenance | Increased quantity of water | Improved quality of water | More use of ground water | Time released | Insanitary disposal of waste water | Water flow from taps (availability) | Mathematical operations: + | - | Σ+ | Σ- | Σ Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural | Land pollution | 2 6+ 3 | 0 | 0 | 0 | 0 | 4 16- 4 | 2 6- 3 | 1 | 2 | 6 | 22 | 16- |
| | Drop of water table | 0 | 0 | 1 1- 1 | 1 2- 2 | 0 | 0 | 0 | - | 2 | - | 3 | 3- |
| | Ground water quality | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Ground water quantity | 0 | 1 1- 1 | 0 | 1 1- 1 | 0 | 0 | 0 | - | 2 | - | 2 | 2- |
| | Waste and drainage problems | 0 | 3 9- 3 | 0 | 0 | 0 | 1 1- 1 | 4 16- 4 | - | 3 | - | 26 | 26- |
| | Visual quality | 2 6+ 3 | 1 2+ 2 | 0 | 0 | 0 | 4 16- 4 | 2 4- 2 | 2 | 2 | 8 | 20 | 12- |
| | Insect and flies problems | 3 9+ 3 | 0 | 0 | 0 | 0 | 5 25- 5 | 2 4- 2 | 1 | 2 | 9 | 29 | 20- |
| Social | Convenience | 2 4+ 2 | 3 12+ 4 | 1 2+ 2 | 0 | 4 16+ 4 | 0 | 0 | 4 | - | 34 | - | 34+ |
| | Better health | 1 2+ 2 | 4 16+ 4 | 4 16+ 4 | 0 | 1 2+ 2 | 3 9- 3 | 1 2+ 2 | 5 | 1 | 38 | 9 | 29+ |
| | Decrease of water borne diseases | 1 2+ 2 | 2 4+ 2 | 3 9+ 3 | 0 | 0 | 1 2- 2 | 2 4+ 2 | 4 | 1 | 19 | 2 | 17+ |
| | Decrease of parasite diseases | 2 4+ 2 | 1 1+ 1 | 0 | 0 | 0 | 4 16- 4 | 1 2+ 2 | 3 | 1 | 7 | 16 | 9- |
| | Adult education | 0 | 0 | 0 | 0 | 3 9+ 3 | 0 | 0 | 1 | - | 9 | - | 9+ |
| | Domestic activity | 0 | 0 | 0 | 0 | 4 16+ 4 | 0 | 0 | 1 | - | 16 | - | 16+ |
| | Non domestic activities | 0 | 2 6+ 3 | 0 | 0 | 4 16+ 4 | 0 | 2 4+ 2 | 3 | - | 26 | - | 26+ |
| | Water use activities | 0 | 3 12+ 4 | 0 | 0 | 0 | 0 | 3 9+ 3 | 2 | - | 21 | - | 21+ |
| | School attendence | 0 | 0 | 0 | 0 | 3 9+ 3 | 0 | 0 | 1 | - | 9 | - | 9+ |
| | Welfare of family | 1 1+ 1 | 3 9+ 3 | 0 | 0 | 2 4+ 2 | 3 9- 3 | 2 6+ 3 | 4 | 1 | 20 | 9 | 11+ |
| Economic | Brick making | 1 2+ 2 | 3 12+ 4 | 0 | 0 | 0 | 0 | 2 6+ 3 | 3 | - | 20 | - | 20+ |
| | Water rate | 0 | 1 1- 1 | 0 | 0 | 0 | 0 | 1 1- 1 | - | 2 | - | 2 | 2- |
| | Income of people | 0 | 3 9+ 3 | 0 | 0 | 0 | 0 | 2 4+ 2 | 2 | - | 13 | - | 13+ |
| | Market for product | 1 1+ 1 | 2 4+ 2 | 0 | 0 | 0 | 0 | 2 4+ 2 | 3 | - | 9 | - | 9+ |
| | Small garden activity | 2 4+ 2 | 3 12+ 4 | 0 | 0 | 3 9+ 3 | 0 | 3 9+ 3 | 4 | - | 34 | - | 34+ |
| Mathematical Operations | + | 11 | 12 | 3 | - | 8 | - | 10 | 44 | | | | |
| | - | - | 3 | 1 | 2 | - | 8 | 5 | | 19 | | | |
| | Σ+ | 41 | 99 | 27 | - | 81 | - | 50 | | | 298 | | |
| | Σ- | - | 11 | 1 | 3 | - | 94 | 31 | | | | 140 | |
| | Σ Total | 41+ | 88+ | 26+ | 3- | 81+ | 94- | 19+ | | | | | 158+ |

Figure 8.4 Application of EIA matrix in the improved villages A1&B1 during operation phase

| Environmental Parameters | | Project activities — Operation phase: Disinfection | Maintenance | Increased quantity of water | Improved quality of water | More use of ground water | Time released | Insanitary waste disposal | Water flow from tap (availability) | Mathematical operations: + | − | Σ+ | Σ− | $\Sigma_{Total}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural | Land pollution | 0 | 3 9+ 3 | 0 | 0 | 0 | 0 | 3 9- 3 | 2 4- 2 | 1 | 2 | 9 | 13 | 4- |
| | Drop of water table | 0 | 0 | 2 4- 2 | 0 | 5 25- 5 | 0 | 0 | 0 | - | 2 | - | 29 | 29- |
| | Insect and flies problems | 0 | 2 6+ 3 | 0 | 0 | 0 | 0 | 3 9- 3 | 1 1- 1 | 1 | 2 | 6 | 10 | 4- |
| | Groundwater quality | 2 4+ 2 | 0 | 0 | 0 | 3 9- 3 | 0 | 0 | 0 | 1 | 1 | 4 | 9 | 5- |
| | Groundwater quantity | 0 | 0 | 3 9- 3 | 0 | 5 25- 5 | 0 | 0 | 0 | - | 2 | - | 34 | 34- |
| | Waste water and drainage problems | 0 | 0 | 2 4- 2 | 0 | 0 | 0 | 0 | 2 4- 2 | - | 2 | - | 8 | 8- |
| | Visual quality | 0 | 2 4+ | 1 1+ 1 | 0 | 3 9- 3 | 0 | 1 2- 2 | 1 2- 2 | 2 | 3 | 5 | 13 | 8- |
| | Pressure of aquifer | 0 | 0 | 0 | 0 | 4 16- 4 | 0 | 0 | 0 | - | 1 | - | 16 | 16- |
| Social | Convenience | 0 | 2 4+ 2 | 0 | 0 | 0 | 4 16+ 4 | 0 | 3 9+ 3 | 3 | - | 29 | - | 29+ |
| | School attendence | 0 | 0 | 0 | 0 | 0 | 3 9+ 3 | 0 | 0 | 1 | - | 9 | - | 9+ |
| | Better health | 1 2+ 2 | 2 6+ 3 | 4 16+ 4 | 3 9+ 3 | 0 | 1 2+ 2 | 1 1- 1 | 2 6+ 3 | 6 | 1 | 41 | 1 | 40+ |
| | Decrease of water borne disease | 3 9+ 3 | 2 4+ 2 | 2 4+ 2 | 3 9+ 3 | 0 | 0 | 1 1- 1 | 0 | 4 | 1 | 26 | 1 | 25+ |
| | Parasite diseases | 1 1+ 1 | 2 6+ 3 | 1 2+ 2 | 0 | 0 | 0 | 1 2- 2 | 0 | 3 | 1 | 8 | 2 | 6+ |
| | Adult education | 0 | 0 | 0 | 0 | 0 | 3 9+ 3 | 0 | 2 4+ 2 | 2 | - | 13 | - | 13+ |
| | Domestic activities | 0 | 0 | 0 | 0 | 0 | 3 9+ 3 | 0 | 0 | 1 | - | 9 | - | 9+ |
| | Non domestic activities | 0 | 0 | 1 1+ 1 | 0 | 0 | 3 9+ 3 | 0 | 2 4+ 2 | 3 | - | 14 | - | 14+ |
| | Water use activities | 0 | 0 | 3 9+ 3 | 0 | 0 | 0 | 0 | 3 9+ 3 | 2 | - | 18 | - | 18+ |
| | Welfare of family | 0 | 1 1+ 1 | 2 4+ 2 | 0 | 0 | 2 6+ 3 | 0 | 2 4+ 2 | 4 | - | 15 | - | 15+ |
| Economic | Water rate | 0 | 0 | 1 1- 1 | 0 | 0 | 0 | 0 | 1 1- 1 | - | 2 | - | 2 | 2- |
| | Carpet making | 0 | 1 2+ 2 | 2 4+ 2 | 0 | 0 | 3 9+ 3 | 0 | 3 9+ 3 | 4 | - | 24 | - | 24+ |
| | Brick making | 0 | 1 1+ 1 | 1 2+ 2 | 0 | 0 | 0 | 0 | 2 4+ 2 | 3 | - | 7 | - | 7+ |
| | Income of people | 0 | 1 1+ 1 | 1 2+ 2 | 0 | 0 | 0 | 0 | 2 4+ 2 | 3 | - | 9 | - | 9+ |
| | Small garden activities | 0 | 1 1+ 1 | 1 1+ 1 | 0 | 0 | 1 1+ 1 | 0 | 1 2+ 2 | | - | 5 | - | 5+ |
| Mathematical Operations | + | 4 | 12 | 11 | 2 | - | 9 | - | 10 | 48 | | | | |
| | − | - | - | 4 | - | 5 | - | 6 | 5 | | 20 | | | |
| | Σ+ | 16 | 45 | 45 | 18 | - | 70 | - | 55 | | | 249 | | |
| | Σ− | - | - | 18 | - | 84 | | 24 | 12 | | | | 138 | |
| | $\Sigma_{Total}$ | 16+ | 45+ | 27+ | 18+ | 84- | 70+ | 24- | 43+ | | | | | 111+ |

Figure 8.5 Application of EIA matrix in the unimproved villages(C&D and C1&D1) during construction phase

| Environmental Parameters \ Project activities | | Construction phase: Land requirement | Maintenance | Labour requirement | Well drilling | Installation of taps | Sanitation facilities construction | Trench digging | Storage tank & spring box construction | Training of people | Drainage construction | Mathematical Operations: + | - | Σ+ | Σ- | ΣTotal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural | Land Use | 2, 4-, 2 | 0 | 0 | 1, 2-, 2 | 0 | 3, 9-, 3 | 2, 6-, 3 | 1, 2-, 2 | | 1, 2-, 2 | - | 6 | - | 25 | 25- |
| | Soil erosion | 0 | 0 | 0 | 1, 2-, 2 | 0 | 2, 4-, 2 | 2, 4-, 2 | 1, 2-, 2 | 0 | 1, 1-, 1 | - | 5 | - | 13 | 13- |
| | Land pollution | 0 | 2, 6+, 3 | 0 | 2, 6-, 3 | 0 | 1, 1-, 1 | 1, 1-, 1 | 1, 1-, 1 | 0 | 1, 1-, 1 | 1 | 5 | 6 | 10 | 4- |
| | Visual quality | 0 | 3, 9+, 3 | 0 | 2, 6-, 3 | 1, 1-, 1 | 2, 4-, 2 | 1, 1-, 1 | 1, 1-, 1 | 0 | 1, 1-, 1 | 1 | 6 | 9 | 14 | 5- |
| | Flora | 0 | 2, 6+, 3 | 0 | 1, 1-, 1 | 0 | 2, 4-, 2 | 1, 1-, 1 | 1, 1-, 1 | 0 | 1, 1-, 1 | 1 | 5 | 6 | 8 | 2- |
| | Groundwater quality | 0 | 1, 1+, 1 | 0 | 3, 9-, 3 | 0 | 1, 2-, 2 | 1, 2-, 2 | 1, 2+, 2 | 0 | 1, 1+, 1 | 3 | 3 | 4 | 13 | 9- |
| | Fauna | 0 | 1, 1+, 1 | 0 | 0 | 0 | 1, 1-, 1 | 1, 1-, 1 | 1, 1-, 1 | 0 | 0 | 1 | 3 | 1 | 3 | 2- |
| Social | Acquisition of skill | 0 | 1, 2+, 2 | 1, 2+, 2 | 0 | 0 | 0 | 0 | 0 | 3, 12+, 4 | 0 | 3 | - | 16 | - | 16+ |
| | Participation | 0 | 1, 2+, 2 | 1, 2+, 2 | 2, 4+, 2 | 2, 4+, 2 | 3, 9+, 3 | 2, 4+, 2 | 1, 1+, 1 | 2, 6+, 3 | 1, 1+, 1 | 9 | - | 33 | - | 33+ |
| | Employment | 0 | 1, 2+, 2 | 3, 9+, 3 | 1, 2+, 2 | 0 | 1, 2+, 2 | 2, 4+, 2 | 1, 1+, 1 | 1, 2+, 2 | 1, 1+, 1 | 8 | - | 23 | - | 23+ |
| Economic | Income of people | 1, 1+, 1 | 1, 2+, 2 | 2, 6+, 3 | 1, 2+, 2 | 0 | 1, 2+, 2 | 1, 2+, 2 | 1, 1+, 1 | 1, 2+, 2 | 1, 1+, 1 | 9 | - | 19 | - | 19+ |
| | Connection fee | 0 | 0 | 0 | 0 | 2, 4-, 2 | 2, 4-, 2 | 0 | 0 | 0 | 0 | - | 2 | - | 8 | 8- |
| Mathematical Operations | + | 1 | 9 | 4 | 3 | 1 | 3 | 3 | 4 | 4 | 4 | 36 | | | | |
| | - | 1 | - | - | 6 | 2 | 8 | 7 | 6 | - | 5 | | 35 | | | |
| | Σ+ | 1 | 31 | 19 | 8 | 4 | 13 | 10 | 5 | 22 | 4 | | | 117 | | |
| | Σ- | 4 | - | - | 26 | 5 | 29 | 16 | 8 | - | 6 | | | | 94 | |
| | ΣTotal | 3- | 31+ | 19+ | 18- | 1- | 16- | 6- | 3- | 22+ | 2- | | | | | 23+ |

Figure 8.6 Application of EIA matrix in the villages C&D and C1&D1 during operation phase

| Environmental Parameters | Project activities | Operation phase: Maintenance | Increase quantity of water | Improved quality of water | Disposal of waste water | Availability of water | More use of ground water | Disinfection of water | Time released | Mathematical Operations: + | - | Σ+ | Σ- | ΣTotal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural | Land pollution | 2 / 6+ / 3 | O | O | 2 / 4+ / 2 | O | O | O | O | 2 | - | 10 | - | 10+ |
| | Water table | O | O | O | O | O | 3 / 9- / 3 | O | O | - | 1 | - | 9 | 9- |
| | Insect, flies problems | O | O | O | 2 / 4+ / 2 | O | O | O | O | 1 | - | 4 | - | 4+ |
| | Groundwater quality | O | O | O | O | O | O | 3 / 12+ / 4 | O | 1 | - | 12 | - | 12+ |
| | Groundwater quantity | O | O | O | O | O | 2 / 4- / 2 | O | O | - | 1 | - | 4 | 4- |
| | Visual quality | 3 / 9+ / 3 | 2 / 4+ / 2 | O | 2 / 4+ / 2 | 2 / 4+ / 2 | O | O | O | 4 | - | 21 | - | 21+ |
| | Waste and drainage problems | O | O | O | O | 1 / 1- / 1 | O | O | O | - | 1 | - | 1 | 1- |
| Social | Decrease of water borne diseases | 2 / 4+ / 2 | 2 / 6+ / 3 | 4 / 16+ / 4 | 2 / 4+ / 2 | 2 / 4+ / 2 | O | 3 / 9- / 3 | O | 5 | 1 | 34 | 9 | 25+ |
| | Decrease of parasite diseases | 2 / 4+ / 2 | 1 / 1+ / 1 | 1 / 1+ / 1 | 3 / 9+ / 3 | 1 / 1+ / 1 | O | 2 / 4- / 2 | O | 5 | 1 | 16 | 4 | 12+ |
| | Adult education | O | O | O | O | O | O | O | 4 / 16+ / 4 | 1 | - | 16 | - | 16+ |
| | Domestic activity | O | O | O | O | O | O | O | 3 / 12+ / 4 | 1 | - | 12 | - | 12+ |
| | Non domestic activity | O | O | O | O | O | O | O | 3 / 12+ / 4 | 1 | - | 12 | - | 12+ |
| | Convenience | 3 / 9+ / 3 | O | O | O | 4 / 16+ / 4 | O | O | 4 / 20+ / 5 | 3 | - | 45 | - | 45+ |
| | School attendence | O | O | O | O | O | O | O | 3 / 9+ / 3 | 1 | - | 9 | - | 9+ |
| | Water use activity | O | 3 / 12+ / 4 | O | O | 3 / 9+ / 3 | O | O | O | 2 | - | 21 | - | 21+ |
| | Welfare of family | O | 2 / 4+ / 2 | O | 2 / 4+ / 2 | 2 / 6+ / 3 | O | O | 3 / 9+ / 3 | 4 | - | 23 | - | 23+ |
| | Better health | 2 / 4+ / 2 | 3 / 9+ / 3 | 3 / 9+ / 3 | 3 / 12+ / 4 | 3 / 9+ / 3 | O | 3 / 9+ / 3 | 2 / 4+ / 2 | 7 | - | 56 | - | 56+ |
| Economic | Brick making | 1 / 1+ / 1 | 2 / 4+ / 2 | O | O | 2 / 4+ / 2 | O | O | O | 3 | - | 9 | - | 9+ |
| | Small garden | 1 / 2+ / 2 | 2 / 4+ / 2 | O | O | 2 / 6+ / 3 | O | O | 2 / 4+ / 2 | 4 | - | 16 | - | 16+ |
| | Market for product | 1 / 1+ / 1 | 1 / 1+ / 1 | O | O | 1 / 2+ / 2 | O | O | O | 3 | - | 4 | - | 4+ |
| | Income of people | 1 / 1+ / 1 | 1 / 1+ / 1 | O | O | 1 / 2+ / 2 | O | O | O | 3 | - | 4 | - | 4+ |
| | Water rate | O | 1 / 1- / 1 | O | O | 1 / 1- / 1 | O | O | O | - | 2 | - | 2 | 2- |
| | Carpet making | 1 / 2+ / 2 | 2 / 4+ / 2 | O | O | 2 / 4+ / 2 | O | O | 3 / 12+ / 4 | 4 | - | 22 | - | 22 |
| Mathematical Operations | + | 11 | 11 | 3 | 7 | 12 | - | 2 | 9 | 55 | | | | |
| | - | - | 1 | - | - | 2 | 2 | 2 | - | | 7 | | | |
| | Σ+ | 43 | 50 | 26 | 41 | 67 | - | 21 | 98 | | | 346 | | |
| | Σ- | - | 1 | - | - | 2 | 13 | 13 | - | | | | 29 | |
| | ΣTotal | 43+ | 49+ | 26+ | 41+ | 65+ | 13- | 8+ | 98+ | | | | | 317+ |

## 8.4: Analysis of the impacts identified by the mathematical operations

In 1990, Braun employed mathematical operations to analyze the impacts of irrigation project in Tanzania. The author used this information to analyze the percentage number of impacts identified in each system ( natural, social and economic), a set of mathematical operations was used for each matrix. Furthermore, the overall environmental impacts of the each study area is also provided by this operation. The analysis and mathematical operations are considered for each matrix separately including:-

### (a). Analysis of Matrix Figure 8.3

As matrix figure 8.3 shows the number of project activities and environmental parameters are:-

| | |
|---|---|
| No. of project activities in operation phase | 7 |
| No. of natural parameters | 7 |
| No. of social parameters | 10 |
| No. of economic parameters | 5 |
| Total No. of environmental parameters | 22 |

**Possible interaction:** The possible number of interactions of environmental impacts ( P. In. E. I ) in the matrix is said by the number of project activities ( A ) multiplied by the number of environmental parameter (E.P) including as: P.In.E.I = A.E.F = 7 x 22 = 154

**Natural system:** The number of possible impacts in the natural system was 7 x 7 = 49. The real interactions in the natural system equals A. E F - M ( M is the number of no interactions or no impacts) = 7 x 7 - 32 = 49 - 32 = 17. From the 17 interactions 4 are positive and 13 negative.

**Social system:** The possible interaction in the social system equals; A.Ef = P.In.E.I = 10 x 7 = 70. The real interactions equals; A. E F - M = 70 - 38 = 32. From the 32 interactions 28 are positive and 4 negative.

**Economic system:** The possible interaction equals A.EF = P.In.E. I = 5 x 7 = 35. The real interactions equals A.EF - M = 35 - 21 = 14. From the 14 interactions 12 are positive and 2 negative.

**Percentage of environmental impact :** The following formula shows the overall percentage of the impacts in the environmental system ( natural, social and economic ).

$$OV = \frac{\sum N, S, E}{\sum ( N + S + E )} \times 100 = \text{Impacts}$$

As figure 8.3 shows the overall impacts of each system are:-

N = Natural system = 79

S = Social system = 181

E = Economic system = 78

$\sum$ ( N + S + E ) = 338

Overall percentage of impact in the natural system

( O V N ) = 79/338 x100 = 23.3 %

Overall percentage of impacts in the social system

( O V S ) = 181/338 x 100 = 54.5 %

Overall percentage of impacts in the economic system

( O V E )= 78/338 x 100 = 22.2 %

**(b) Analysis of Matrix Figure 8.4**

The mathematical operations of this matrix is similar to the previous matrix. As matrix figure 8.4 on page 416 shows the number of the project activities in the operation phase in the villages A1 & B1 and environmental parameters including:-

| | |
|---|---|
| No. of project activities in operation phase | 8 |
| No. of the natural parameters | 8 |
| No. of the social parameters | 10 |
| No. of economic parameters | 5 |
| Total No. of environmental parameters | 23 |

**Possible interaction** The possible number of interactions of environmental impacts in this matrix equal = P.In.E.I = A.E F = 8 x 23 = 184

**Natural system:** The possible interaction in natural system = P.In.E.I = A.E F = 8 x 8 = 40. The real interaction = A. E F - M = 64 - 44 = 20. From the 20 interactions 5 are positive and 15 negative.

**Social system:** The possible interactions in social system = P.In.E.I = A.E F = 10 x 8 = 80. The real interaction = A.E F - M = 80 - 48 = 32. From the 32 interactions 29 are positive and 3 negative.

**Economic system:** The possible interaction in economic system = P.In.E.I = A.E F = 5 x 8 = 40. The real interaction = A. EF - M = 40 - 24 = 16. From the 16 interactions 14 are positive and 2 negative

**Percentage of environmental impact**

As figure 8.4 shows, the overall impacts in each system are:-

Overall natural system ( N ) = 108

Overall social system ( S) = 178

Overall economic impacts ( E ) = 47

$\sum ( N + S + E )$ = 333

Based on the overall percentage of the impacts in the environmental system formula;

$$OV = \frac{\sum N \text{ or } S \text{ or } E}{\sum ( N + S + E )} \times 100 \text{ Impacts } \%$$

Overall percentage of impact in the natural system

(OVN) = 108/333 x 100 =32.4 %

Overall percentage of impact in the social system

(OVS) = 178/333 x 100 = 53.4 %

Overall percentage of impact in the economic system

(OVE) = 47/333 x 100 = 14.2 %

**(c) Analysis of Matrix Figure 8.5**

As matrix figure 8.5 shows the number of the project activities in the construction phase in the unimproved villages ( C & D and C1 & D1 ) and environmental parameters are:

| | |
|---|---|
| No. of project activities in the construction phase | 10 |
| No. of natural parameters | 7 |
| No. of social parameters | 3 |
| No.of Economic parameters | 2 |
| Total of environmental parameters | 12 |

**Possible interaction:** The possible number of interactions of environmental impacts in the matrix figure 8.5 equals = P.In.E.I = A.EF = 10 x 12 = 120.

**Natural system:** The possible interactions in the natural system equals = P.In.E.I = 7 x 10 = 70. The possible real interactions = P.In.E.I = A.EF -M = 70 - 30 = 40. From the 40 interactions 7 are positive and 33 negative.

**Social system:** The possible interactions in the social system equal = P.In.E.I = A.Ef = 3 x 10 = 30. The real interactions = A. EF - M = 30 - 10 = 20. From the 20 interactions all are positive.

**Economic system:** The possible interaction in economic system = P.In.E.I = A.EF = 2 x 10 = 20. The possible real interaction = P.In.E.I = A.EF - M = 20 - 9 = 11. From the 11 interactions 9 are positive and 2 negative.

**Percentage of environmental impact**

As matrix figure 8.5 shows, the overall impacts of each system are:

Overall Natural system = 60

Overall Social system = 72

Overall Economic system = 27

$\sum$ ( N + S + E ) system = 159

Based on the overall percentage of the impacts in the environmental system formula:

$$OV = \frac{\sum N \text{ or } S \text{ or } E}{\sum ( N + S + E )} \times 100 \text{ Impacts } \%$$

Overall percentage of impact in the natural system

(O V N) 60/159 x 100 = 37.7 %

Overall percentage of impact in the social system

( O V S) = 72/159 x 100 = 45.4 %

Overall percentage of impact in the economic system

( O V E ) = 27/159 x 100 = 16.9 %

**(d) Analysis of Matrix Figure 8.6**

The number of project activities in the operation phase and environmental parameters in the unimproved villages (C & D and C1 & D1) are shown in matrix figure 8.6, on page 418 including:

| | |
|---|---|
| No. of project activities | 8 |
| No. of natural parameters | 7 |
| No. of social parameters | 10 |
| No. of economic parameters | 6 |
| Total No. of environmental parameters | 23 |

**Possible interaction:** The possible number of interactions of environmental impacts in this matrix equals P.In.EI = A.EF = 23 x 8 = 184.

**Natural system:** The possible interaction in the natural system P.In.E.I = A.EF= 7 x 8 = 56. The real interaction equals P.In.E.I = A.EF - M = 56 - 45 = 11. From the 11 interactions 8 are positive and 3 negative.

**Social system** In the social system the possible interactions equals P.In.E.I = A.EF = 10 x 8 = 80. The real interactions equals A.EF - M = 80 - 48 = 32. From the 32 interactions 30 are positive and 2 negative.

**Economic system** The possible interaction equals P.In.EF = A.EF = 6 x 8 = 56. The real interaction A.EF - M = 48 - 29

= 19. From the 19 interactions 17 are positive and 2 negative.

**Percentage of environmental impact**

As figure 8.6 illustrates the overall impacts in each system are:-

Overall N = 61

Overall S = 231

Overall E = 57

$\sum$ ( N + S + E ) = 349

Based on the overall percentage of the impacts in the environmental system formula;

$$OV = \frac{\sum N \text{ or } S \text{ or } E}{\sum ( N + S + E )} \times 100\ \%$$

The overall percentage of each system are:

Overall percentage of impact in the natural system (OVN )= 61/349 x 100 = 17.4 %

Overall percentage of impact in the social system (OVS) = 231/349 x 100 = 66.2 %

Overall percentage of impact in the economic system (OVE) = 57/349 x 100 = 16.4 %

However, EIA matrices analysis revealed that, the overall percentage of impacts identified in each system ( natural, social and economic ) in the sample villages during the operation and construction phase of project are different. Table 8.2 compares the overall percentage impacts identified in each system.

Table 8.2 Comparison of percentage of impacts identified

| Percentage<br>Matrices | O V N<br>% | O V S<br>% | O V E<br>% | Total<br>% |
|---|---|---|---|---|
| Matrix Figure.8.3 | 23.3 | 54.5 | 22.2 | 100 |
| Matrix Figure.8.4 | 32.4 | 53.4 | 14.2 | 100 |
| Matrix Figure.8.5 | 37.7 | 45.4 | 16.9 | 100 |
| Matrix Figure.8.6 | 17.4 | 66.1 | 16.4 | 100 |

As above Table shows, the overall percentage of impacts identified in the natural system during construction phase of projects in matrix figure 8.5 (villages C & D and C1 & D1), with 37.7% is more than other villages. While, the overall percentage of impacts identified in the social system in matrix figure 8.6 during operation phase (villages C & D and C1 & D1 ) with 66.1% and economic system in matrix figure 8.3 (villages A & B) with 22.2% during the operation phase of project is further than others.

The EIA matrices analysis also indicated that, all impacts identified in the natural system are negative. Whilst, the majority of impacts identified in the social and economic system are positive.

**8.5: EIA Matrix Presentation Survey**

EIA was developed in order to show the importance of the positive and negative impacts identified in a visual approach (Braun, 1990). To try to evaluate the best technique for presenting a Leopold matrix the author enroled the help of the postgraduate students of Environmental Resources Unit.

I prepared a questionnaire included four questions and the opinions of students were asked to rank them in order of preference in the situation of a postgraduate, and in the situation of an environmental consultant about to prepare an EIA, a member of local authority staff who will receive an EIA and as an elected member of local authority. The questionnaire and EIA matrix ( numeric, black & white and colour) are attached in Appendix C. Table 8.3 and diagram 8.7 compares the percentage of rank order of numerical, black & white and colour matrix.

Table 8.3 Perception of postgraduate students about EIA matrix presentation of Numerical, Black & White and colour

| Type of matrices / Situation of students | Numerical | | | | | | Black & White | | | | | | Colour | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1 | | *2 | | *3 | | 1 | | 2 | | 3 | | 1 | | 2 | | 3 | | |
| | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | No | % | |
| As a post graduate | 12 | 52.1 | 2 | 8.6 | 9 | 39.3 | 2 | 8.6 | 11 | 47.8 | 10 | 43.6 | 9 | 39.1 | 10 | 43.6 | 4 | 17.3 | 100 |
| As environmental- consultant | 16 | 69.7 | 2 | 8.6 | 5 | 21.9 | 4 | 17.3 | 9 | 39.1 | 10 | 43.6 | 3 | 13 | 13 | 56.5 | 7 | 30.4 | 100 |
| As a member of local authority | 11 | 47.8 | - | - | 12 | 52.1 | 3 | 13 | 12 | 52.1 | 8 | 34.7 | 9 | 39.1 | 11 | 47.8 | 3 | 13 | 100 |
| As an elected member of local authority | - | - | 4 | 17.3 | 19 | 82.7 | 2 | 8.6 | 17 | 73.9 | 4 | 17.3 | 21 | 91.4 | 2 | 8.6 | - | - | 100 |

In order of preference:
- *1 = First order
- *2 = second order
- *3 = Third order

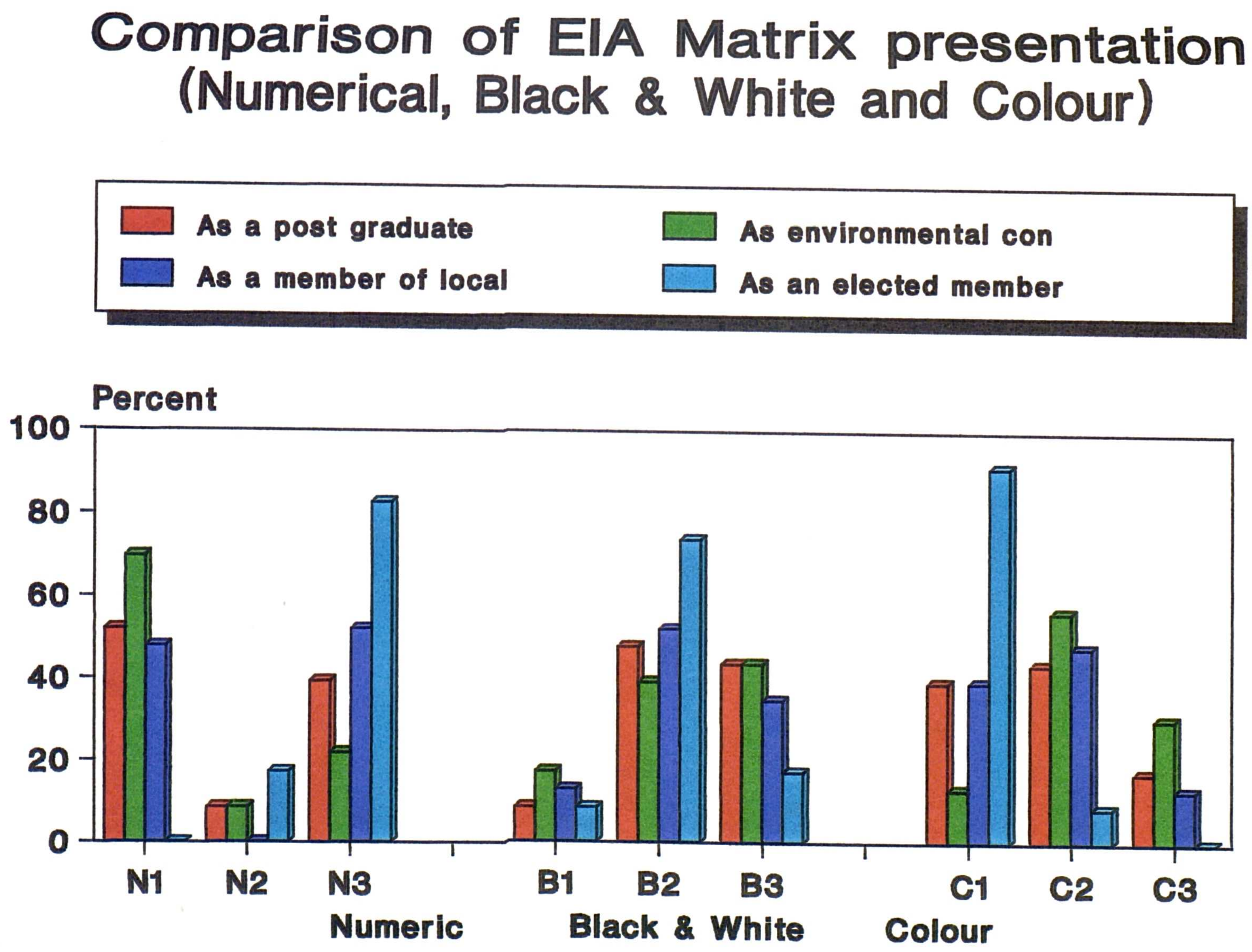

Comparison of EIA Matrix presentation
(Numerical, Black & White and Colour)
As a post graduate
As a member of local
As environmental con
As an elected member
Percent
100
80
60
40
20
0
N1
N2
N3
Numeric
B1
B2
B3
Black & White
C1
C2
C3
Colour

Figure 8.7

**8.5.1: Findings of EIA Matrix presentation Survey**

With regard to Table 8.3 and diagram 8.7, the following conclusions can be drawn from the survey for EIA matrix presentation:

**1.** In the case of post graduate, and as environmental consultant the numerical matrix is the first preference whilst in the case of local authority and as an elected member of local authority, the numerical matrix is the third preference. The main reason in the first case is that, a numerical matrix gives the quantity of data and more details. It is also suitable for justifying and weighting the positive and negative impacts and can see easily the values assigned to each possible impact. But in the latter case, a numerical matrix is not clear to more-professionals such as many elected representative.

**2.** In the case of as an elected member of local authority the colour matrix is the first preference and black and white is the second preference. While, as a member of a local authority, as environmental consultant and as a post graduate, colour matrix is the second preference. The major reason is that colour matrix gives the best visual impact, and information about the positive and negative impacts can be easily seen and understood by people.

However, with regard to above findings, it is concluded that, the combination of numerical and colour matrix for the presentation of visible matrix is appropriate. The numerical matrix has been illustrated in the figures 8.3 to 8.6 previously. The colour matrix for the water supply and sanitation project in the improved and unimproved villages is illustrated in Figures 8.8 to 8.11. So what dose this information tell us. They are as follows:

1. That for setting up an EIA with professionals a weighted matrix is the best method.
2. That for showing the impact and their importance a coloured matrix is probably the best method.

Figure 8.8 EIA colour matrix in the villages A&B

| | Project activities / Environmental Parameters | Operation phase: Maintenance | Increased quantity of water | Improved quality of water | More use of groundwater | Time released | Insanitary disposal of waste water | Water flow from taps ( avialability of water) |
|---|---|---|---|---|---|---|---|---|
| Natural | Land pollution | Positive Impact | No Impact | No Impact | No Impact | No Impact | Negative Impact | Negative Impact |
| Natural | Drop of water table | No Impact | No Impact | Negative Impact | Negative Impact | No Impact | No Impact | No Impact |
| Natural | Groundwater quality | No Impact | No Impact | No Impact | No Impact | No Impact | No Impact | No Impact |
| Natural | Groundwater quantity | No Impact | Negative Impact | No Impact | Negative Impact | No Impact | No Impact | No Impact |
| Natural | Waste and drainage problems | No Impact | Negative Impact | No Impact | No Impact | No Impact | Negative Impact | Negative Impact |
| Natural | Visual quality | Positive Impact | Positive Impact | No Impact | No Impact | No Impact | Negative Impact | Negative Impact |
| Natural | Insects e.g. flies problems | Positive Impact | No Impact | No Impact | No Impact | No Impact | Negative Impact | Negative Impact |
| Social | Convenience | Positive Impact | Positive Impact | Positive Impact | No Impact | Positive Impact | No Impact | No Impact |
| Social | Better health | Positive Impact | Positive Impact | Positive Impact | No Impact | Positive Impact | Negative Impact | Positive Impact |
| Social | Water borne diseases | Positive Impact | Positive Impact | Positive Impact | No Impact | No Impact | Negative Impact | Positive Impact |
| Social | Parasite diseases | Positive Impact | Positive Impact | No Impact | No Impact | No Impact | Negative Impact | Positive Impact |
| Social | Adult education | No Impact | No Impact | No Impact | No Impact | Positive Impact | No Impact | No Impact |
| Social | Domestic activity | No Impact | No Impact | No Impact | No Impact | Positive Impact | No Impact | No Impact |
| Social | Non domestic activity | No Impact | Positive Impact | No Impact | No Impact | Positive Impact | No Impact | Positive Impact |
| Social | Water use activities | No Impact | Positive Impact | No Impact | No Impact | No Impact | No Impact | Positive Impact |
| Social | School attendence | No Impact | No Impact | No Impact | No Impact | Positive Impact | No Impact | No Impact |
| Social | Welfare of family | Positive Impact | Positive Impact | No Impact | No Impact | Positive Impact | Negative Impact | Positive Impact |
| Economic | Brick making | Positive Impact | Positive Impact | No Impact | No Impact | No Impact | No Impact | Positive Impact |
| Economic | Water rate | No Impact | Negative Impact | No Impact | No Impact | No Impact | No Impact | Negative Impact |
| Economic | Income of people | No Impact | Positive Impact | No Impact | No Impact | No Impact | No Impact | Positive Impact |
| Economic | Market for product | Positive Impact | Positive Impact | No Impact | No Impact | No Impact | No Impact | Positive Impact |
| Economic | Small garden activity | Positive Impact | Positive Impact | No Impact | No Impact | Positive Impact | No Impact | Positive Impact |

Positive Impact (purple) Negative Impact (green) No Impact (pink)

Figure 8.9 EIA colour martix in the villages A1 & B1

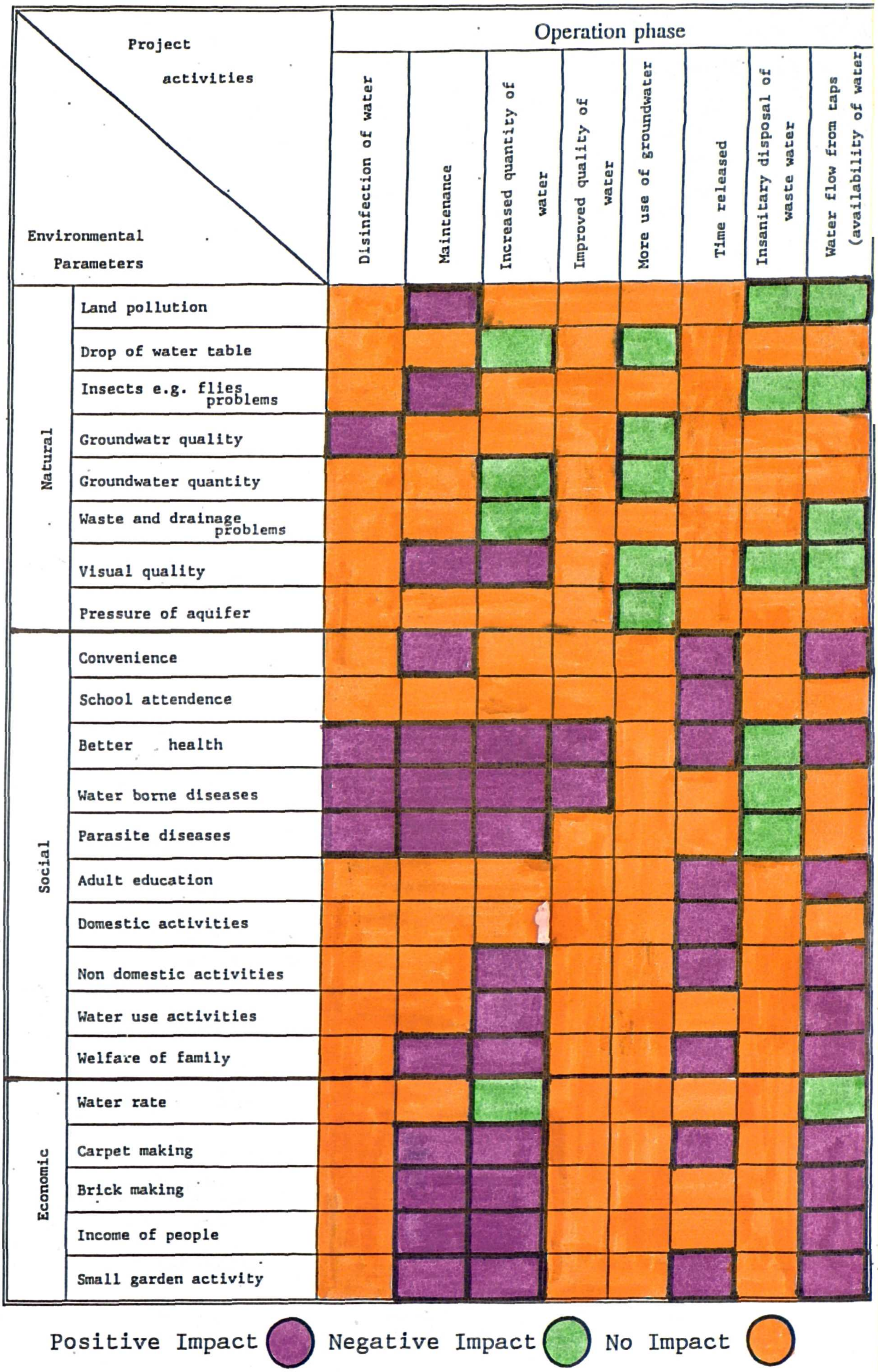


Figure 8.10 EIA colour matrix in the villages C & D and C1 & D1 during construction phase

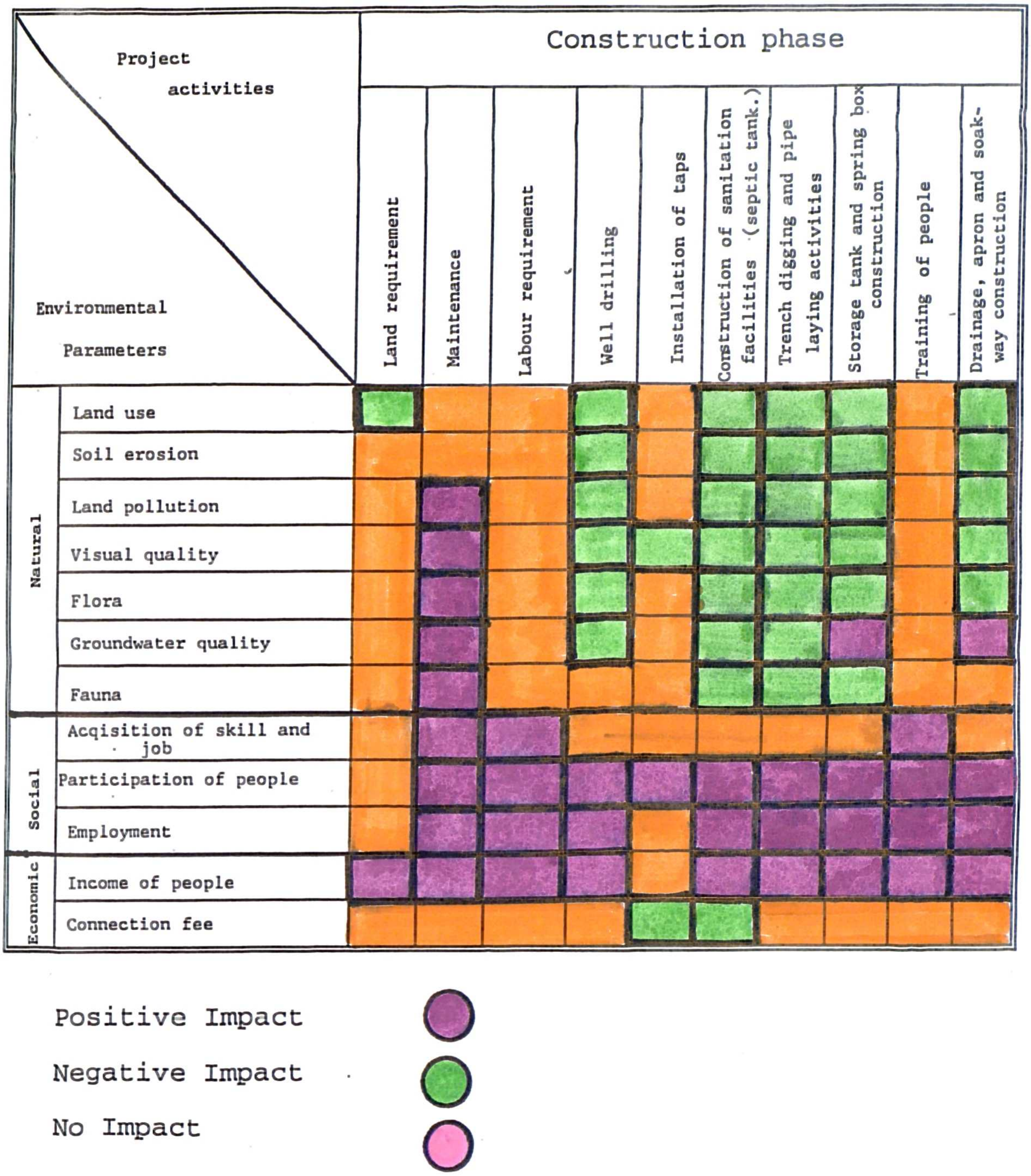
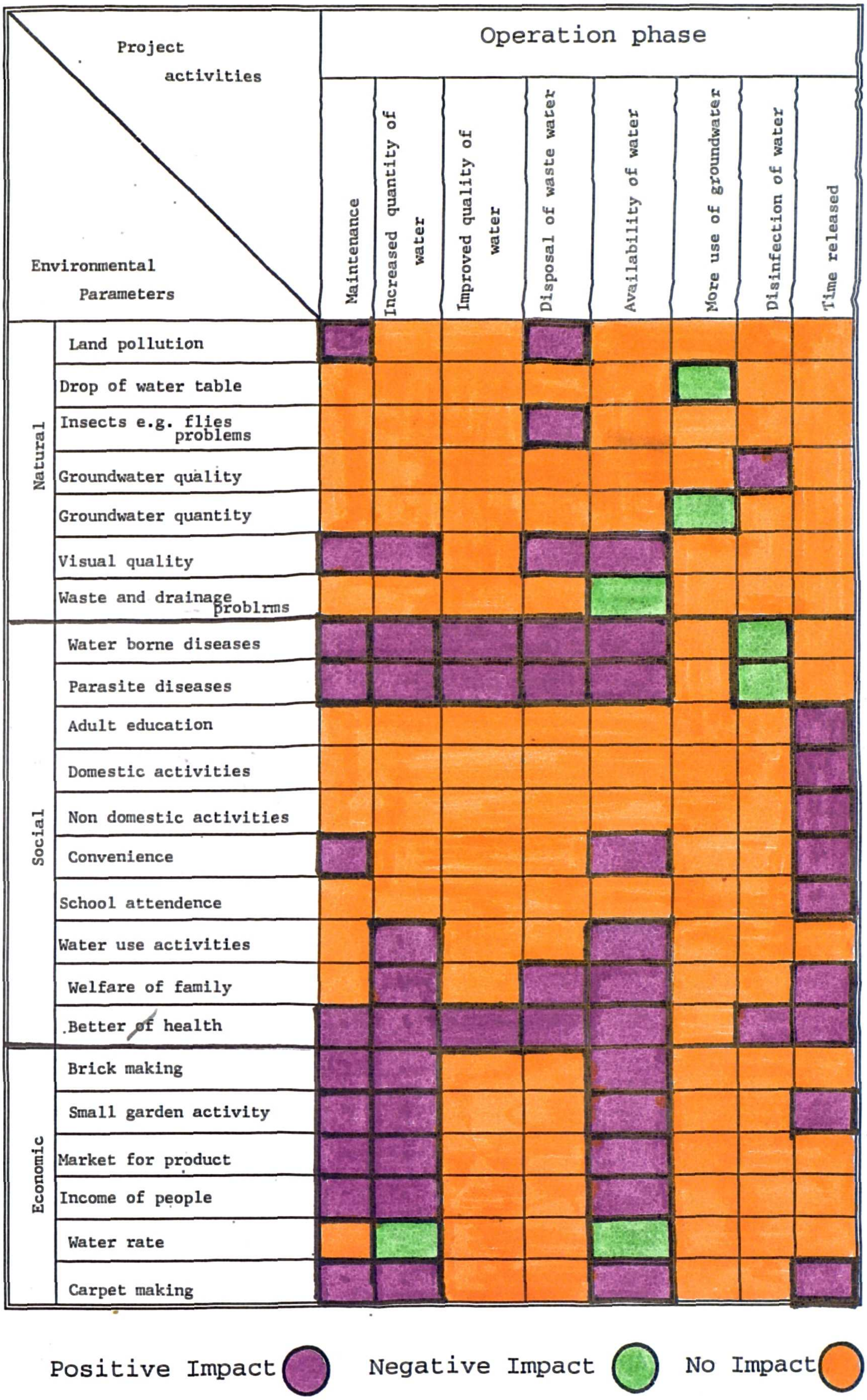


Fig 8.11 EIA colour matrix in the villages C&D and C1&D1



## 8.6: Comments on the most important environmental Impacts (Positive and negative) identified

After the application of an EIA in the sample villages the results of assessment of matrices Figure 8.3 to 8.6 were illustrated in the right hand of each matrix. In this section, the author gives a brief description of the most significant environmental impacts including their possible cause and dynamic interaction with environmental system. The environmental impacts identified, based on positive and negative impacts, are classified according to their specific characteristics, dynamics, and relationships with time including; direct, indirect, short and long term impact. The direct and indirect impacts were defined in chapter one. The short and long term impact are defined as follows;

1. **Short term impact:** When the impact ranges is less than 6 months.
2. **Long term impact:** When the impact ranges is more than 6 months.

The most important positive and negative impacts identified in the EIA matrices ( figure 8.3 to 8.6) in the improved and unimproved villages during the operation and construction phase of project are illustrated in Tables 8.4 to 8.7.

Table 8.4 The most important positive and negative impacts identified in the villages A & B during the operation phase

| Impacts / Environmental parameters | Positive | Negative | Direct | Indirect | Short-term | Long-term |
|---|---|---|---|---|---|---|
| Small garden activity | x | - | - | x | x | x |
| Convenience | x | - | x | - | - | x |
| Better health | x | - | x | - | - | x |
| Non domestic activity | x | - | - | x | - | x |
| Water use activities | x | - | x | - | - | x |
| Brick making | x | - | - | x | x | x |
| Water borne diseases | x | - | x | - | x | x |
| School attendance | x | - | - | x | - | x |
| Domestic activity | x | - | - | x | - | x |
| Adult education | x | - | - | x | - | x |
| Waste and drainage problem | - | x | x | x | - | x |
| Insect and flies problems | - | x | x | - | x | x |
| Land pollution | - | x | x | - | x | x |
| Visual quality | - | x | x | - | x | x |
| Parasite diseases | - | x | x | - | x | x |

Table 8.5 The most important positive and negative impacts identified in the villages A1&B1 during operation phase

| Impacts / Environmental parameters | Positive | Negative | Direct | Indirect | Short-term | Long-term |
|---|---|---|---|---|---|---|
| Better health | x | - | x | - | - | x |
| Convenience | x | - | x | - | - | x |
| Water borne disease | x | - | x | - | - | x |
| Carpet making | x | - | - | x | - | x |
| Water use activity | x | - | x | - | - | x |
| Welfare of family | x | - | x | - | - | x |
| Non domestic activity | x | - | - | x | - | x |
| Adult education | x | - | - | x | x | x |
| school attendance | x | - | - | x | - | x |
| Drop of water table | - | x | - | x | - | x |
| Ground water quality | - | x | - | x | - | x |
| Ground water quantity | - | x | - | x | - | x |
| Reduced pressure of aquifer | - | x | - | x | - | x |

Table 8.6 The most important positive and negative impacts identified in the villages (C1 & D1 and C1 & D1) during construction phase of project

| Impacts / Environmental parameters | Positive | Negative | Direct | Indirect | Short-term | Long-term |
|---|---|---|---|---|---|---|
| Better health | x | - | x | - | - | x |
| Participation | x | - | x | - | x | x |
| Employment | x | - | x | - | x | x |
| Income of people | x | - | x | - | x | x |
| Acquisition of skilful | x | - | x | - | x | - |
| Land use | - | x | x | - | x | x |
| Soil erosion | - | x | x | - | x | x |
| Ground water quality | - | x | x | - | x | x |
| Connection fee | - | x | x | - | - | x |
| Visual quality | - | x | x | - | x | x |
| Land pollution | - | x | x | - | x | x |
| Flora and fauna | - | x | x | - | x | x |

Table 8.7 The most important positive and negative impacts identified in the villages ( C & D and C1 and D1) during operation phase

| Impact / Environmental parameters | Positive | Negative | Direct | Indirect | Short-term | Long-term |
|---|---|---|---|---|---|---|
| Better health | x | - | x | - | - | x |
| Convenience | x | - | x | - | - | x |
| Water borne diseases | x | - | x | - | - | x |
| Welfare of family | x | - | x | - | - | x |
| Water use activities | x | - | x | - | - | x |
| Visual quality | x | - | - | x | - | x |
| Carpet making | x | - | - | x | - | x |
| Adult education | x | - | - | x | - | x |
| Small garden activity | x | - | - | x | x | - |
| Parasite diseases | x | - | x | - | - | x |
| Domestic activities | x | - | - | x | - | x |
| School attendance | x | - | - | x | - | x |
| Non domestic activities | x | - | - | x | - | x |
| Drop of water table | - | x | x | - | - | x |
| Ground water quality | - | x | x | - | - | x |
| Annual rate of water | - | x | x | - | - | x |
| Waste and drainage problems | - | x | x | - | - | x |

As Table 8.4 - 8.7 shows, the provision of a potable water supply and sanitation project in the construction and operation phase may have some positive and negative ( direct, indirect, short term and long term) impacts on the natural, social and economic environment in the rural areas of Iran. But, these impacts are different in many aspects in the sample villages due to the changes in the climate, culture and environment ( see chapter 7, village case studies). The most important positive and negative impacts identified are:

**(a) During operation phase**

**i. Positive impacts**:

1. **Convenience :** As noted earlier in chapter 6 on page 236, convenience of rural people especially women and children is a significant positive direct impact of the water supply project.

2. **Increase of water use activities :** These activities contain; washing clothes, bathing adult and children. As noted earlier, in chapter 7 on page 315 bathing adult and children and washing clothes in the villages A&B and A1& B1 is more than in the unimproved villages C&D and C1&D.

3. **Domestic and non domestic activities :** According to my finding in chapter 7 on page 337 improved potable water supply project indirectly effect in the creation of these

activities for women through released time and convenience from fetching water.

**4. Adult education activity :** Based on my finding in chapter 7 on page 337 and literature review in chapter 6 on page 242, the majority of rural women who had enough time from fetching water can participate in the adult education classes.

**5. School attendance :** According to my literature review in chapter 6 on page 245 and my finding in the case study on page 337 children, like women.may use their extra time to attend in school.

**6. Reduce of water borne diseases:** Improved quality of water can have direct impact in reducing of the water borne diseases such as diarrhoea. especially children under 5 years old ( see chapter 6, page 210-213 ).

**7. Reduce of parasite diseases:** According to literature review in chapter 6, improved a piped water supply combine with sanitation facilities may lead to decrease the parasite disease. Moreover, with reference to my finding in chapter 7 on page 349 the incidence of parasite diseases in the Urmia villages is more than Yazd villages due to insanitary disposal of human and animal waste.

**8. Small garden activities :** With reference to literature review in chapter 6, on page 253 and my finding in case study on page 342 and my observation from the fields, revealed that, the water supply project may have positive indirect impact in the irrigation of small garden activity.

**9. Carpet making:** This economic activity is a positive indirect benefit of a piped water supply in the improved villages of Yazd city ( see chapter 7, page 388). My finding showed that, many women and their daughters spend their extra time to carpet making.

**10. Brick making :** Based on the literature review in chapter 6 on page 255 and my findings in the case study on page 342, increased the quantity of water may generate this economic activity in the rural areas. This economic activity in the rural areas of Yazd has great benefit for rural people.

## ii. Negative Impacts

**1. Drop of water table, decrease pressure of aquifer and degradation of ground water quality:** More usage of ground water and increase well drilling especially in the Yazd villages may lead to drop a water table ( see the case study on page 307 ). Moreover, based on the literature review in chapter 3 on page 98, these problems in rural areas of developing countries are a negative impact of the excessive use of ground water on environment.

**2.Land pollution, waste and drainage problems:** According to my observation and survey from the fields( see chapter 7 page 291-295), insanitary disposal of human and animal waste especially in the Urmia villages has been caused the environment to become contaminated. Moreover, my observation also showed that, many villagers threw their sanitary waste water out of their house to the street.

This problem is caused as a result of the availability of piped water supply in the improved villages which can have negative impact on the environment (see chapter 4 on page 169).

**(b) During the construction phase**

All impacts identified during construction phase are based on the literature review and personal view of the author. As Table 8.6 on page 420 shows, the most important positive and negative impacts identified including:

**i.Positive impacts:**

1. **Employment:** As noted earlier in chapter 6 on page 242, a number of villagers may be employed as labourers and carpenters to help the project, and this can have positive impact on rural community.

2. **Participation of rural people :** According to the literature review in chapter 6 on page 243-244 the piped potable water supply and sanitation project in rural areas during construction may lead rural communities taking part in the project in all stages including; site selection, planning, finance, installation and operation and maintenance.

3. **Acquisition of skills and new job:** with respect to literature review in chapter 6 on page 242, a group of villagers may train and help in the project. This in turn

will be very fruitful for villagers, due to learning a new job.

**4. Income of people :** Employment of rural people as labourers or in other forms mentioned above can help to increase their income ( See chapter 6 page 242).

**ii. Negative impacts:** The most important negative impacts during the construction phase of projects are:-

**1. Land use :** Construction of a small scale piped water supply and sanitation project may require; land for digging pipe line works, storage tanks and spring boxes, well drilling and sanitation facilities such as latrines and septic tanks (see chapter 3 ).

**2. Destruction of Flora and fauna:** As stated above, all construction activities mentioned above may have adverse impacts on local flora and fauna.

**3. Land pollution :** Land may be polluted by the materials which can be used in construction works such as; oil, chemical materials, solid waste disposal, waste water of workers, and drilling of wells ( see chapter 4 ).

**4. Visual quality :** I believe that, any change in ecosystem can have adverse impact on visual quality. Thus, all construction activities of a project may have deleterious impact on the landscape and visual quality.

**5. Soil erosion :** As noted in chapter 3 on page 84-98 well drilling operations and other construction works may involve the removal of vast areas of vegetation during the construction phase of a project. According to the United

Nations in 1987, removing vegetation on a sloped run often causes soil erosion which may:

I. Affect the recharge of the aquifer

II. Contaminate streams and drinking water supplies if silt and nutrient and pesticides laden run off water enter them.

III. Damage pipelines and result in water wastage and contamination.

6. **Contamination of ground water quality :** Digging a well or qanat or the repair of them in rural areas may lead to pollution of the ground water with construction materials (see chapter 4 ground water pollution ). Thus this may have negative impact on the quality of drinking water.

7. **Connection fee and annual water rate:** As stated in chapter 6 on page 248, rural people who are willing to have access to a piped potable water supply and sanitation facilities must pay a connection fee during the construction phase and monthly or annually water rate during operation of project. This may be a negative impact on the economic status of some rural people but it will be helpful for the maintenance and operation of the project.

EIA matrix analysis and comments on the positive and negative impacts identified revealed that, the provision of a potable water supply and sanitation project in the rural areas of Iran may generate many beneficial impacts from the health, social and economic point of view and some adverse negative impacts on natural environment. All negative impacts identified must be mitigated. In the following section the mitigation measures are considered.

## 8.7: Mitigation measures

The existing environmental view in the sample villages as well as the results of the EIA matrix analysis indicated that, it is essential to provide an environmental plan of action for the regions. This plan attempts to introduce some measures for maximizing positive beneficial impacts and minimizing negative adverse impacts of the project.

As noted above, the most important positive and negative impacts were identified. The negative impacts should be the target for immediate action. The positive impacts of the project should be enhanced by utilizing local resources and techniques, for instance; education of rural people regarding environmental problems and water use activities. However, the mitigation measures are suggested by the author including:

### (a): Mitigation measures for land pollution, waste disposal and drainage problems

1. A good drainage system should be built around the water supply site and or public stand pipe. The drainage ditch as often as needed should be cleaned by villagers.
2. Minimize contamination of the surrounding water and

soil, for example; proper siting of facilities with adequate spacing between properly designed latrines and their correct maintenance.

3. Render of sanitation waste free of pathogenic organisms through composting technique and so make it useful as agricultural fertilizer .

4. Minimize peoples contact with raw waste.

5. Minimize odours and mosquito and flies by for instance; using ventilation pipe for pit latrines.

**(b): Mitigation measures for dropping of water table and depletion and degradation of ground water**

The results of the matrix assessment showed that, a drop of the water table and depletion and degradation of ground water in the Yazd villages (A1 & B1 and C1 & D1) have a significant negative impact of the more excessive use of ground water. As stated earlier in chapter 3 on page 38 the most important mitigation measures include:

1. Farmer education; it is essential that, rural people in the Yazd villages should be educated concerning the water requirements of plants and the potential damage that more usage of water and over irrigation may cause. Moreover, villagers should be warned that ground water sources are limited and more use of it may lead to deplete ground water in the next few years.

2. Feeding the ground water by building small scale dams,

and making regional plans for water supply.

3. Improving the traditional irrigation and water supply system,such as qanat which is very popular in these areas, may be useful for saving ground water source in the region.

4. Mandatory regulation. This should be carried out by the government to prevent the drilling of more boreholes without permission and in relation to regional water flow.

5. Conducting systematic survey of ground water quality to detect the presence of pollution.

6. To prevent the ground water from pollution during construction phase, it is essential to disinfect the water after finishing construction operations.

**(c): Mitigation measures for the risk of soil erosion**

1. Identification of soil erosion risk areas by inspection of pipelines and septic tank and waste water conduits.
2. Protecting soils with natural materials such as humid hay, palm tree leaves.
3. Managing livestock in order to avoid potential erosion around the water source.

## 8.8: Conclusions of the application EIA matrices and main findings

The conclusions of the present study express the main findings of the EIA developed for the provision of a potable water supply and sanitation project in the rural areas of Iran. This research considered the construction and operational activities of projects in the unimproved villages and only the operational activities of the project in the improved villages.

The conclusions are based on the environmental impact techniques applied, the checklist and the matrix, to identify and assess the positive/beneficial and negative/ deleterious impacts. The following major findings have been drawn from the EIA methods used. I have summarized the overall results of EIA numerical matrices figures 8.3 to 8.6, in the improved and unimproved villages of the Urmia and Yazd city in Table 8.8.

Table 8.8 Summary of the results of EIA matrix in the sample villages

| EIA Matrix | Project activities | | Total identified impact | | | Environmental parameters | | | | | | | | | Overall sum (+) & (-) impact | | Overall impact activities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Operational phase No. activity | Construction phase No. activity | No | + | - | Natural | | | Social | | | Economic | | | Σ + | Σ - | Σ TOTAL |
| | | | | | | No | + | - | No | + | - | No | + | - | | | |
| Figure 8.3 | 7 | - | 63 | 44 | 19 | 17 | 4 | 13 | 32 | 28 | 4 | 14 | 12 | 2 | 298 | 140 | 158 |
| Figure 8.4 | 8 | - | 68 | 48 | 20 | 20 | 5 | 15 | 32 | 29 | 3 | 16 | 14 | 2 | 249 | 138 | 111 |
| Figure 8.5 | - | 10 | 71 | 36 | 35 | 40 | 7 | 33 | 20 | 20 | - | 11 | 9 | 2 | 117 | 94 | 23 |
| Figure 8.6 | 8 | - | 62 | 55 | 7 | 11 | 8 | 3 | 32 | 30 | 2 | 19 | 17 | 2 | 346 | 29 | 317 |

## 8.8.1: Findings of EIA matrix in the villages(A & B )

With regard to Matrix figures 8.3 ( page 396) and Table 8.8 the main findings are:-

1. In the application of an EIA matrix in the improved villages ( A & B ) the total number of impacts identified in the matrix is 63, of which 44 are positive and 19 negative.
2. The number of environmental impacts in the natural system is 17, of which 4 are positive and 13 negative.
3. The number of environmental impacts in the social system is 32, of which 28 are positive and 4 negative.
4. The number of environmental impacts in the economic system is 14, of which 12 are positive and 2 negative.
5. The maintenance activity and time released because of easier water availability in the project has generated only positive impacts on natural, social and economic systems.
6. The highest scores for positive impact are for small garden activity, better health, water use activities and the convenience of water carriers.
7. The highest scores for negative impacts are waste disposal and drainage problems, visual quality and parasite diseases.
8. The overall sum ( + ) of positive impacts is 298
9. The overall sum ( - ) of negative impacts is 140
10. The overall impact of the activities generated by the project activities is 158.

11. The activity which generated the great number of impacts were increased quantity of water with 12 positive impacts and 3 negative impacts

**8.8.2: Findings of EIA matrix in the villages A1 & B1**

As matrix figure 8.4 (page 397) illustrates, the main finding are:-

1. The total number of impacts identified in the matrix is 68, of which 48 are positive and 20 negative.
2. The number of environmental impacts in the natural system is 20, of which 5 are positive and 15 negative.
3. The number of environmental impacts in the social system is 32, of which 29 are positive and 3 negative.
4. The number of environmental impacts in the economic system is 16, of which 14 are positive and 2 negative.
5. The activity which generated the greatest number of impacts was availability of water with 10 positive impacts and 5 negative impacts.
6. The activity which generated the most positive impacts is maintenance, with 12 positive impacts.
7. The highest scores for positive impacts are better health, convenience.
8. The highest scores for negative impacts are a drop of water table, depletion of ground water and more pressure on the water in the aquifers.
9. The overall sum ( + ) and ( - ) of positive and

negative impacts are 249 and 138 respectively.

10. The overall impact of the activities generated by the project activities is 111.

**8.8.3: Findings of EIA matrix in the unimproved villages {C&D} and {C1&D1} during construction phase**

With regard to Figure 8.5 (page 398), the major findings are:-

1. The total number of impacts identified in the matrix is 71, of which 36 are positive and 35 negative.
2. The number of environmental impacts in the natural system is 40, of which 7 are positive and 33 negative.
3. The number of environmental impacts in the social is 20, of which all are positive.
4. The number of environmental impacts in the economic is 11, of which 9 are positive and 2 negative.
5. The highest scores for positive impacts are for better health, participation of rural people and employment.
6. The highest scores for negative impacts are for land use, risk of soil erosion and ground water quality.
7. The overall sum ( + ) and ( - ) of positive and negative impacts are 117 and 94 respectively.
8. The overall impact of the activities generated with the construction of the project is 23.

**8.8.4: Findings of EIA matrix in the unimproved villages ( C & D and C1 & D1 ) during operation phase**

The chief findings of EIA matrix figure 8.6 (page 399) including:

1. The total number of impacts identified in the matrix is 62, of which 55 are positive and 7 negative.
2. In the natural system the number of environmental impacts is 11, of which 8 are positive and 3 negative.
3. The number of environmental impacts in the social is 32, of which 30 are positive and 2 negative.
4. In the economic system, the number of environmental impacts is 19, of which 17 are positive and 2 negative.
5. The activities which generated the greatest number of positive impacts were availability and increased quantity of water.
6. The activities which generated the greatest number of negative impacts were those causing more use of ground water.
7. The highest scores for positive impacts are the better health and convenience of water carriers.
8. The highest scores for negative impacts are a drop of water table and decrease of ground water quantity.
9. The overall sum ( + ) of positive impacts is 346 and sum (-) negative impacts is 29.
10. The overall impact of the activities generated with the operation of the project is 317.

# CHAPTER 9

# CONCLUSIONS AND RECOMMENDATIONS

## 9.1: Conclusions:

This final chapter details the conclusions which may be drawn from my research and makes some recommendations which may be useful for the EIA of future water supply and sanitation projects in rural areas of developing countries, and particulary in Iran.

Water is essential for maintaining settlements, and its presence or absence in an area has a profound impact on their development and prosperity. In the development of rural communities, water plays a vital role, hence, a reliable supply of water is an essential prerequisite for the establishment of permanent communities. In the first chapter of this thesis, I tried to show that, the majority of people in developing countries live in rural areas and there is increasing concern about the potable water supply available to this large population. Poor water supplies are considered a significant restraint on the economic development of rural populations and inadequate supplies are the cause of much hardship, and acute suffering from natural disasters such as drought.

Improved potable water supplies and sanitation facilities in rural areas of developing countries may lead to improvement in peoples' health and this in turn, may lead to increased prosperity and population. It is a paradox that a consequence of these beneficial effects may have a potential for adverse impacts on the environment. The most important of which is increasing population which may increase pressure on hydrologically limited water availability.

In the second chapter, I tried to indicate the importance of Environmental Impact Assessment (EIA), which may be used as a tool to identify and predict both beneficial and adverse impacts in the planning and implementation of a project. In this chapter, the main problems of EIA in developing countries, particularly in Iran, was discussed. I found that, with regard to such problems, some countries have tried to implement EIA systems in their planning process and encouraged environmental consciousness amongst their people. In the same chapter I also tried to demonstrate that the lack of environmental assessment in the development of water supply projects may result in severe effects on the natural environment and also on the socio-economic and health status of the communities.

The third chapter of my thesis, was devoted to outlining the advantages and disadvantages of various ways of obtaining water for potable supply. Each technique has its own beneficial and adverse characteristics. For instance; from the point of view environmental impact, the qanat water system has a drainage role in an area and thus withdraws water from surrounding land which may have an adverse impact on the environment by altering the balance in underground waters. I also explained that more drilling of boreholes and excessive use of groundwater in many rural areas of developing countries may have adverse impacts on environment and economic situation of rural people.

In the fourth chapter I tried to outline various ways in which water sources may become polluted and the mitigating methods which may be used in rural areas of developing countries. I also mentioned that the contamination of water source concerned both the quality and quantity of water. The vast majority of rural people in developing countries are still affected by source contamination as they largely depend on small water supply systems without treatment facilities.

In chapter four, the process of water treatment and associated problems was discussed. I came to the conclusion that, as a result of comparison of water treatment process for rural areas of developing countries that the application of slow sand filtration with 21 positive (+) impacts had the best potential for removing impurities in water. The application of Chlorine to the water with 13 positive (+) impacts in the second stage of removing impurities of water after slow sand filtration was very significant. I also found that the implementation of water treatment projects had both beneficial and deleterious impacts on the environment, social behaviour and health.

The implications of potable water supplies and sanitation projects on the health and socio economic status of rural people were discussed in chapter 6. In this chapter, I tried to show that investment in potable water supply and sanitation projects in rural areas had various positive and negative impacts on rural people. A primary input in the improvement of potable water supply and sanitation project might create " direct" health and social benefits by preventing the prevalence of water-related diseases and improving nutritional status. The resulting reduction in illness allowed more time for productive work and education activities which in turn increased the general well being of the people concerned and so creates "indirect" health benefits. I came to the conclusion that, the provision of potable water supplies might create various indirect economic benefits such as; improved productivity, increased income of people, improved home based industrial activity and improved dairy technology.

The seventh chapter of my thesis was devoted to a case study which was carried out in the rural areas of the North West and Central regions of Iran. Data were obtained by:-

questionnaire, interview and my own survey and observation from four villages in Urmia City and four villages in Yazd City. I identified and evaluated statistically some positive and negative impacts in the improved and unimproved villages. I noted the differences between the areas resulting from the presence of improved potable water supply and sanitation facilities.

I started this chapter with comments on the adverse effects of physical features on the development of water resources, and problems of potable water supply and sanitation projects in rural areas of Iran. The main findings of the field research divided into two main parts (I) positive and (II) adverse impacts. The positive impacts also divided into direct and indirect effects. They are as follows:

**(I). Direct positive impacts:**

**1. Increase per capita consumption of water:** I found that there was significant (P=<0.001) difference between the mean per capita consumption of water in the improved and unimproved villages. My findings demonstrated that, the mean per capita consumption of water in the improved villages of Urmia (A&B) was 22.5 and 23.5 litres, while, in the unimproved villages (C&D) was 15.1 and 14.5 litres respectively. In the Yazd villages A1&B1, it was 23.1 & 22.7, litres whilst, in the villages C1&D1 was 16 & 14.6

litres.

Similarly Warner (1973) in Tanzania villages before and after installation of water supply found that there was significant increase in per capita consumption of water in the improved villages. Research in East Africa villages was carried out by White et al; (1972) found that providing household water connection increased the per capita consumption of water two to three fold.

My findings also showed that there was a significant positive correlation (P=<0.001) between the mean per capita consumption of water and mean household size. It was also found that there was a significant negative correlation ( P = < 0.001) between the mean per capita water consumption and mean distance of water source from households. I also found that, increased consumption of water in the improved villages indicated on increase of daily water usage activities such as washing clothes, bathing adult$^{s}$ and children and washing dishes.

**2. Improved quality of water:** My investigation indicated that the quality of water in the improved villages was better than unimproved villages and they did not need any treatment facilities. While, in the unimproved villages the majority 62.8% in the Urmia and 22.8% in the Yazd villages reported that they use individual treatment such as boiling and chlorination method. This might be related to potable water supply and protection of water sources in the improved villages.

**3. Decrease the distance of water source to households:**

My findings in the sample villages demonstrated that there was a significant (P = < 0.001) difference between the mean distance to water source for households in the improved and unimproved villages. I found that the mean distance in the improved villages A&B was 4.5&3.5 metres while, in the unimproved settlements, it was 234 & 296 metres. In the Yazd villages A1&B1 it was 3 & 135 metres whilst in the villages C1&D1 was 196 & 242 metres respectively. Similarly, Warner (1969a) and (1969b) found that people in the unimproved villages of Tanzania fetched water from a long distance ranged from 1.0 to 5.6 miles. White (1977) in Tanzania found that the distance of water source from households after the installation of a piped potable water supply has been reduced significantly. He also found that many rural people in the DONGORE areas of Ethiopia in the dry season had to go 5 or more kilometres to the only accessible source of water.

I came to the conclusion that the provision of a potable water supply in the improved villages both decreased the distance over which water was carried and, that as a result there was a positive social and economic impact on water carriers in villages.

**4. Decrease the round trip (travelled time)**

I found that there was a significant (P=<0.001) difference between the mean round travel time for fetching water in the improved and unimproved villages. My findings showed that the mean round trip travelled time in the villages A&B was 2.20 & 2 minutes, whilst in the villages C&D was 39.42 & 36.4 minutes. In the Yazd villages A1&B1 it was 2.3 & 18.1 minutes, while, in the villages C1&D1 it was 30.3 and 30.1 minutes respectively. I also found that there was a significant (P=<0.001) positive correlation between the mean round trip and distance to water source.

Similarly, Feachem et, al;(1977), in Lesotho Low land villages, found that the mean round trip travel times in the improved and unimproved villages was 12 and 20 minutes respectively. While, in the mountain areas, the figures were 3 and 7 minutes. Warner (1969a) in the improved villages of Tanzania found that the mean round trip travelled time was 40 minutes and 3.5 hours.

I came to the conclusion that the provision of potable water supply in the improved villages decreased the round trip travelled time and created great convenience for water carriers.

**5. Decrease total daily time spent in fetching water**

My results showed that the mean total daily time spent in fetching water among women and children in the improved and unimproved villages were significantly (P=< 0.001) different. The total daily time spent for fetching water in the villages A&B for women was 20.5 & 14.5 minutes and 11.5 & 10.5 minutes for children. Whilst, in the unimproved villages C&D it was 157 & 175 minutes for women and 124 & 153 minutes for children respectively.

Similarly, Featchem et al;(1977) in Lesotho villages found that the time saving for women was over one hour per day. White et al;(1972) in East Africa villages found that the mean daily time spent for women in fetching water was 264 minutes. Moreover, Falkenmark (1982) found that some women spent four hours or more for a single journey to fetch water.

My finding demonstrated that the majority of women, first, and children, second, in all villages were the main carriers of water. In the unimproved villages men sometimes also carried water due to far away location of the water source. Moreover, women and children in the improved villages used a smaller containers between 10 and 5, litres over a short distance, but in villages without a potable water supply adults and children used a big container bucket between 10-20 litres to fetch water over a long distance.

Similarly, Warner (1973) in Tanzania villages found that in two thirds of the households, women were the main carriers of water, in one half of the households children and in only one fifth of households men. Farrar (1974) in the unimproved villages of Swaziland found that men never carry buckets, they used ox-drawn sledges or carts carrying nearly 200 litres drums of water.

**6. Decreased the incidence of diarrhoea disease**

My findings indicated that the proportion of children less than five years old who suffered frequently from diarrhoea in the unimproved villages was more than improved villages. I found that there was significant (p=<0.001) difference between the mean number of children per household in the villages A&C and A1&C1. No significant difference (P= 0.08) was found between the villages B & D and B1 & D1.

Similarly Warner (1973) in Tanzania villages before and after installation of water found that there was significant reduction in the mean number of children who suffered frequently from diarrhoea.

Nevertheless, my investigation revealed the incidence of parasitic diseases such as ascariasis, giardiasis and oxyu re occurred in all villages particularly in the Urmia areas. It was found that, the majority of housewives in all villages reported that the contaminated water was the main cause of diarrhoea.

**(1.1) Indirect positive effects:**

Several indirect positive effects of potable water supplies occurred in the improved villages as a result of time saving for women and children including, extra time spent on:-

**(1).** Participation of women in adult education classes (18.5% and 11.5% of women in the Urmia and Yazd villages participated in adult education classes respectively).

**(2).** Domestic activities such as; housework and baby care, cooking and cleaning the house (33.5% and 22.8% of women in the Urmia and Yazd villages reported that they spent their extra time available in domestic activities).

**(3).** Agricultural work such as weeding and irrigation of small gardens in their yards by the majority 45.6% of women in the Urmia villages.

**(4).** Carpet making for the majority 51.3% of women in the Yazd villages.

**(5).** Studying and playing for the majority 88.6% of children in the Urmia villages and or carpet making for the majority 38.5 % of children in the Yazd villages.

Some indirect positive economic effects stemmed from the improved potable water supply in the improved villages including:-

**I. Improved small garden activity:** My finding showed that there was significant (P=<0.001) difference between the mean weekly water used for small garden activity in the improved and unimproved villages. I also found that this benefit occurred more in the Urmia villages than Yazd villages.

Similarly, Jakobsen et al;(1971) found that small scale irrigation of vegetable garden especially around the water point,becomes possible. Carruthers (1973) found that improved potable water supplies may have positive beneficial impacts on increasing agricultural production in a small scale garden in the household's yard.

**II. Increased brick making activity:** My investigation demonstrated that there was significant (P=<0.001) difference between the mean weekly water used in the improved and unimproved villages. I also found that this activity was greater in the Urmia villages than that of the Yazd area.

Similarly Warner (1973) in the improved Tanzania's villages found that increased water can have positive impact on the home industrial activity such as brick making.

**III. Livestock activity:** I found that there was no significant (P=<0.08) difference between the mean number of cattle & sheep in the improved villages. Hence I came to the conclusion that, no significant increased occurred in the improved villages.

It should be noted, however, that Jakobsen, et al;(1971) in Kenya found that there was significant difference in the mean number of sheep between the study and comparison areas. Carruthers and Browne (1977), found that in the dry regions where rural people depend on cattle, water supply may provide a real benefit in keeping cattle alive if water is more limited than grazing. However, the impact of potable water supply for cattle may be slight unless individual connection are installed. Saunders and Wardford (1976) found that increase might be over a four years period in the number of cattle and sheep where there was potable water supplies. Warner(1973), investigating 15 villages in Tanzania before and after installation of water supplies found that only between two villages was there a statistically significant increase in the mean number of cattle herds.

**(II) Adverse effects**

The consequences of the adverse environmental impacts of a piped potable water supply and more usage of ground water the Yazd villages included:-

1. Lowering of the water table
2. Degradation of ground water quality
3. Decreased pressure in the aquifer
4. Damage to or destruction of qanat waters in the Yazd areas

**III. Village sanitation**

The results of my observations on village sanitation status showed that there were some significant problems regarding environmental health in all villages except village A1 in the Yazd area. They were:-

1. the discharge of waste water from households to the streets and open canals.
2. the reuse of human and animal excreta practiced in all the sample villages particularly in the Urmia areas.
3. the likely pollution of the environment, surface waters and ground waters by insanitary disposal of human and animal waste.

In the eight chapter I discussed the selection and application of appropriate EIA techniques to assess the environmental impacts of potable water supply and sanitation projets in the rural areas of Northwest and Central areas of Iran.

The application of Environmental Impact Assessment (EIA) techniques is appropriate for the assessment of the environmental implications associated of water supply and sanitation projets. It is widely employed in other areas of development in many different parts of the world. I believe, therefore, that it is an appropriate as a tool for the prediction of impacts and the identification of remedial actions in relation to water supply projects.

I found that, through the application of some EIA techniques and particularly the Leopold's matrix it was possible to quantify the magnitude and significance of impacts and to identify the cause effect relationship between them.

The impacts were analyzed and assessed in terms of the interaction between the project activities in the construction phase (in the unimproved villages) and operation phase (in the improved villages) and environmental parameters in the natural, social and economic system (see figures 8.3 to 8.6). The results showed that the impacts identified were positive, negative, direct, indirect, short term and long term (see Tables 8.4 to 8.7).

A Leopold matrix was developed in order to show the importance of the positive and negative impacts identified in a visual form. The results of my EIA matrix presentation survey by a questionnaire indicated that; (a) ~~that~~ for setting up an EIA with professionals, a weighted matrix was the best method (see matrix figures 8.3 to 8.6), and (b) that for the general purpose of showing the impacts and their importance a coloured matrix was possibly the best method (see matrices figures 8.7 to 8.10).

On the basis of my reading and case study information I was able to design Leopold matrices for villages in Iran. Although there are site specific they form a versatile and useful model for the use of an EIA techniques in predicting the environmental effects of *water supply and sanitation* in the rural areas of practically any developing country.

An important conclusion of my research is that water supply projects in rural areas of Iran cannot bring all their potential social, economic and health benefits without improved sanitation facilities and hygiene education.

## 9.2: Recommendations

### 9.2.1: Introduction:

The recommendation section is divided into three parts relating to:- qanats, because of their importance in Iran; sanitation, because during my research I came to realize that the provision of sanitation is vital if the full potential of water supply projects is to be realized; and a general section bringing out suggestions from the bulk of my research.

### 9.2.2: Specific recommendations for restoring the qanat water system

In spite of the importance of the qanat in the long history of Iran, in the last two decades the system is facing a new crisis. Many qanats have dried up and the rate of water flow in many others has decreased. As a result of the collapse of agriculture, the over-use of underground water, and the neglect and mismanagement of qanats, the following suggestions are made for restoring the systems in Iran, particulary in the study areas:-

1. The reconstruction and proper maintenance of qanat water systems should be carried out.
2. Regional plans should be considered for potable water supplies.

3. In order to ensure water continues to supply qanats, ground water should be fed by small dams.
4. The Government should make mandatory regulations to prevent the drilling of bore holes near to qanats.
5. In order to protect ground water sources, farmers should be educated regarding the water needs of various crops and the potential harm which irrigation may cause by the over extraction of groundwater.

### 9.2.3: Specific recommendations for sanitation and environmental health

With regard to my observations and survey from the study areas, the situation of village sanitation was not good. To get more benefit from the water supply projects the following suggestions are made:-

I. In order to avoid contamination of groundwater and surface water bodies, special attention must be given to sanitation facilities in areas prone to flooding or with periodically high water tables.

II. In the planning and implementation of sanitation programmes, special attention should be given to the habits, needs, values and economic status of the intended beneficiaries.

III. Special attention should be given to the type and location of sanitary facilities.

IV. To ensure maximum health benefits from improved water supply, such projets should be coupled with human waste disposal systems. Adequate attention to sanitation should be given and may help in preventing the contamination of the environment and water sources and so in minimizing the spread of disease.

**V.** Research is needed into converting animal waste to energy by introducing biogas systems so as to make the technique economically attractive. It may then become the sanitary and preferred method of animal waste disposal in rural areas of Iran.

**VI.** Animals should be kept away from the water supply sites and areas around water points should be fenced and well drainag .

**VII.** Hygiene education programme should be considered for all people but particularly for women and children.

**VIII.** More attention is needed for the training of local staff and water users, enabling them to play an active role in water source protection.

**IX.** Helping to involve women to both attend and to speak out during community water supply planning meetings is important, as they often most directly feel the impacts of deteriorating water quality and quantity.

**X.** To improve general sanitation appropriate latrines at suitable places should be selected and constructed.

**XI.** Health awareness education to rural people should be given regarding the water and excreta related diseases.

**9.2.4: General recommendations**

Many recommendations can be made from my research and may be expected to be fruitful for the development of future rural potable water supply and sanitation projets in Iran. The following general suggestions are directed at the Ministry of Health and Medical Education in Iran.

1. Rural programmes of water supply and sanitation from planning to implementation, should be concentrated in the environmental health section of the Ministry of Health. There should be a unit headed by an engineer, economist, or sociologist and staffed with several sub-professional, but reliable, assistants capable of carrying out field evaluation surveys and subsequent data processing.
2. An EIA Bureau should be established in the Ministry of Health, and all engineers and technicians who are responsible for potable water supply and sanitation projets should be trained in the use of EIA techniques.
3. EIA should be used in every attempt at development.
4. All evaluated projects, before and after survey should be supervised and assessed by an EIA team.
5. The results of field evaluations may be used to continually review the effectiveness of current priorities and planning methods. All evaluation efforts should be designed to improve methods of

planning.

6. Planners should give adequate emphasize to the social and environmental consequences stemming from the development of water supply and sanitation projects.
7. In the long term, improvements in the EIA of water supply and sanitation projects should include; survey, research and extension activities and also the application of legislation.
8. For better understanding of environmental impacts of water supply projects in the rural areas of Iran, other studies should be carried out including social and cultural impacts assessments.
9. Environmental Impacts Assessment (EIA), together with environmental cost should be taken into account in the water projets by the use of EIA and Cost Benefit Analysis (CBA) which might then provide the essential data for estimating impacts with controversial and conflicting consequences.
10. As more than 46 % of the population of Iran live in rural areas, great investment should be carried out in the planning of water supply and sanitation projects and every aspects of the EIA process and public participation should be strongly encouraged in such investment.
11. Incorporate environmental features into the design, construction, operation and maintenance of water supply and sanitation projects in order to reduce undesirable consequences, and enhance environmental

quality.

12. Formulate long term policies that reflect changing water demand patterns consistent with efficient use of water and better assessment of environmental effects.

13. The education and training efforts of developing countries should be supported by the international organizations in order to enhance their ability to assess the status of water projects and to formulate and carry out water project development strategies compatible with the need to protect and improve the environment for the benefit of all.

14. The quality of water in a village may be affected more by individual household methods of handling water than by centralized treatment processes. There is therefore a demand for more information on the transport, treatment, and storage of water in the villagers' houses.

15. The training of some villagers in the operation and maintenance of water supplies and sanitation facilities is essential.

16. To make sure that the quality of water in a village, is good, bacteriological and chemical laboratory analyses of water from both traditional and improved sources should be achieved on a regular basis.

17. Water conservation practices emphasizing traditional technology to reduce surface evaporation, seepage from channels, village tanks, rain water harvesting,

artificial groundwater storage must be undertaken.

18. Maintenance and operating costs; in addition to the heavy initial capital which the projet will incur, the water authority or environmental health department should be given funds for the maintenance and operating of pumps and other facilities. (Participation of rural people in maintenance and operation programme can be helpful in keeping costs low).

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# APPENDIX A: QUESTIONNAIRE OF THE CASE STUDY

**University of Salford**
**Environmental Resources Unit**
**Environmental Impacts of Rural Water**
**Supply and Sanitation Study**
**Households Survey Questionnaire**

---

Country ..... Province.........District.......

Village.........

Interviewer................

Date...................

Identifications of household.........................

1. Number of household members [ 5 codes ]

| Adults | | Children <5 | | Total |
|---|---|---|---|---|
| Male | Female | Male | Female | |
| | | | | |
| 1 | 2 | 3 | 4 | 5 |

2. Who answers the question ? [ 1 code ]

( ) Housewife of household 1
( ) Head of household (man) 2
( ) Daughter of household 3
( ) Son of household 4
( ) Other ( specify ....) 5

3. What are the adverse environmental impacts of more use of ground water? [ 1 code]

( ) Do not know 1
( ) Drop of water table 2
( ) Decrease pressure of aquifer,delpetion and degration of groundwater 3
( ) Other(specify.......) 4

4. How much water per day are used at your house for drinking, cooking and personal washing ? [ 1 code]

............... litres

5.In the following water activities which one occur daily, irregularly or does not occur ? [ 9 code ]

| | |
|---|---|
| ( ) Drinking | 1 |
| ( ) Cooking | 2 |
| ( ) Washing of utensils | 3 |
| ( ) Personal washing | 4 |
| ( )Washing of clothes | 5 |
| ( ) Watering animals | 6 |
| ( ) Bathing adults and children | 7 |
| ( ) Watering garden | 8 |
| ( ) Other ( specify .....) | 9 |

6. Could you say which activities in question 5 used the most amount of water at your house. [ 1 code ]

....................

7. Who usually collects and carries water at your house ?

[ 1 codes ]

| | |
|---|---|
| ( ) Women | 1 |
| ( ) Children | 2 |
| ( ) Men | 3 |
| ( ) Women &children | 4 |

8. What type of water container do the adults employ to carry water at your house ? [ 1 code ]

| | |
|---|---|
| ( ) Large bucket ( 10 - 20 ) litres | 1 |
| ( ) Small bucket < 10 litres | 2 |
| ( ) Plastic bottle 5 litres | 3 |
| ( ) Other ( specify ........) | 4 |

9. What kind of water container do the children employ to fetch water at your house ? [ 1 code ]

| | |
|---|---|
| ( ) Do not know | 1 |
| ( ) Small bucket < 10 litres | 2 |
| ( ) Plastic bottle 5 litres | 3 |
| ( ) Other ( specify ......) | 4 |

10. What kind of water source do you use for drinking?

[ 1 code]

| | | |
|---|---|---|
| ( ) | Protected spring | 1 |
| ( ) | Unprotected spring | 2 |
| ( ) | Protected qanat water | 3 |
| ( ) | Protected cistern water | 4 |
| ( ) | protected tube wells | 5 |
| ( ) | Unprotected tube wells | 6 |
| ( ) | Piped potable water supply | 7 |
| ( ) | Small stream water | 8 |
| ( ) | Other ( specify.......) | 9 |

11. Would you say the source of the drinking water which is used at your house has bad quality, good quality or average quality? [ 1 code ]

| | | |
|---|---|---|
| ( ) | Do not know | 1 |
| ( ) | Good | 2 |
| ( ) | bad | 3 |
| ( ) | Average | 4 |
| ( ) | Other ( specify ....) | 5 |

12. Which method do you use to treat polluted water at your house? [ 1 code]

| | | |
|---|---|---|
| ( ) | Do not know | 1 |
| ( ) | Boiling and cooling water | 2 |
| ( ) | Use chemical disinfectants | 3 |
| ( ) | Do not use | 4 |
| ( ) | Other ( specify .....) | 5 |

13. How many metres are one way distance from your house to drinking water source [ 1 code ]

................. Metres 1

14. How much time does it take(round trip) to fetch water from your house to the water source? [ 1 code ]

................ Minute 1

15. Could you say how much do women spent total daily time in fetching water ? [ 1 code ]

................ Minute 1

16. How much time do children spent total daily time in fetching water ? [ 1 code ]

................ Minute 1

17. How much do men spent total daily time in fetching water? [ 1 code]

........... Minute 1

18. How do you spend the extra time saved from fetching water ? [ 1 code ]

( ) Do not know 1
( ) Housework and baby care 2
( ) Adult education classes 3
( ) Rug making and housework 5
( ) Housework and agricultural work 6
( ) Other ( specify .......) 7

19. How do children spend their extra time from fetching water? [ 1 code ]

( ) Do not know 1
( ) Studying & playing 2
( ) Carpet making 3
( ) Agricultural work 4
( ) Other ( specify .......) 5

20. Do you own any livestock? [ 1 code ]

( ) Yes 1
( ) No 2

If yes ask question 21

21. What type of livestock do you have ? [ 2 codes ]

( ) Sheep & Goat 1
( ) Cattle 2

22. Does anybody in your house making brick of concrete or earth for the house building purpose? [1code ]

( ) yes 1
( ) No 2

If yes ask the question 23

23. How much water per week do you use for making brick? [ 1 code ]

   ........... Litres 1

24. Do you have a garden in your house? [ 1 code ]

   ( ) yes 1
   ( ) No 2

| If yes, ask the question 25 |
|---|

25. How many litres of water per week do you use for irrigation of small garden? [ 1 code ]

   .......... litres 1

26. How many children less than five years old frequently suffer from diarrhoea? [ 1 code ]

   ..............

27. What is the main cause of diarrhoea ? [ 1 code ]

   ( ) Do not know 1
   ( ) Contaminated water 2
   ( ) Contaminated food 3

28. How do you dispose of human excreta at your house? [ 1 code ]

   ( ) Empty by car and carry it out of village 1
   ( ) Use it as fertilizer 2
   ( ) Leave it in a deep well 3
   ( ) Other ( specify....... ) 4

29. How do you dispose of your animal waste? [ 1 code]

   ( ) Dumping it next to the house and use it as fertilizer 1
   ( ) Collect and carry it out side of house and use as fertilizer 2
   ( ) Other ( specify ...... ) 3

# APPENDIX B: TABLES OF THE CASE STUDY

Table B.1 Characteristics of population in the sample villages

| Village / Population | Urmia | | | | Yazd | | | |
|---|---|---|---|---|---|---|---|---|
| | Improved | | Unimproved | | Improved | | Unimproved | |
| | A | B | C | D | A1 | B1 | C1 | D1 |
| Total village population | 1035 | 716 | 1100 | 755 | 1005 | 987 | 618 | 750 |
| Total household | 233 | 150 | 215 | 115 | 201 | 179 | 135 | 156 |
| No.Household - interviewed | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| Average household size | 6.6 | 5.6 | 6.8 | 4.1 | 6.4 | 5.8 | 4.5 | 5.9 |
| Total population in the sample | 231 | 196 | 238 | 143 | 224 | 203 | 157 | 206 |
| Total population of children < 5 | 52 | 41 | 58 | 43 | 49 | 78 | 42 | 48 |

Source: Based on questionnaire and Environmental health office report

Table B.2 Characteristics of the interviewed persons

| Village | Urmia | | | | | | | | Yazd | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Improved | | | | Unimproved | | | | Improved | | | | Unimproved | | | | |
| Interview | A | % | B | % | C | % | D | % | A1 | % | B1 | % | C1 | % | D1 | % | Total |
| No.housewives interviewed | 24 | 68.5 | 22 | 62.8 | 25 | 71.4 | 28 | 79.7 | 30 | 85.6 | 29 | 82.6 | 30 | 85.6 | 32 | 91.3 | 78.4 |
| No.head of house (men) interviewed | 7 | 20 | 8 | 22.8 | 6 | 17.3 | 4 | 11.6 | 3 | 8.7 | 5 | 14.2 | 3 | 8.7 | 3 | 8.7 | 14 |
| No.daughters interviewed | 3 | 8.7 | 4 | 11.6 | 4 | 11.6 | 3 | 8.7 | 2 | 5.7 | 1 | 2.8 | - | - | - | - | 6.1 |
| No.sons interviewed | 1 | 2.8 | 1 | 2.8 | - | - | - | - | - | - | - | - | 2 | 5.8 | - | - | 1.5 |
| Total | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 100 |

Table B.3 Perception of households about environmental effects of more use of ground-water

| Village / Environmental effects | Urmia | | | | | | | | Yazd | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Improved | | | | Unimproved | | | | Improved | | | | Unimproved | | | |
| | A | % | B | % | C | % | D | % | A1 | % | B1 | % | C1 | % | D1 | % |
| Drop of water table | 20 | 57.1 | 23 | 65.7 | 12 | 34.2 | 14 | 40 | 25 | 71.4 | 27 | 77.1 | 17 | 48.5 | 15 | 42.8 |
| Decrease pressure of aquifer | 2 | 5.7 | 1 | 2.8 | 0 | 0 | 0 | 0 | 9 | 25.7 | 8 | 22.8 | 3 | 8.5 | 2 | 5.7 |
| Do not know | 13 | 37.2 | 11 | 31.4 | 23 | 65.7 | 21 | 60 | 1 | 2.8 | 0 | 0 | 15 | 42.8 | 18 | 51.4 |
| Total | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 |

Table B.4 Comparison of mean water consumption per capita (LCD) and per family

| Water used / Village | No. Households interviewed | Average household size | Water consumption (Mean litres) | | Standard deviation | | T value | | Degree of freedom | | Probabilit level( P) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LCD | Per Family | LCD | Per family | LCD | Per family | LCD | Per family | |
| A | 35 | 6.51 | 22.55 | 151.57 | 1.894 | 48.58 | | | | | |
| C | 35 | 6.74 | 15.11 | 101.71 | 0.758 | 23.30 | 21.32 | 5.47 | 43.06 | 48.85 | P=<0.001 |
| B | 35 | 5.62 | 23.37 | 127.71 | 2.829 | 33.88 | | | | | |
| D | 35 | 4.28 | 14.57 | 63.51 | 0.739 | 21.99 | 17.80 | 9.40 | 38.62 | 58.32 | P=<0.001 |
| A1 | 35 | 6.42 | 23.68 | 153.72 | 2.139 | 48.45 | | | | | |
| C1 | 35 | 4.57 | 16.00 | 74.86 | 1.435 | 33.24 | 17.65 | 7.94 | 59.45 | 60.20 | P=<0.001 |
| B1 | 35 | 5.91 | 22.71 | 135.43 | 1.673 | 43.66 | | | | | |
| D1 | 35 | 5.88 | 14.57 | 83.35 | 0.502 | 29.64 | 27.58 | 5.84 | 40.08 | 59.85 | P=<0.001 |

Table B.5 Comparison of water carriers in the sample villages

| Village | Urmia | | | | | | | | Yazd | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Improved | | | | Unimproved | | | | Improved | | | | Unimproved | | | |
| | A | | B | | C | | D | | A1 | | B1 | | C1 | | D1 | |
| Water carriers | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Women | 26 | 74.2 | 30 | 85.5 | 20 | 57.1 | 18 | 51.8 | 31 | 88.6 | 24 | 68.5 | 17 | 48.7 | 19 | 54.2 |
| Children | 9 | 25.8 | 5 | 14.5 | 4 | 11.4 | 6 | 17.2 | 4 | 11.4 | 8 | 22.8 | 3 | 8.5 | 2 | 5.7 |
| Men | - | - | - | - | 5 | 14.3 | 6 | 17.2 | - | - | 3 | 8.7 | 7 | 20 | 5 | 14.4 |
| Women& children | - | - | - | - | 6 | 17.2 | 5 | 14.2 | - | - | - | - | 8 | 22.8 | 9 | 25.7 |
| Total | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 |

Table B.6 Types of water containers adults

| Village<br><br>Container | Improved areas<br><br>Frequency | % | Unimproved areas<br><br>Frequency | % | Total |
|---|---|---|---|---|---|
| Large bucket(10-20) | - | - | 160 | 56.9 | 56.9 |
| Small bucket <10 litres | 102 | 36.3 | - | - | 36.3 |
| Plastic bottle<10 litres | 18 | 6.8 | - | - | 6.8 |
| Total | 220 | 43.1 | 160 | 56.9 | 100 |

Table B.6.1 Types of water containers children

| Village<br><br>Container | Improved<br><br>villages | % | Unimproved<br><br>villages | % | Total |
|---|---|---|---|---|---|
| Small bucket < 10 litres | - | - | 159 | 56.8 | 56.8 |
| Plastic bottle<5 litres | 121 | 43.2 | - | - | 43.2 |
| Total | 121 | 43.2 | 159 | 56.8 | 100 |

Table B.7 Perception of households about the water quality

| Village | Urmia | | | | | | | | Yazd | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Improved | | | | Unimproved | | | | Improved | | | | Unimproved | | | |
| Water quality | A | | B | | C | | D | | A1 | | B1 | | C1 | | D1 | |
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Good | 35 | 100 | 35 | 100 | 27 | 77.1 | 3 | 8.6 | 35 | 100 | - | - | - | - | 35 | 100 |
| Average | - | - | - | - | 2 | 5.7 | 9 | 25.7 | - | - | - | - | 26 | 74.2 | - | - |
| Bad | - | - | - | - | 6 | .17.2 | 23 | 65.7 | - | - | 35 | 100 | 9 | 25.8 | - | - |
| Total | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 |
| Water treatment | | | | | | | | | | | | | | | | |
| Do not use | - | - | - | - | 8 | 28.7 | 2 | 5.7 | - | - | - | - | 5 | 14.2 | - | - |
| Boiling | - | - | - | - | 10 | 22.8 | 6 | 17.2 | - | - | - | - | 4 | 11.5 | - | - |
| Chemical | - | - | - | - | 17 | 48.5 | 27 | 77.1 | - | - | - | - | 26 | 74.3 | 35 | 100 |
| Total | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | - | - | - | - | 35 | 100 | 35 | 100 |

Table B.8 Comparison of mean distance between households and water source

| Distance Village | No Household interviewed | One way distance to water source Mean (metre) | Standard Deviation | T value | Degree of freedom | Probability level P |
|---|---|---|---|---|---|---|
| A | 35 | 4.5 | 1.55 | -16.07 | 34.01 | P < 0.001 |
| C | 35 | 234 | 108.56 | | | |
| B | 35 | 3.5 | 1.73 | -17.76 | 34.02 | P < 0.001 |
| D | 35 | 296.57 | 97.68 | | | |
| A1 | 35 | 2.82 | 1.20 | -11.82 | 34.01 | P < 0.001 |
| C1 | 35 | 196.00 | 96.68 | | | |
| B1 | 35 | 134.85 | 44.15 | -5.88 | 47.15 | P < 0.001 |
| D1 | 35 | 242.00 | 98.42 | | | |

Table B.9 Correlation between variables

| Correlation<br><br>Variables | Total number of cases | Coefficient | Probability level( P) |
|---|---|---|---|
| **Between:** | | | |
| Total average family size and water used LCD | 280 | 0.2020 | P= 0.001 |
| **Between:** | | | |
| Total average family size and mean water used per household | 280 | 0.7989 | P < 0.001 |
| Mean distance and water used in family | 280 | - 0.6072 | P < 0.001 |
| **Between :** | | | |
| Mean round trip travelled time and distance | 280 | 0.9473 | P < 0.001 |

Table B.10 Comparison of mean round trip time spent

| Round trip / Village | No Household interviewed | Round trip mean ( minute) | Standard Deviation | T value | Degree of freedom | Probability level |
|---|---|---|---|---|---|---|
| A | 35 | 2.2000 | 0.719 | | | |
| C | 35 | 39.4286 | 13.382 | -16.43 | 34.20 | P < 0.001 |
| B | 35 | 1.8286 | 0.985 | | | |
| D | 35 | 36.4246 | 19.004 | -10.76 | 34.18 | P < 0.001 |
| A1 | 35 | 2.3143 | 0.471 | | | |
| C1 | 35 | 30.3857 | 14.354 | -11.36 | 34.07 | P < 0.001 |
| B1 | 35 | 18.1243 | 5.983 | | | |
| D1 | 35 | 30.1429 | 15.121 | -4.52 | 44.39 | P < 0.001 |

Table B.11 Comparison of mean total daily women time spent

| Time spent / Village | No household interviewed | Total daily time spent women mean (minute) | Standard Deviation | T value | Degree of freedom | Probability level P |
|---|---|---|---|---|---|---|
| A | 35 | 20.51 | 6.630 | | | |
| C | 35 | 157.000 | 66.190 | -12.14 | 34.68 | P < 0.001 |
| B | 35 | 14.28 | 5.021 | | | |
| D | 35 | 174.8571 | 47.781 | -19.77 | 34.75 | P < 0.001 |
| A1 | 35 | 12.7429 | 3.221 | | | |
| C1 | 35 | 107.8857 | 59.084 | -9.51 | 34.20 | P < 0.001 |
| B1 | 35 | 59.5714 | 32.571 | | | |
| D1 | 35 | 119.7143 | 59.717 | -5.23 | 52.58 | P < 0.001 |

Table B.12 Comparison of mean total daily time spent by children

| Time spent / Village | No household interviewed | Total daily time spent mean (minute) | Standard Deviation | T value | Degree of freedom | Probability level (P) |
|---|---|---|---|---|---|---|
| A | 35 | 11.457 | 6.904 | | | |
| C | 35 | 123.8571 | 43.337 | -15.15 | 35.72 | P < 0.001 |
| B | 35 | 10.2857 | 4.191 | | | |
| D | 35 | 153.0000 | 63.190 | -13.33 | 34.30 | P < 0.001 |
| A1 | 35 | 9.8286 | 2.728 | | | |
| C1 | 35 | 95.20000 | 48.312 | -10.44 | 34.22 | P < 0.001 |
| B1 | 35 | 50.0000 | 23.702 | | | |
| D1 | 35 | 104.8571 | 43.648 | -6.53 | 52.45 | P < 0.001 |

Table B.13 Comparison of mean total daily time spent by men

| Time spent / Village | No household interviewed | Total time spent mean (minute) | Standard deveiation | T value | Degree of freedom | Probability level( P ) |
|---|---|---|---|---|---|---|
| A | 35 | 0,0000 | 0.0000 | | | |
| C | 4 | 62.5000 | 23.979 | - | - | - |
| B | 35 | 0.0000 | 0.0000 | | | |
| D | 6 | 82.3333 | 21.639 | - | - | - |
| A1 | 35 | 0.0000 | 0.0000 | | | |
| C1 | 5 | 30.0000 | | - | - | - |
| B1 | 3 | 26.6667 | 5.774 | | | |
| D1 | 5 | 24.0000 | 32.863 | 0.18 | 4.40 | 0.867 |

Table B.14 Effects of time saving on water carriers ( Women and children )

| Village / Activities | Urmia | | | | Yazd | | | |
|---|---|---|---|---|---|---|---|---|
| | Improved | | | | Improved | | | |
| | A | % | B | % | A1 | % | B1 | % |
| **Womens' activities** | | | | | | | | |
| Housework and baby care | 12 | 34.2 | 11 | 31.5 | 9 | 25.7 | 7 | 20 |
| Carpet making and housework | - | - | - | - | 19 | 54.2 | 17 | 48.5 |
| Adult education classes | 6 | 17.1 | 9 | 25.7 | 3 | 8.5 | 5 | 14.4 |
| Housework and agricultural work | 17 | 48.5 | 15 | 42.8 | 4 | 11.6 | 6 | 17.1 |
| Total | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 |
| **Childrens' activity** | | | | | | | | |
| Studying & playing | 30 | 85.7 | 32 | 91.5 | 11 | 31.4 | 16 | 45.7 |
| Carpet making | - | - | - | - | 22 | 62.8 | 18 | 51.4 |
| Agricultural work and helping their parents | 5 | 14.3 | 3 | 8.5 | 2 | 5.7 | 1 | 2.9 |
| Total | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 |

Table B.15 Comparison of mean number of livestock activities

| Livestock | Households interviewed | | Livestock mean number of S & C | | Standard Deviation | | T-value | | Degree of freedom | | Probability level (P) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Village | No | % | Sheep (mean) | Cattle (mean) | Sheep | Cattle | Sheep | Cattle | Sheep | Cattle | Sheep | Cattle |
| A | 22 | 60 | 3.4091 | 4.5455 | 1.297 | 2.041 | | | | | | |
| C | 16 | 45.7 | 2.8125 | 3.7500 | 0.750 | 0.856 | 1.79 | 1.64 | 34.53 | 29.94 | P<0.083 | P<0.011 |
| B | 19 | 51.4 | 3.00 | 4.1667 | 1.291 | 1.618 | | | | | | |
| D | 14 | 40 | 2.50 | 3.5333 | 1.019 | 1.407 | 1.24 | 1.20 | 30.81 | 30.93 | P<0.223 | P<0.238 |
| A1 | 10 | 25.7 | 1.9000 | 2.3000 | 0.876 | 1.059 | | | | | | |
| C1 | 7 | 20 | 1.8571 | 2.2857 | 0.690 | 0.756 | 0.11 | 0.03 | 14.70 | 14.97 | P<0.912 | P<0.975 |
| B1 | 12 | 31.4 | 2.0000 | 2.3636 | 1.044 | 1.027 | | | | | | |
| D1 | 6 | 17.1 | 1.6667 | 2.3333 | 0.516 | 0.516 | 0.91 | 0.08 | 15.98 | 14.98 | P<0.378 | P<0.937 |

Table B.16 Comparison of mean weekly water used for brick making activity

| Brick making Village | Household interviewed | | Water used for brick making mean (litre) | Standard deviation | T value | Degree of freedom | Probability level (P) |
|---|---|---|---|---|---|---|---|
| | No | % | | | | | |
| A | 8 | 22.8 | 731.2500 | 207.020 | | | |
| C | 2 | 5.7 | 165.0000 | 7.071 | 11.79 | 7.06 | P < 0.001 |
| B | 7 | 17.1 | 714.2847 | 483.046 | | | |
| D | 5 | 8.8 | 96.0000 | 42.190 | 5.20 | 6.13 | P < 0.002 |
| A1 | 9 | 20.5 | 433.5556 | 259.391 | | | |
| C1 | 2 | 5.7 | 110.0000 | 14.142 | 3.72 | 8.20 | P < 0.006 |
| B1 | 5 | 14.2 | 400.0000 | 158.114 | | | |
| D1 | 5 | 11.4 | 92.0000 | 55.857 | 4.11 | 4.98 | P < 0.009 |

Table B.17 Comparison of mean weekly water used for small garden activity

| Water used Village | Household interviewed | | Weekly water used mean (litre) | Standard Deviation | T value | Degree of freedom | Probability level (P ) |
|---|---|---|---|---|---|---|---|
| | No | % | | | | | |
| A | 24 | 68.5 | 612.5000 | 261.372 | 8.36 | | |
| C | 7 | 20 | 144.2857 | 31.547 | | 25.11 | P < 0.001 |
| B | 23 | 65.7 | 217.3913 | 88.688 | 6.63 | | |
| D | 6 | 17.1 | 63.3333 | 34.445 | | 22.17 | P < 0.001 |
| A1 | 14 | 40 | 300.0000 | 196.116 | 4.42 | | |
| C1 | 6 | 17.1 | 48.3333 | 54.559 | | 16.70 | P < 0.001 |
| B1 | 9 | 25.7 | 97.7778 | 18.559 | 6.26 | | |
| D1 | 5 | 14.2 | 50.0000 | 10.0000 | | 11.99 | P < 0.001 |

Table B.18 Comparison of mean number children < 5 suffered frequently from diarrhoea

| Diarrhoea / Village | Households interviewed | | Children suffered from diarrhoea ( mean ) | Standard deviation | T Value | Degree of freedom | Probability level(P) |
|---|---|---|---|---|---|---|---|
| | No | % | | | | | |
| A | 9 | 25.7 | 0.5556 | 0.726 | | | ** |
| C | 27 | 74.2 | 1.9630 | 0.706 | -5.07 | 34 | P=< 0.001 |
| B | 6 | 17.1 | 1.1667 | 0.408 | | | * |
| D | 26 | 77.1 | 1.5769 | 0.758 | -1.84 | 14.30 | P = 0.87 |
| A1 | 9 | 25.7 | 0.7778 | 0.667 | | | ** |
| C1 | 26 | 74.2 | 1.8846 | 0.653 | -4.36 | 33 | P =<0.001 |
| B1 | 7 | 20 | 1.1429 | 0.690 | | | * |
| D1 | 25 | 71.4 | 0.7600 | 0.926 | 1.01 | 30 | P= 0.319 |

** = significant * = Non significant

Table B.19 Main cause of diarrhoea

| Frequency / Cause | Frequency | % |
|---|---|---|
| Do not know | 17 | 6.4 |
| Contaminated water | 176 | 62.6 |
| Contaminated food | 87 | 31 |
| Total | 280 | 100 |

Table B.20 Comparison of human and animal waste disposal

| Village | Urmia | | | | | | | | Yazd | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Improved | | | | Unimproved | | | | Improved | | | | Unimproved | | | |
| | A | | B | | C | | D | | A1 | | B1 | | C1 | | D1 | |
| Methods of disposal | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Empty by car | 25 | 71.4 | 30 | 85.7 | - | - | - | - | - | - | - | - | - | - | - | - |
| Use it as a fertilizer | 10 | 28.6 | 5 | 14.8 | 22 | 62.8 | 24 | 68.5 | 4 | 11.4 | 2 | 5.7 | 8 | 22.8 | 14 | 40 |
| Leave it in a deep hole | - | - | - | - | 13 | 37.2 | 11 | 31.5 | 31 | 88.5 | 33 | 94.2 | 27 | 77.1 | 21 | 60 |
| Total | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 |
| <u>Animal waste disposal</u> | | | | | | | | | | | | | | | | |
| Dumping close to house and use it as fertilizer& fuel | 24 | 68.5 | 22 | 62.8 | 29 | 82.8 | 25 | 71.1 | - | - | - | - | - | - | - | - |
| Collect and carry it out of village and use as fertilizer | - | - | - | - | - | - | - | - | 18 | 51.4 | 16 | 45.7 | 14 | 40 | 12 | 34.2 |
| Do not have animal | 11 | 31.5 | 13 | 37.2 | 6 | 17.2 | 10 | 28.9 | 17 | 48.5 | 19 | 54.2 | 21 | 60 | 23 | 65.7 |
| Total | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 | 35 | 100 |

# APPENDIX C:Questionnaire of EIA MATRIX

# PRESENTATION SURVEY

**EIA Matrix Presentation Survey**

You have been presented with these version of leopold matrix. Please examine each matrix carefully and then rank them in order of preference in the following contexts:

1. As in your present situation as a postgraduate.

   ( ) Numerical

   ( ) Black and white

   ( ) Colour

2. As you believe you would rank them as environmental consultant about to prepare an EIA.

   ( ) Numerical

   ( ) Black and white

   ( ) Colour

3. As a member of a local authority staff who will receive EIA's.

   ( ) Numerical

   ( ) Black and white

   ( ) Colour

4. As an elected member of local authority

   ( ) Numerical

   ( ) Black and white

   ( ) Colour

Please answer the questions with the main reason.

Figure C1 EIA numerical matrix in the villages C&D and C1&D1

| | Project activities / Environmental Parameters | Construction phase: Land requirement | Maintenance | Labour requirement | Well drilling | Installation of taps | Sanitation facilities construction | Trench digging | Storage tank & spring box construction | Training of people | Drainage construction | Mathematical Operations: + | - | Σ+ | Σ- | Σ Tot… |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural | Land Use | 2 / 4- / 2 | 0 | 0 | 1 / 2- / 2 | 0 | 3 / 9- / 3 | 2 / 6- / 3 | 1 / 2- / 2 | | 1 / 2- / 2 | - | 6 | - | 25 | 25 |
| Natural | Soil erosion | 0 | 0 | 0 | 1 / 2- / 2 | 0 | 2 / 4- / 2 | 2 / 4- / 2 | 1 / 2- / 2 | 0 | 1 / 1- / 1 | - | 5 | - | 13 | 13 |
| Natural | Land pollution | 0 | 2 / 6+ / 3 | 0 | 2 / 6- / 3 | 0 | 1 / 1- / 1 | 1 / 1- / 1 | 1 / 1- / 1 | 0 | 1 / 1- / 1 | 1 | 5 | 6 | 10 | 4 |
| Natural | Visual quality | 0 | 3 / 9+ / 3 | 0 | 2 / 6- / 3 | 1 / 1- / 1 | 2 / 4- / 2 | 1 / 1- / 1 | 1 / 1- / 1 | 0 | 1 / 1- / 1 | 1 | 6 | 9 | 14 | 5 |
| Natural | Flora | 0 | 2 / 6+ / 3 | 0 | 1 / 1- / 1 | 0 | 2 / 4- / 2 | 1 / 1- / 1 | 1 / 1- / 1 | 0 | 1 / 1- / 1 | 1 | 5 | 6 | 8 | 2 |
| Natural | Groundwater quality | 0 | 1 / 1+ / 1 | 0 | 3 / 9- / 3 | 0 | 1 / 2- / 2 | 1 / 2- / 2 | 1 / 2+ / 2 | 0 | 1 / 1+ / 1 | 3 | 3 | 4 | 13 | 9 |
| Natural | Fauna | 0 | 1 / 1+ / 1 | 0 | 0 | 0 | 1 / 1- / 1 | 1 / 1- / 1 | 1 / 1- / 1 | 0 | 0 | 1 | 3 | 1 | 3 | 2 |
| Social | Acquisition of skill | 0 | 1 / 2+ / 2 | 1 / 2+ / 2 | 0 | 0 | 0 | 0 | 0 | 3 / 12+ / 4 | 0 | 3 | - | 16 | - | 16 |
| Social | Participation | 0 | 1 / 2+ / 2 | 1 / 2+ / 2 | 2 / 4+ / 2 | 2 / 4+ / 2 | 3 / 9+ / 3 | 2 / 4+ / 2 | 1 / 1+ / 1 | 2 / 6+ / 3 | 1 / 1+ / 1 | 9 | - | 33 | - | 33 |
| Social | Employment | 0 | 1 / 2+ / 2 | 3 / 9+ / 3 | 1 / 2+ / 2 | 0 | 1 / 2+ / 2 | 2 / 4+ / 2 | 1 / 1+ / 1 | 1 / 2+ / 2 | 1 / 1+ / 1 | 8 | - | 23 | - | 23 |
| Economic | Income of people | 1 / 1+ / 1 | 1 / 2+ / 2 | 2 / 6+ / 3 | 1 / 2+ / 2 | 0 | 1 / 2+ / 2 | 1 / 2+ / 2 | 1 / 1+ / 1 | 1 / 2+ / 2 | 1 / 1+ / 1 | 9 | - | 19 | - | 19 |
| Economic | Connection fee | 0 | 0 | 0 | 0 | 2 / 4- / 2 | 2 / 4- / 2 | 0 | 0 | 0 | 0 | - | 2 | - | 8 | 8- |
| Mathematical Operations | + | 1 | 9 | 4 | 3 | 1 | 3 | 3 | 4 | 4 | 4 | 36 | | | | |
| Mathematical Operations | - | 1 | - | - | 6 | 2 | 8 | 7 | 6 | - | 5 | | 35 | | | |
| Mathematical Operations | Σ+ | 1 | 31 | 19 | 8 | 4 | 13 | 10 | 5 | 22 | 4 | | | 117 | | |
| Mathematical Operations | Σ- | 4 | - | - | 26 | 5 | 29 | 16 | 8 | - | 6 | | | | 94 | |
| Mathematical Operations | Σ Total | 3- | 31+ | 19+ | 18- | 1- | 16- | 6- | 3- | 22+ | 2- | | | | | 23 |

Figure C2 EIA matrix ( white and black ) in the villages C&D C1 & D1 during construction phase

| Environmental Parameters \ Project activities | | Land requirement | Maintenance | Labour requirement | Well drilling | Installation of taps | Construction of sanitation facilities (septic tank.) | Trench digging and pipe laying activities | Storage tank and spring box construction | Training of people | Drainage, apron and soak-way construction |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural | Land use | □ | O | O | □ | O | □ | □ | □ | O | □ |
| | Soil erosion | O | O | O | □ | O | □ | □ | □ | O | □ |
| | Land pollution | O | ■ | O | □ | O | □ | □ | □ | O | □ |
| | Visual quality | O | ■ | O | □ | □ | □ | □ | □ | O | □ |
| | Flora | O | ■ | O | □ | O | □ | □ | □ | O | □ |
| | Groundwater quality | O | ■ | O | □ | O | □ | □ | ■ | O | ■ |
| | Fauna | O | ■ | O | O | O | □ | □ | □ | O | O |
| Social | Acqisition of skill and job | O | ■ | ■ | O | O | O | O | O | ■ | O |
| | Participation of people | O | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | Employment | O | ■ | ■ | ■ | O | ■ | ■ | ■ | ■ | ■ |
| Economic | Income of people | ■ | ■ | ■ | ■ | O | ■ | ■ | ■ | ■ | ■ |
| | Connection fee | O | O | O | O | □ | □ | O | O | O | O |

Positive Impact ■

Negative Impact □

No Impact O

Fig C3 EIA colour matrix in the villages C&D and C1&D1