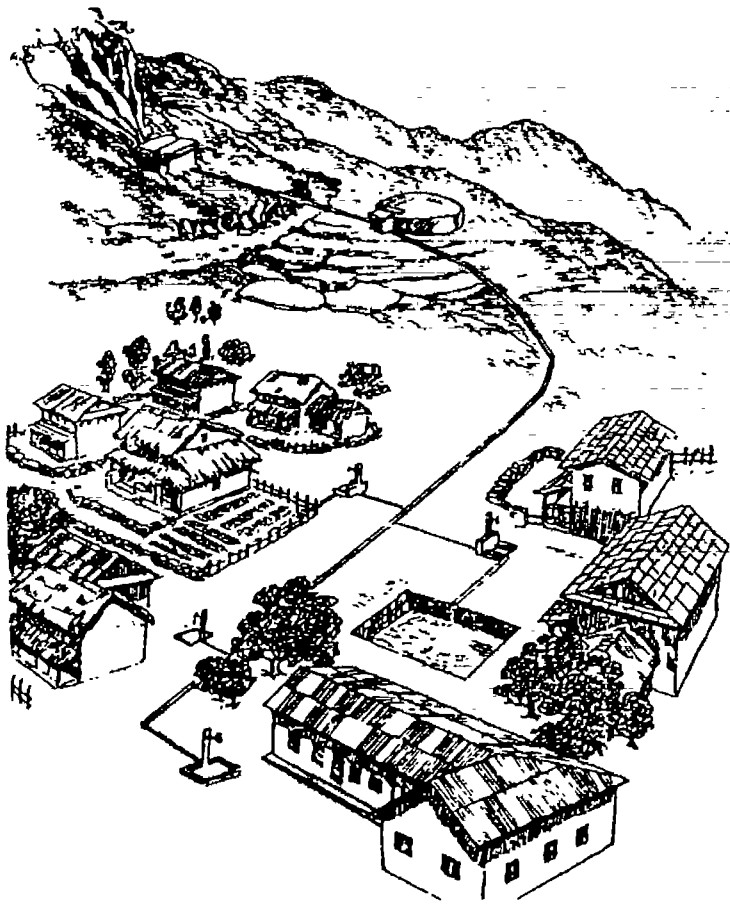

Performance Evaluation on Operation and Maintenance of Rural Water Supply Schemes in Bhutan

Payden

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PERFORMANCE EVALUATION ON OPERATION AND MAINTENANCE OF RURAL WATER SUPPLY SCHEMES IN BHUTAN

by

Payden

A thesis submitted to the Sanitary Engineering Department at the International Institute for Infrastructural, Hydraulic and Environmental Engineering in partial fulfilment of the requirement for the degree of

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Supervised by

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The findings, interpretations and conclusions expressed in this study do neither reflect the views of the International Institute for Infrastructural, Hydraulic and Environmental Engineering, nor of the individual members of the MSc-committee nor of their respective employers.

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Acronyms and abbreviations

BHU	Basic Health Unit
BPT	Break Pressure Tank
DE	District Engineer
DYT	Dzongkhag Yargey Tshogtshung (District Development Committee)
FCR	Ferro Cement Reservoir
GI	Galvanised Iron
GYT	Block Development Committee
HDPE	High Density Polyethylene
HRD	Human Resources Development
IRC	International Water and Sanitation Centre
MOC	Ministry of Communications
MOH&E	Ministry of Health and Education
Nu.	Ngultrum (Bhutanese currency)
PHES	Public Health Engineering Section
PWD	Public Works Division
RGOB	Royal Government of Bhutan
RWS	Rural Water Supply
SM	Stone Masonry
UNICEF	United Nations Children Fund
VHW	Village Health Worker
VMC	Village Maintenance Committee
VMW	Village Maintenance Worker
WEDC	Water Engineering and Development Centre
WHO	World Health Organisation

Bhutanese words

Shaptolemi	-The villagers are expected to contribute voluntary labour for community work, like the repair of a monastery, construction of a community school etc. as the most usual form of beneficiary participation i.e. 15 days per year per household. Such participation is called shaptolemi.
Gup	- Headman of a number of villages under one block

Summary

The research had been carried out in 6 rural water supply schemes serving six villages. The schemes selected are located in the western part of Bhutan - two schemes from Thimphu district and four schemes from Paro district.

The techniques used for data collection from the field consisted of interview of users, water caretakers and village maintenance committee members, observation of the conditions of the schemes, sanitary survey of the catchment area with the help of mapping exercise by the caretakers and observation.

The sources of the schemes visited were either a spring or a stream source. The schemes consisted of an intake structure, a reservoir, break pressure tanks and tapstands serving a minimum of two households. HDPE pipe is used for the main pipeline and for gully or stream crossings, GI pipe is used. The reservoirs and break pressure tanks of schemes built prior to 1990 were built of stone masonry and those built later than 1990 were built in ferrocement.

A total of 76 tapstands had been visited. A total of 8 caretakers, 17 VMC members and 113 users including both male and female were interviewed.

The implementation of rural water supply schemes is shared between the Public Health Engineering Section and the District Engineering Units. The design, estimate is done by the PHE. The technical and training support to the district staff is also given by PHE. The district staff select, survey and construct water supply schemes together with the rural communities.

After the construction, the scheme is handed over to the community and the operation and maintenance is the responsibility of the community. There is no monitoring of the O&M of the schemes by the districts. The district staff extend some help only when approached by the users for some technical help or spare parts.

Operation and Maintenance Policy had been adopted by the department in 1990 which sets out the roles and responsibilities of the village maintenance committee and caretakers. At the moment it is PWD Policy.

Summary

At present 65% of all the schemes in Bhutan have a trained caretaker and 32% of the schemes have a VMC. Some schemes have both caretaker and VMC and some schemes have either a caretaker or a VMC only.

In the research area it is found that about 76% of the people interviewed use water within 30 to 40 litres per day and the rest use less than 30 lpcd, which is well below the design flow of 45 lpcd which includes leakages. Through the interviews it was understood that the water is mainly used for cooking, washing, cleaning of dishes and for cattle.

The water from the source was found sufficient for all the schemes except one scheme. Contrary to this finding, some users of a scheme with sufficient flow at the source were collecting water from other sources because they did not get water in the taps. At many places cutting of pipes were observed in this scheme and the caretaker was also not doing any work. The leakage in pipes and the caretaker not doing any maintenance work has resulted in the people at the end of the scheme not getting any water.

5 out of 6 schemes visited were functioning well and maintained properly. But still some leakages in the mainline, exposed pipes, leaking taps, dirty tapstand surrounding and overgrown plants around some reservoirs/BPTs were observed. A lot of illegal connections were also observed.

All the schemes had 24 hours of water supply but some schemes like Gepti and Bara had water shortage in the summer. This was caused because the source was diverted to the rice fields during the rice transplantation season. Some temporary discontinuity of the water in some schemes were experienced due to the blockage of the pipes by leaves and debris in rainy and autumn season.

82% of the users interviewed said that they have an alternative water source but only 5.3% of them used the alternative source because they were not getting water in he taps. Though the users had no knowledge of faecal contamination of water, they still were aware that the alternative source (i.e. irrigation channel and stream) was of bad quality. 81% of the users said that the alternative source is dirty.

All the users interviewed said that there is no smell in the water, it tastes good and the quality is good. 83% of them said that the water is turbid in the monsoon season. Some complained that frogs get into the pipeline. 78% of the users store water in containers like metal drums, jerry cans and plastic buckets. 90% of the containers are kept covered. There might be some risk of contamination in transportation, storage and handling of water in the house.

The assessment on the risk of the catchment area was carried out. The sources were located far away from the villages and it was found that there were no houses or defecation occurring in the catchment area of the schemes surveyed. Some deforestation, erosion and cattle grazing were occurring in the catchment.

None of the rural water supply schemes are given any sort of treatment and therefore, the water is likely to get contaminated. In case of spring intakes if it is constructed correctly/properly at the right place it usually ensures good quality of water. But out of the six schemes, three schemes have a spring source and none of them have a proper intake i.e not fully covering and protecting the source. Therefore, the water of those schemes with cattle grazing in the catchment areas have a risk of contamination.

The schemes visited had at least one caretaker and all were trained except one and all of them had a tool box. The caretakers consisted of male and female out of which 38% of the caretakers were female. Among those trained caretakers, 43% still faced problems like not being able to detect the blockage in the pipeline.

Among the caretakers, 38% were compensated by getting a salary, 49% were exempted from "shaptolemi" and 13% got nothing from the community. The amount of salary ranged from Nu.50/year per household to Nu.120/year per household.

The caretakers job was mainly to clean the tanks and its surrounding, check leakages in the pipeline, controlling the flows and small repairs. They do not work on a daily basis. The frequency of cleaning varied from scheme to scheme. The frequency ranged from once in 3 days, once in a month to once in 3 months. During the rainy season the frequency increased due to the frequent blockage of the pipes by the debris.

Summary

The caretaker of Bara scheme did not do any preventive maintenance works, he did some work only when asked by the users.

As mentioned by the caretakers in the interviews regarding the frequency of cleaning the schemes, it was also observed by the researcher that the least cleaned schemes were dirtier than the other schemes.

Only 35% of the users interviewed feel that they own the water supply schemes. Whereas 71% of the VMC members feel that the community own the water supply schemes. The higher percentage of the VMC may be due to the training given to them.

Village maintenance committees were formed in 5 schemes. Out of five, 4 committees were trained for a duration of 3 days. The VMCs had a varying size of 1, 3, 4 and 6 members in contrast to the size mentioned in the policy i.e minimum of 6 members. Among the total 17 members, 41% were female.

The VMCs could explain their objectives and duties but not all of them knew what they should do in practice. From the 5 VMCs, only 2 committees were active. Even these two committees did not have a revenue collection system, they did not keep any records of expenses on maintenance and they did not conduct any regular meetings nor do they make any decisions.

It was found that there was not much coordination between the caretakers and the VMCs. In 60% of the schemes, the VMCs did not assist the caretakers in O&M. In one scheme it was found that the caretaker takes all the committee members with him whenever he went for a maintenance or repair work. He explained that since they are also trained, they should work with him. It may be that they get confused with their respective roles and responsibilities.

In general the schemes are in good condition but an ideally functioning maintenance system is still lacking. A lot of improvements in O&M are required for the sustainability of the schemes.

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1.0 INTRODUCTION

Water is essential to man, animals and plants and without water life on earth would not exist. From the very beginning of human civilization, people have settled close to water sources, along rivers, besides lakes or near natural springs. Indeed where people live, some water is normally available for drinking, domestic and other use. This does not imply, however, that the available water is convenient and of sufficient capacity, nor that the water is safe and wholesome. Therefore, it is essential to construct water supply schemes for the safe delivery of water and it is more essential to maintain the scheme in the most efficient way.

It was already considered at the United Nations Conference in Mar del Plata, 1977, that 'all peoples, whatever their stage of development and their social and economic conditions, have the right to have excess to drinking water in QUANTITIES and of a QUALITY equal to their basic needs'. In pursuing the fulfilment of this right, quantitative and qualitative aspects of supplying safe and adequate drinking water have to be equally taken into consideration (Lloyd and Helmer, 1991). These aspects can be fulfilled by constructing technically sound and feasible schemes and by setting up a good operation and maintenance system. Operation and maintenance is one of the most vital factors contributing to the long life and sustainability of water supply schemes (Davis and Brikke,1995).

Operation and maintenance is not limited to the sole activity of a caretaker or a technician, it includes the activities of various actors at different levels. It requires forward planning and technical transfer at all stages of the project cycle, from installation of plant and equipment through operator training and handover, to routine operation and upkeep, including purchasing of spare parts, repair procedures and financial management as well as best practice in operating and maintaining the system (IRC, 1995)

But Davis and Brikke (1995) say that the operation and maintenance of water supply systems of small communities has been neglected in the past in a great number of developing countries. It is estimated that 30 to 60 percent of existing water supply

systems are not operational, which has an important impact on the well-being of concerned populations (WHO). Unless operation and maintenance issues are resolved, systems will continue to perform badly at low levels of service, with wastage of investment funds. New investments do not seem justified if the operation and maintenance issue is not dealt with and if the sustainability of the system is not guaranteed before investing in the construction of new systems.

Governments and external support agencies, as well as local communities, are more and more concerned about the importance of integrating operation and maintenance components in the planning, implementation, management and monitoring of project activities, since operation and maintenance is a key factor of sustainability. Operation and maintenance needs to be taken into account in the design-phase and needs to be concerted with the community organization responsible for the management of the system (Davis and Brikke, 1995).

Professionals in the sector are also realizing that operation and maintenance is not just a technical issue. It also compasses social, gender, economic, institutional, political, managerial and environmental aspects. Unless operation and maintenance is properly implemented, continued investment in the development of water supplies is not worthwhile.

Maintenance problems are reported to have occurred in many handpump programmes (Hessing et al, 1984; Baldwin, 1984; UNICEF, 1985; Hofkes, 1982; Bannerman, 1986). Maintenance was also reported as a major problem in small gravity water supply programmes (Strauss, 1983; WASH, 1983), and other rural water supply systems (WASH, 1981; WHO, 1983; Sundaresan et al, 1982). Most reports point at the lack of maintenance capacities and lack of finance as major causes of maintenance problems. Other general problems mentioned are lack of responsibility on the part of the users; lack of spare parts and materials; lack of capable manpower; poor financial management by local bodies; lack of monitoring, feed-back, control, poor operation; lack of water during dry periods; inadequate communication; lack of transport; insufficient revenues. Many problems occurred due to poorly constructed wells, boreholes, standposts and storage reservoirs (Visscher and Bastemeyer, 1987).

Summary of maintenance problems in existing piped gravity systems with public standposts are as follows (Visscher and Bastemeyer, 1987):

- insufficient spring protection
- poor quality control and inadequate construction leading to leaking spring boxes, pipes and reservoirs
- insufficient monitoring and control
- maintenance organisations are not legally established
- inadequate revenue collection systems

1.1 COUNTRY BACKGROUND

The Kingdom of Bhutan is a land-locked country with an approximate area of 46,500 sq. km; roughly 150 km north to south and 300 km east to west. It lies between the parallel ranges of the outer Himalayas in the north and inner Himalayas in the south. It is bordered by the Tibetan region of China in the north and the Indian states of Sikkim, West Bengal, Assam and Arunachal Pradesh respectively in the west, the south and the east .

The land rises from an elevation of about 160 metres above the sea level in the south to more than 7,550 metres above sea level in the north. Annual rainfall is concentrated in the monsoon season - mid June to September. Annual rainfall varies between 500 mm to 2000 mm in the northern region and from 200 mm to 5000 mm in the south.

Bhutan is a constitutional monarchy. His Majesty the King Jigme Singye Wangchuk is the Head of State or government. The country is sub- divided into 20 districts. Thimphu is the official capital of Bhutan. Official religions are Buddhism and Hinduism. The official language is Dzongkha and other languages like Nepali, Sharchop and Khenkha are also spoken.

According to official estimates, the population of Bhutan is about 600,000. In addition there is a significant number of non-nationals who live on a work permit or are seasonal

migrants. About 90% of the Bhutanese population live in the rural areas. The national urban population is estimated at 60,000 and the national rural population at 540,000. The rate of population growth is about two percent (RGOB, 1993).

Most of the people in the rural areas live in small villages with 5 to 20 houses which are sometimes clustered together, but in many villages the houses are rather scattered on the mountain slopes. Also there are many solitary houses far away from any village. The mountainous terrain make communication difficult and slow and most villages are only accessible on foot.

General health conditions in Bhutan are affected by low nutrition intake, poor sanitation and high prevalence of parasitic infections and contagious diseases. Efforts to establish modern medical facilities in Bhutan began in 1962. In 1988, the network of health facilities had a staff of 42 doctors and 674 para-medical workers working in 28 hospitals, 69 BHUs and 46 dispensaries throughout the country (RGOB, 1992).

The economy in Bhutan is mainly agrarian. Most of the people are engaged in agriculture, livestock farming and forestry. The main constraints for the development of Bhutan's economy is it's geographical location, scattered population, and lack of skilled personnel. With the increase in internal road links, improvement in farming, trade links, the introduction of industries and the commissioning of hydropower from the early 1960s, there is an upward trend in the Bhutanese economy.

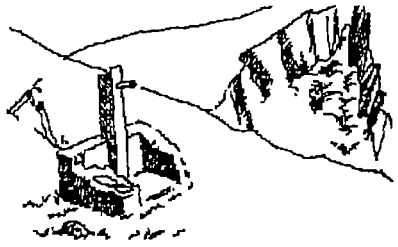
1.2 WATER SUPPLY

The rural drinking water supply programme in Bhutan started in 1974 under the Royal Government and United Nations Children's Fund (UNICEF) cooperation. The programme moved through different phases.

1.2.1 First phase (1974-1989)

Beginning from 1974 till the end of 1980s, about 1500 rural water supply schemes were

built all over the country. However, the success of the programme cannot be measured exclusively from the quantity of schemes built. During this period, schemes were built but left without any maintenance system to look after the O&M. The pictures below depict a typical situation of the water supply schemes built in the earlier years i.e till end of 1980s.



- A broken tap, no water

- Woman collecting water from the old polluted source

As the programme moved on, the situation improved. Hence in the course of programme implementation, many lessons were learnt. It was realised that there were many defects in the programme design that contributed to the unsuccessful programme implementation (UNICEF, 1994):

- The provision of drinking water supply was taken to be purely a technical programme. A team of technical staff visited a village, surveyed and then executed without much involvement of the community concerned or any other agencies. The success was measured by the achievement in terms of physical construction only.

- It was a centrally planned programme with very little participation from the

beneficiaries. The involvement of the community was limited to contribution of physical labour only during construction. The community did not fully understand the "whys" and "hows" of the programme and therefore, there was very little appreciation, and no sense of ownership.

- The targets were not realistic. Rural water supply was a donor driven project and therefore, targets were overambitious.
  For example a certain amount of funds was available for RWSS and with that amount as many schemes had to be built within a stipulated time given by the donor.

- There was no system of operation and maintenance after completion. The community did not bother even if there was no water coming out from the tap. They referred to it as "PWD's (Public Works Division) tap", "PWD's water supply" and expected PWD to take care of O&M.

- A sanitation component which is very essential to fulfill the objective of improved health was missing.

- There was lack of knowledge and awareness among the users on the relation between water, sanitation and health and therefore, people did not understand the benefit of safe water.

- Trained technical manpower in the implementing agencies was limited. This seriously affected the quality of construction.

All these causes contributed to a number of defunct schemes giving no/little benefit to the community as found out in the inventory in 1990-93 which is explained under the problem identification topic. The huge investment put into the programme was almost going to total waste (Dorji Choden, 1996). Thus, from 1990 onwards, a major change in the approach in planning and implementing rural water supply took place.

1.2.2 Present phase (1990 onwards)

Beginning 1990 promotion of sanitation, health and hygiene education, community participation and women's involvement are all being integrated with water supply. These aspects are now among the priority activities in water supply programme implementation. The present strategy can be briefly summarised as follows:

- The present programme, to bring about quality improvement in construction has provided:
  - Improved technical designs
  - A standardisation manual and computerised system design
  - Operation and maintenance manual
  - Training courses and training materials for staff of PHES and District Engineering Units.

- Government and UNICEF have invested over US$15 million for rural water supply and sanitation. To protect and safeguard these costly infrastructures rehabilitation programmes are given higher priority than new construction. Also in mid 1990s due to the exhaustion of funds, more schemes were rehabilitated since rehabilitation is cheaper than new schemes. The result of the 1991-92 inventories showed many schemes were deteriorating and this also contributed to the rehabilitation of more schemes.

- Protection of traditional spring sources to serve scattered households (otherwise not reached by the normal gravity systems) with safe water has been initiated since 1994 and will continue.

- To further complement, support and sustain the technical infrastructure, emphasis is placed on sanitation, hygiene education, community participation and training.

Sanitation (latrine and smokeless stove) is being promoted together with water supply construction. Efforts are being made to bring health and hygiene education to the people reached with improved water schemes through awareness campaigns, training etc. Sanitation promotion primarily towards increasing sanitary latrine use,

improved hand washing, bathing and laundering practices are given more and more emphasis.

Community participation is not only limited to physical labour contribution during construction. Community members participate right from the planning stage. The request for a water supply scheme comes from a community through the Block Level Committee meeting. The community also participates during survey in selection of water sources and location of public tapstands and after completion, in operation and maintenance.

Two village water caretakers are appointed for every water supply scheme. To encourage women's participation, one out of the two caretakers has to be a woman.

Village Maintenance Committees (VMC) are established wherever possible. The main function of this committee is to facilitate the caretakers in operating and maintaining the water supply scheme through mobilisation of maintenance funds and labour.

A practical training is provided to the caretakers on operation and maintenance. VMC members are given training on the overall objective and their role in the sustenance of the water supply scheme. From 1990-97, a total of about 2225 caretakers have been trained out of which 611 are females. This is shown in annex 1.1. Some of the trained caretakers are also given refresher training and this is indicated in annex 1.2. There are 2185 members of VMC being trained out of which 668 are females. The number of VMCs trained is shown in 1.3. Establishment of maintenance funds has also started in some districts.

1.2.3 Water Supply Coverage

About 60% of the rural population is having access to improved water supply and sanitation. This progress has been made possible by the establishment of the Department of Works and Housing in 1974. The rest of the uncovered rural population

(40%) are depending on streams, springs and irrigation channels for their drinking water supply.

Rural water supply is based on fairly small and simple gravity fed piped systems. Due to the abundance of a lot of springs and streams, only gravity fed schemes are provided in rural Bhutan. None of the rural schemes are treated. Each scheme serves a population of 150-200 and costs on an average US$7000. Water is mainly tapped from springs or stream sources. The approach, adopted in providing water to the rural community is through simple protection of the source and then conveyance and distribution.

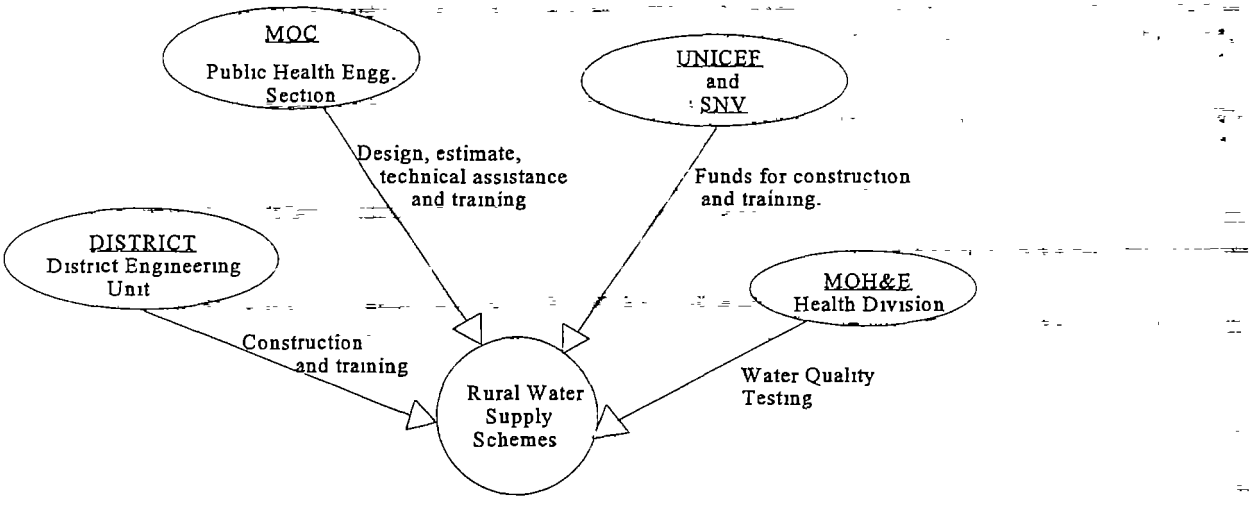
In 1996 it is estimated that 1800 schemes have been built throughout Bhutan (PHES, 1996). The number of schemes constructed in all the districts year wise is shown in annex 1.4. The construction of new schemes has been reduced dramatically during the end of 1994 to 1996 due to the exhaustion of funds. After 1996, funds have started coming in and the constructions of new schemes is improving again.

There are 25 urban communities, out of which 20 urban centres have piped gravity water supply systems serving only part of the urban population through house connections and public taps. Six of these urban centres have water treatment systems. In 1994, in urban areas water supply coverage is found to be 75 percent and sanitation coverage is 90 percent. (RGOB, 1995)

1.2.4 Institutional Setting

The Ministry of Communications (MOC) has the overall responsibility for the water supply sector, which includes planning, coordination of budgets and programmes and development of policy proposals. PHES (Public Health Engineering Section) under MOC and the District Engineering Unit are responsible for the implementation of the rural water supply. The Ministry of Health and Education is responsible for water quality testing. International Non-Governmental Organizations active in the sector are UNICEF and Netherlands Development Cooperation (SNV).

The different institutions involved in the rural water supply is shown in the following chart.



Institutions involved in RWSS

The country is divided into 20 districts and the districts are further divided into blocks. Each block consists of a few villages. The district is headed by a District Administrator which falls under the Ministry of Home Affairs and the blocks are headed by a village headman called the Gup. Two committees exist at the local level i.e the Block Level Committee (GYT) chaired by the Gup and the District Development Committee (DYT) chaired by the District Administrator. The GYT consists of representatives from all the villages and the DYT consists of the block heads, and the sector heads such as District Engineer, Irrigation Officer etc. at the district. These two committees are responsible for all the development activities in the villages including water supply and sanitation. Therefore, the request of a new water scheme by the village goes through the GYT, DYT and finally to the district administration.

1.2.5 Project Planning

The RWS programmes are planned and implemented in Bhutan as follows:

The District-wise 5 year plans are prepared by the District Administration after discussion in the GYT and DYT meetings. This plan is submitted to the concerned Ministries e.g the water supply and sanitation plan goes to the Ministry of Communications etc. The plans are further discussed at ministerial level and finally submitted to the planning commission.

Based on the availability of resources (financial, technical staff) and District plans, the Planning Commission prepares the budget allocations for the planned period to the water and sanitation sector. All the programs included in the district plan may or may not be included. Then PHES plans and allocates the number of schemes to be provided District, year wise based on population and percentage coverage.

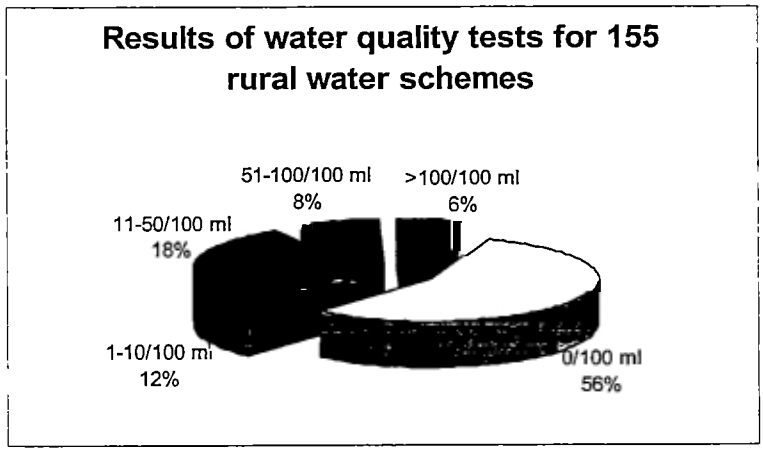
The schemes approved by the district administration are surveyed by the district engineer and his subordinate. The survey reports are then submitted to PHES for approval, design, estimate and materials. Designs, estimates and materials is then sent to district administration for implementation.

The construction of the project is carried out by the district administration along with the beneficiaries. Skilled works such as masonry, carpentry, plastering, pipe fitting are carried out by the masons, plumbers and carpenters employed by the district administration. Whereas excavation, trenching and laying of pipes as well as transportation of construction materials from the road head to site store, sand and other local materials collection is done by the villagers under the close supervision of the technical staff of the district engineering unit.

1.2.6 Water Quality Monitoring

Bhutan lacks a fully adequate drinking water quality surveillance program. Water

quality surveillance is technically the responsibility of the Ministry of Health and Education. The need for water quality testing of all the water supply schemes is apparent from the chart shown below. This chart is based on water quality tests for 155 rural water schemes conducted in 1989 (RGOB, 1992).



From the chart it is clear that about half of the 155 schemes have been found to be faecal contaminated.

Tests for faecal contamination in piped water supplies are limited to checks conducted on proposed sources for new water supply schemes. From 1993, Public Health Engineering requires that water from proposed sources for new schemes is tested and pollution levels be less than 50 faecal coliform per sample. The planned requirement to keep pollution levels at the source for new schemes below 10 faecal coliform per sample is not yet enforced. If the water quality of a source is found to be unsatisfactory and a safe alternative source is not found within a reasonable distance, the proposed scheme can be cancelled. But in reality, if there are no other sources available, the same source may be used instead of cancelling the scheme.

It is difficult to assess the improvement of water quality of rural water supply schemes, as the water quality of rural piped water supplies is not monitored. After the construction of a rural water supply scheme, the water quality testing is seldom carried

out by the Health Division. They conduct the water quality testing only when asked to do so by the PHES or by the District Administration which is rarely asked. In such a case, the Health Division sends the test result to the PHES. If the faecal coliform count is found to be high, the PHES writes to the concerned district advising them to look for another source higher up if it is a stream source, or to conduct sanitary survey to see if the source is contaminated by people or animals located nearby the source. Tests are also conducted whenever an outbreak of water-borne diseases occurs but in reality these measures are not always taken.

Several districts are still not equipped or staffed to conduct such tests, while sometimes sources are located too far away from the district laboratories. Where equipped, a district will normally have a single lab technician for clinical as well as public health work. This limitation is the main reason for the absence of routine system for monitoring the quality of water from rural piped water supply schemes.

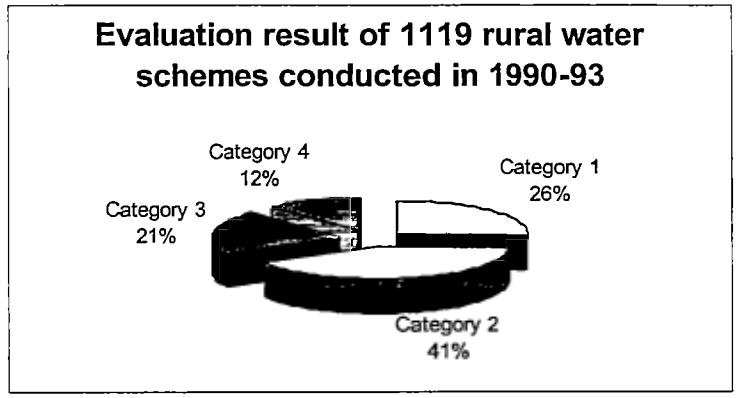
1.3 PROBLEM IDENTIFICATION

Before starting this study, the following two problems were found to be existing. By considering these problems, the research objectives have been framed which are explained after identifying the problems.

- The evaluation of 1990 shows the importance of O&M problems but since then no such study on O&M has been carried out.

One of the problems of the RWS has been the lack of data on the performance of the schemes built during the last 18 years. Everyone involved in the sector has rough estimates of how many of the schemes constructed in the past are still working, based on one's personal experience. Invariably these estimates are somewhat unclear as to the functioning of the water supply schemes. Therefore, an inventory study of RWSs operating status and rehabilitation requirement of the existing schemes in Bhutan was carried out from 1990-93 (RGOB, 1993). It was planned to regularly update the data, but in practice this was not done due to shortage of manpower.

The status of the schemes, grouped into four categories, category 1,2,3 and 4 is graphically represented below:



Category 1- working, good discharge from all tapstands as per design standards

Category 2- working, needs minor repair of some structures, good discharge from more than 50% of tapstands

Category 3- working, needs major repair of most structures, little discharge from 50% or more tapstands

Category 4- not working, no or insufficient discharge from all tapstands

The percentage of water supply schemes working and giving full benefit was only 26%. The rest of the schemes required minor/major repairs or were not working at all. This has been caused by lack of O&M, poor quality of construction, poor technology etc. As a result of the inventories (RGOB, 1993), it was decided to start with the rehabilitation of the RWSS schemes. Over the last 17 years the number of schemes rehabilitated in all the districts is shown in annex 1.5. But if O&M does not improve, rehabilitation is not very useful and it is likely that the same problems will occur in future.

- Policy on the formation of village maintenance committee and caretaker was established since 1991, but the performance of the community managed schemes have not been measured.

In the past few studies were conducted to assess the impact of rural water supply schemes but they are mainly of a technical nature. After the formulation of the Policy, no study was carried out to assess how rural water supply schemes are functioning with the help of VMC and caretakers. Therefore, it is necessary to find out the impact of community managed schemes.

1.4 RESEARCH OBJECTIVES

The main objective of the research is:

- to contribute to the improvement of operation and maintenance of the rural water supply schemes in Bhutan

The specific objectives are :

- to study the existing problems with regard to operation and maintenance of the schemes
- to assess operation and maintenance procedures and strategies in rural water supply systems with emphasis on protected springs and gravity fed piped water systems
- to review the performance of a number of selected schemes which have a VMC and caretaker

2.0 LITERATURE STUDY

A literature review concerning operation and maintenance systems which have been successful in other developing countries and also O&M problems and constraints which have been faced by many was done. The important points are stated in the following sub topics.

From the literature study, a number of themes and indicators to evaluate the performance of the operation and maintenance system of rural water supply in Bhutan has been identified and these are stated in the next chapter.

2.1 MANAGEMENT SYSTEM

Good organisation and effective management are essential elements for the success of a water supply system. The responsibility is often divided: planning and construction fall under a government department, while a local authority is responsible for operation and maintenance. The alternative is to have both planning and management governed by a unitary water authority, that also has a high degree of autonomy regarding finance. This agency should be responsible to the government and has to coordinate its activities with local and municipal authorities. A legal framework is always required to define the rights and responsibilities of the water authorities, the local committees and other agencies involved in the organization and management of the water supply system.

When management is poor, the operation of the water supply tends to be irregular and maintenance is neglected, resulting in low water pressure, irregular and unpredictable flow, frequent breakdowns and general malfunctioning. The factors that lead to those problems may be inadequate training, staff shortages and political pressures. The institutional arrangements within which management staff have to work may also be the cause of some failures (IRC, 1985).

In Bhutan, the design, estimate, technical support and training is the responsibility of the PHES, the construction is carried out by the District Engineering Units together with community, and operation and maintenance is in the hands of the community but for major breakdowns the support from the district is asked for. The rehabilitation of old

or defunct schemes is carried out by the PHES and District Unit. Rehabilitation consists of replacing the scheme fully i.e it is as good as a new construction or major repairs like replacement of a reservoir, intake, pipeline etc.

2.2 SPARE PARTS

One feature of the maintenance system which needs more emphasis is that of spare parts. Wherever there may be delays in delivery, the maintenance organisation will need to build up a stock of parts and operate stock control systems which anticipate in future demands for parts, so that they can be ordered in advance. It is preferable, where possible, to use equipment which is manufactured locally.

The key to good stock control and to other aspects of maintenance is record keeping. If all visits of maintenance staff to the scheme and the materials used by them are recorded, it is possible to see at what rate different parts are being used. The same records make it possible to check that each component of the scheme is serviced regularly and can help to identify trouble spots where repairs are being called for more often than average (IRC, 1985).

2.3 STAFF REQUIREMENTS AND HRD

Shortage of trained manpower, particularly for supervision and management is a major factor in the poor performance of many water supplies. The reason for this is that the need for technical training is usually recognized, but the need for training in management skills is often overlooked (IRC, 1985). But the need is there, often at a very basic level, for water caretakers and supervisors as well as for technical staff, and each employee should be given short additional periods of training during his employment with the water supply organisation. Planners and designers of water systems also require training and in-service refresher courses to up-date them on new thinking and new techniques (IRC, 1985).

Thus training programmes will need to include management as well as technical skills. A water supply programme is not merely an engineering project, but it involves social, health, financial and management aspects as well. Training and recruitment policies

need to recognize that a water program is a multi-disciplinary effort.

In Colombia, the following aspects are included in the training programmes of the villagers especially the maintenance committees and the caretakers of the rural water supply schemes (IRC, 1997)

- O&M of the systems, with or without treatment
- Monitoring and control of water quality
- Administration of water supply systems
- Social control
- Caretaking

2.4 WATER MAINTENANCE COMMITTEE

For a committee set up specifically to deal with water, it will be beneficial to include women and other underprivileged groups. Women should be involved mainly because they are more closely involved in water use and hygiene practice. Apart from that it is important that the committee represents all sections of the community, including the underprivileged ones which are in many cases women. If these are not adequately represented on the committee, it becomes much more difficult to effect the health benefits which an improved water supply should bring.

The precise roles of water committees vary from place to place, but it is possible to draw up basic list of committee's functions. In general terms, a water committee might have responsibility to do the following things:

- to facilitate/support communication between the water authority and water users
- to organise self-help, voluntary labour for construction
- to draw up the rules to be observed by users of the supply, to enforce these rules and prevent misuse
- to select local people for training as water caretakers, community health workers etc. together with users
- to collect financial contributions from users
- to reimburse caretakers for any expenses (eg. purchase of spare parts), and perhaps to pay for other costs, provide salary for caretakers
- to assist with hygiene education (IRC, 1985)

Operational management includes operation, maintenance, supervision, revenue collection and liaison with the users. It is important that the organization of maintenance includes regular inspection and preventive maintenance as well as repairs after breakdowns. Supervision is necessary where water is scarce, where there is a risk of vandalism and where water has to be paid for at the spot. Revenue collection, whether periodical, or per volume should be acceptable to the community. Open communication between the water agency and the community is of great importance in the planning, implementation and operation stage (IRC, 1985).

A good example of a community managed water supply system can be found in Pakistan. The responsibility for water system maintenance in the village of Gulkin in northern Pakistan is shared between the village water committee and individual users. The water committee uses village funds to take care of the supply and distribution mains, while individuals are responsible for taking care of the smaller diameter pipes which deliver water to their yard tap and for care and maintenance of the tap itself. Fines imposed by the water committee for leaking or unattended taps provide a motive for good maintenance at the household level (Evans and Appleton, 1993).

A case study in the Bomono-Gare water supply project in Cameroon shows that a single person dominating the maintenance committee creates problems. This project had been successful due to Mr. Ebongue's efforts and he was recognised by the community to lead the committee. Unfortunately Mr. Ebongue managed the water scheme as a one-man business by collecting tariffs set by himself, buying the spare parts, paying the caretakers etc. He did not involve anybody and no meetings were held. Finally the community decided to form a new maintenance committee and Mr. Ebongue was very angry for this decision. That very night the village faced problems because both the electric motors of the pump were stolen. Thus the village was without water for three months (IRC, 1997).

2.5 WATER CARETAKER

Perhaps already during the planning phase, prior to the official inauguration ceremony, arrangements for care taking, operation and maintenance, repair and administration will have to be made, including the supervision of these tasks.

Where there is a water agency maintenance team to look after the water supply, local caretakers may only be responsible for operation or they may exercise a guarding task as well and carry out non-technical maintenance, such as repairing fences, clearing blocked drains, providing protection against night frost, checking the covering of the pipes, etc. and recognising and reporting problems at an early stage. In some instances (Scotney, 1976; Pineo, 1976b, 1977) a nearby household watches over the proper use and functioning of the supply. In a mountain village in Lesotho, the pipeline was divided into sections and the tasks of covering exposed pipes and protecting them against frost and damage were given to the families living near these sections (Feachem et al,1978).

An alternative, finding increasing acceptance is the training of local inhabitants for operation, maintenance and carrying out simple repairs. Such operators can be selected by the agency with or without suggestions from the village water organisation or other village representatives or can be elected by the community. The sex of the operator will depend on local conditions and functions. For health education tasks a woman is considered to be more suitable. In Guinea-Bissau a male and female operator are therefore elected, for technical and hygiene educational tasks respectively (Van der Ploeg and Van Wijk, 1980).

It may be advisable to train more than one operator so that prolonged absence does not lead to complications (Ketcham, 1970; Matango and Mayerle, 1971). Kreysler (1970) also pointed at the importance of preventing any monopoly. When only one operator is present, he knows that during his absence nobody from the village can do his job if some breakdown occurs. Therefore, he will feel more demanded and he may try to exploit or harass the users in demanding more salary.

Operators could be paid by the agency directly or by the community from the water rates if water rates are collected. In the latter case they may also be made responsible to the community as is the case with some health personnel (Allan, 1977; Tomic et al, 1977). Non-financial, or indirect financial rewards can also be given, such as exemption from communal labour (Matango and Mayerle, 1971), a free agricultural or housing plot, or materials and equipment for starting a small village workshop (Matango and

Mayerle, 1971; Whyte, 1976). Where it is decided to combine the two functions of primary health worker and operator, the community may save one salary post, while at the same time the continuation of the sanitation education component of the programme is facilitated.

An option for the good maintenance of a scheme is to use local private sector services to maintain and repair improved water systems. While maintenance of a simple water supply system may not always provide full time employment, it can be an attractive additional source of income for a local mechanic who also undertakes repairs to bicycles, agricultural implements and so on. In larger communities or where community associations enable resources to be pooled, plumbers, pump mechanics and other specialists may be retained specifically to undertake water system maintenance (Evans and Appleton, 1993).

This has been successful in the case of Mutengene, Cameroon, where the daily operation and maintenance of the village water supply is the responsibility of a local plumber, paid from community contributions. The plumber reports every day to the chairman of the community water committee, and enters all faults detected and tasks to be undertaken in a log book. The plumber routinely inspects the whole system and is informed by the users of breakdowns and leakages. Major repairs that can not be undertaken by the local plumber are reported to the government and assistance is requested. The plumber is assisted with free labour by the population in each affected quarter whenever a major breakdown occurs (Evans and Appleton, 1993).

The plumber is well paid by local standards and enjoys additional benefits such as insurance and a preferential housing loan. The Cameroon case study indicates that the plumber is highly motivated and very reliable.

2.6 REVENUE COLLECTION

Poor administration, irregular collection of payment and a poor standard of service all decrease people's willingness to pay. Besides, the financial circumstances of the users are important: those with a regular income are more likely to be able to pay a monthly sum than those who have not; the latter group often prefers to pay on the spot according

to quantity used. But, on the contrary, willingness-to-pay studies, and analysis of payments made to water vendors by those not served by public systems, generally indicate that even in the poorest areas many communities have both the ability and the willingness to pay significant amounts for reliable services (IRC, 1985).

It is important to devise an appropriate method of collecting payments which is both fair and effective. It depends on the local customs and the political situation in a country which arrangements for revenue collection will give the most satisfactory results.

In case of financial revenue collection, there are two options i.e contribution to capital costs and contribution to O&M costs. In most cases the second option is applied. An example of revenue collection for the upkeep of the scheme is stated here.

An effective way of fund raising for maintenance of water supply can be quoted from the example of a village in Kenya. Kidoda village is an agricultural community of 196 households in Southern Kenya. It has a piped gravity system with 4 public taps. In addition there is one hand-pump well. Unlike other villages in the area, Kidoda has no community income to finance the upkeep of the water supply. The costs of upkeep have been calculated to be 4000 shillings per year. A maintenance fund had therefore been set up, to which each family pays a monthly contribution of 2 shillings. Soon, however, payments were in arrears. Stimulation did not work as people say they had no cash and the supply was still working. The water committee thereupon decided to invite all male and female heads of households to a meeting to find another way of financing. The meeting settled for a public fund raising, directly after the harvest. The target for the maintenance fund for the coming year was set and explained by the water committee. Each family decided for itself whether to pay more or less than the average contribution needed. The committee registered the contributions, issued receipts and visited non-paying families. Households known to be poor could also pay the value of their contribution in kind, including labour. In-kind products such as chickens and maize were auctioned at the meeting, so that the water committee could bank all the money in its water account (van Wijk-Sijbesma, 1987).

An example for the recovery of capital cost of the scheme is presented here.

The active participation by one of the villages in Guatemala to generate revenue for their water supply is cited as follows. Pacul is one of the many communities in Guatemala in which a small piped water supply has been built. The project started after a community request and a technical and socio-economical feasibility study. The community paid on average 40% of the construction costs in labour, local materials and loan instalments. After completion, the schemes are being operated, maintained and managed by a local water committee. The community has learned all this during the planning. Men and women also have participated in the siting of the private and shared taps. In Pacul, construction was completed in little over a month. One and a half years later the system was still functioning without problems. But meanwhile, the community had built a second piped gravity system. Its water serves to grow strawberries for the urban market. With the extra income the committee hopes to pay off the two loans ahead of schedule and maintain both water supplies (van Wijk-Sijbesma, 1987).

2.7 COMMUNITY PARTICIPATION

The degree of community participation depends to a large extent on the development of an appropriate community organisation. Many communities, particularly in rural areas possess a well-established formal organisation and the committees and caretakers necessary for the O&M of water supplies will need to fit in this structure. Very often though no existing organisation is appropriate, it may be necessary to form a special "water committee" representing the local community.

It is generally considered important to involve the users in the planning and implementation of water supply schemes, to the greatest possible extent. Active community participation can be beneficial both for the success of the water supply project and for the development of a spirit of self-reliance in the community (van Wijk-Sijbesma, 1987). Community participation depends a lot on the degree of organisation of a particular community. Another very influential/determining factor is the approach which is used in projects or programmes, being the integration of technical and social aspects in planning and implementation, the amount of awareness raising and capacity building of communities and the support given to communities by local government and other actors in the water supply sector.

A case study based on gravity flow drinking water scheme of Bishashaya village in Nepal (IRC, 1997).

Before the construction of the water scheme, the community of this village have been dependent on unprotected streams, rivers and springs for their drinking water. Gradually the villagers realised that their health was being affected by the water since they were suffering from hepatitis, diarrhoea etc. Due to this problem the community requested for a better drinking water supply. The users were involved right from the planning stage to the implementation such as collection of money for maintenance, transportation of construction materials, contribution of unskilled labour during construction, collection of local materials, selection of a village maintenance worker, health worker and users committee and contribution in information sharing. The agencies involved in the water supply, gave a copy of the design report and cost estimate to the users committee.

The users committee was formed under the guidance and assistance of the agencies. The members were selected on the basis of capability and are responsible for mobilising local resources, planning, implementing, operating and maintaining the scheme in its various stages. They are not paid. For operation and maintenance a village maintenance worker (VMW) had been selected and trained for one month and has been involved throughout the whole process of the scheme which helped him to gain practical skills. One woman was selected by the community and trained as community health volunteer (VHW) for community health education but after marriage she left the village.

The community were observed to be motivated enough to pay for upkeep of the scheme but not for the VHW and the agency staff feels that this has negative implications for the sustainability of the scheme. The tools provided to the VHW has not been kept carefully. He has given them away to people in the village. The money collected for O&M has been deposited in the bank in the name of the users committee and is operated through two signatures. The expenses for minor repairs of the scheme have been covered from the interest generated from the the deposited maintenance fund. Two financial records are kept for the administration of the water scheme, a personnel investment record and a financial statement on the maintenance. Both are kept by the community, they are simple and can be well understood by all the community members. (continued on page 25)

(continued from page 24)

On the whole, this scheme is running quite well but there are some problems like inadequate protection of source and the less motivated VHW since he is unpaid by the community.

Another good example for community participation is presented below:

Ensuring O&M in water schemes, ACTIONAID Pakistan's Approach (IRC, 1995)

ACTIONAID Pakistan (AAPk) initiated implementation work in its project area of Kalinger Union Council, North West Frontier Province of Pakistan by working in the water, sanitation and health sectors. Insufficient water supply has been singled out by many men and women as a major problem. AAPk has tried to contribute management and accountability, thereby ensuring planning, maintenance and operation of sustainable development activities. Its projects are characterised by the following:

Involvement of community throughout the project cycle: Members of the community are involved in the planning, design and implementation of their water scheme, as well as monitoring and evaluation of interventions. When options are presented, the cost of maintenance is also presented and poorer members of the community are given the opportunity to voice their concerns about each option.

A community management structure (CMS) is responsible for monitoring the water supply scheme; drawing up agreements between AAPk suppliers and consultants and the community; ensuring the community's physical contributions and reporting progress on a regular basis.

Involvement of women: Women are involved in deciding about the location of the standpipes. They feel a sense of ownership and have even been able to exert peer pressure within the communities for fairer development.

Quality of materials used: materials of optimum quality is used. Together with AAPk technical and procurement personnel, the community (continued on page 26)

(continued from page 25)

forms a part of the purchasing committee so that they are aware of where the material is purchased and what is involved, enabling them to act on their own in the future.

Community commitment: Before initiating any work on a water scheme the community has to guarantee that it will take the responsibility of maintaining the scheme. Money for maintenance is collected on a monthly basis and is saved in an account in the name of the community. The signatories (2 community members and an AAPk staff member) keep the financial records of funds deposited and maintenance expenses and the members of the CMS collect the household's monthly contributions.

System of caretaking: The community has to decide on a system of caretaking once the water supply has been completed, to ensure that problems are quickly identified and remedied. In the Swali Meira water supply scheme, the community decided to employ an operator. The man on whose land the water tank was built was chosen for the position and he receives a monthly salary from the community's bank account for his services, which includes opening and closing the valves, examining the main line for damages and overseeing repair work.

In monthly meetings CMS members and AAPk staff discuss issues related to the water supply, which creates a habit of regular monitoring. The community can seek technical assistance from AAPk but must take the financial responsibility of sustaining the scheme.

2.8 GENDER AWARENESS

Gender as a concept connotes classification by sex. It is concerned with socially ascribed roles and relationships between women and men, which are determined - not by biology but by the social, economic, and political context or environment. It indicates the social relations between men and women.

It should be noted that gender is an important variable in the development and sustainability of development projects and those projects and programmes which

incorporate gender are more successful than those which do not. It follows that sustainability of water and sanitation systems has to incorporate gender if success is to be registered (WEDC, 1995).

In an endeavour to involve the whole community, the role of women has become more prominent. As the principal users of rural water supplies, women are encouraged to participate in decision making and take active roles in management and maintenance activities.

Involving women more should not, however, lead to increased physical work for women or greater demands on their time as they already work longer hours than men in carrying out household and subsistence chores. A gender approach to maintenance and maintenance management ensures that work, authority and benefits are equally shared with men. If women have to do the work alone, conflicts arise and maintenance and villagers suffer in the end.

A balance of men and women on committees may help to achieve the gender aspects of committee management, but not necessarily ensure, an equitable division of work and responsibilities between men and women. The aim is to avoid either men or women doing all the work or making all the decisions. Gender often plays a role in the division of tasks. A man usually chairs a committee but a woman may be secretary or treasurer. Widespread experience indicates that women treasurers often perform better than men but appropriate training is required (Davis and Brikke, 1995).

Through water supply projects men and women can also be encouraged to step a bit out of their traditional roles. So a man can be involved in hygiene education and a woman can chair a committee. In such cases training is required.

This approach is practised in Kenya as cited here. The Kochogo/Kakola project in Western Kenya is run through committees in which women form over 50% of the members. Women are trained in operation and maintenance of the installed Afridev handpumps. Women's group are taught basic book keeping to register project revenues which are used for maintenance or banked for later use (Mwangola, 1991).

2.9 WATER QUANTITY

Water is essential to sustain life, and a satisfactory supply must be made available to consumers. Depending on climate and work load, the human body needs about 3 to 10 litres of water per day for normal functioning. Part of this water is derived from food. The use of water for food preparation and cooking is relatively constant. The amount of water used for other purposes varies widely and is generally influenced by the type and availability of the water supply. Factors influencing the use of water are cultural habits, pattern and standard of living, whether the water is charged for and the cost and quantity of water (IRC, 1985).

2.10 WATER QUALITY

Every effort should be made to achieve a drinking water quality sufficient to safeguard the health of the population served. Protection of water supplies from contamination is the first line of defence (WHO, 1993). Source protection is almost invariably the best method of ensuring safe drinking water and is preferred to treating a contaminated water supply to render it suitable for consumption. Once a potentially hazardous source has been recognized, the risk to health, the availability of alternative sources, and the availability of suitable remedial measures must be considered so that a decision can be made about the acceptability of the supply.

As far as possible, water sources must be protected from contamination by human and animal waste, which can contain a variety of bacterial, viral and protozoan pathogens and helminth parasites. Failure to provide adequate protection and effective treatment will expose the community to risks of outbreaks of intestinal and other infectious diseases.

Many potential problems of drinking water contamination can be prevented by safeguarding the integrity of the raw water source and its watershed, by proper maintenance and inspection of the source and distribution system, by the training of water caretakers and by consumer education.

Many people collect water from tapstands away from the point of use or store water in the household. Similarly, even with adequate quality of the water supplied, household storage tanks and domestic plumbing may be sources of contamination if not properly installed and maintained. For these reasons, water may be subject to contamination in the household and this may often be the most important source of microbiological contamination (WHO, 1993). Where household storage occurs, the surveillance agency should investigate the risk that this represents to human health and remedial actions such as education regarding water handling and promotion of maintenance of household storage tanks should be instigated (WHO, 1993).

2.10.1 Protection of water sources

Before a new source of drinking water supply is selected, it is important to ensure that the quality of the water is satisfactory or treatable for drinking and the quantity available is sufficient to meet continuing water demands, taking into account daily and seasonal variations and projected growth in the size of the community being served.

The watershed should be protected from human activities. This could include isolation of the watershed and/or control of polluting activities in the area. Sources of ground water such as springs and wells should be sited and constructed so as to be protected from surface drainage and flooding. Zones of spring sources should be fenced to prevent public access, kept clean of rubbish and sloped to prevent the collection of pools in wet weather. If sloping is not possible, options can be created for the water to be used, eg fish ponds, irrigation or planting trees which consume a lot of water. Animal husbandry should be controlled in such zones (WHO, 1993).

Managing the system and the resource - an example from Guatemala (Evans and Appleton, 1993).

Community Management in Guatemala goes beyond simple care of water supply systems and addresses basic problems of water source and environmental protection. Agua del Pueblo advisers not only offer training to the community in local management and technical skills to undertake basic care and maintenance of water systems, and promotes good environmental sanitation around water points, but also offers advice on watershed protection through training such as tree planting. This helps to build broader capacities within the community to conserve basic resources as well as to manage new technologies

3.0 METHODOLOGY

This chapter deals with the methodology adopted for the research. It explains the different techniques of data collection adopted in the field and describes the indicators used for the survey.

3.1 COLLECTION OF DATA

The various techniques that were used for the data collection are summarised in the following sub headings.

3.1.1 Sampling

In a survey, it may not be necessary or possible to include the whole target group, for example all households, all caretakers etc. Therefore, a sample may be drawn to represent the total. To meet the requirement of representatives, the first step of sampling is to define the total "population". A total population may be defined as all people living in the project area; all households in a village; all caretakers who followed a training course two years ago; all latrines constructed with project support during a period of year; all improved wells in the dry part of the project area.

When the total population has been defined, random samples can be drawn. A random sample gives each unit of the population, for example, each household, each caretaker, each well an equal chance of being selected. This is done by assigning a number to each unit, for example, to all households on a village map, on an official list, or to the houses themselves and then selecting at random the numbers to be included in the selection.

Depending on the research objectives, it is not always necessary or possible to draw a random and representative sample. In this particular case, sampling has been biassed since the researcher selected two districts viz. Thimphu and Paro, which are close by her home town. This has been done due to the limited time available and constraints in resources.

Furthermore due to the scattered rural water supply schemes in Bhutan and the limited

time available for data collection, a sample size of six working schemes which have a caretaker and village maintenance committee (VMC) were selected for research purpose. The two districts selected for the survey are shown on the map in annex 3.1. One research objective was to find out how well the VMCs are functioning since their formation in 1991, therefore working schemes with caretaker and VMC have been selected. The sample size is very small and does not enable for statistical extrapolation of findings, but it will give an impression and the methodology may subsequently be applied in more systems to obtain an overall picture. Furthermore, it will be possible to compare the findings with O&M systems of other countries.

Though the sample of the schemes is very small and is not sufficient to extrapolate to Bhutan as a whole, but the number of households interviewed per scheme is quite sufficient to conclude something about the individual schemes and about the two districts as a whole. The number of households interviewed is presented in the table below.

Scheme name	Bara	Isuna	Shinkana	Gepti	Lunten	Jushina
Total number of households	28	31	26	61	21	36
No. of Households interviewed	20	8	18	33	20	14

The first research district, Paro, at present has 101 rural water supply schemes out of which 64 schemes have trained caretakers and 16 schemes have village maintenance committees. This information has been found from office records. The list of caretakers and VMCs trained by the districts are maintained in a database file in the head office. The lists were used to make a selection of those schemes which have both a caretaker and VMC. Some schemes only have a caretaker while some only have a VMC. From the schemes with a caretaker and VMC, 4 schemes were selected by lottery system from the following list of schemes.

Sl. No	Project No.	Project name	Sl. No	Project No.	Project name
1	78/44/04	**Gepti**	8	89/44/01	**Bara**
2	82/44/03	Tashigang	9	89/44/02	Khamzam
3	82/44/04	Tshangkha	10	90/44/01	Atcho
4	82/44/05	Susulongpa	11	91/44/07	**Isuna**
5	85/44/14	Khangkhoo	12	91/44/08	Chandori-map
6	85/44/13	Taju	13	91/44/10	Mendi
7	88/44/03	Nabisa-1	14	91/44/11	**Shinkana**

The second district Thimphu is provided with 100 water supply schemes, 73 schemes have a trained caretaker and 28 schemes have a VMC. In the same way as the previous district, the two schemes with a caretaker and VMC, were selected for the survey from the following list.

Sl.No	Project No.	Project name	Sl.No	Project No.	Project name
1	78/45/05	Patshikha	9	87/45/04	Shoshi
2	78/45/07	Patshaka	10	88/45/02	Gapjakha
3	81/45/01	Sosukha	11	88/45/06	Khasadrapchu
4	81/45/05	Gemkha	12	89/45/01	Simthokha
5	82/45/09	Zangleykha	13	90/45/02	Wang baamu
6	83/45/03	Dhaji	14	90/45/04	**Jushina**
7	83/45/05	Genikha	15	91/0/45/08	**Lunten**
8	87/45/02	Phongshi	16	92/45/03	Tshafu

A total of 113 households, 8 caretakers and 17 VMC members have been interviewed i.e. two households per each tapstand, caretakers and VMCs of each scheme.

3.1.2 Questionaries

A questionnaire consists of a fixed number of questions. It is used as a standardized interview to collect qualitative data on:

- population characteristics, such as socio-economic background, attitudes and feelings
- project achievements, such as functioning and use of water supply facilities; the performance of trained manpower.

Open questions were used for the survey. This method of data collection was very useful and it provided a lot of information. Since the researcher could converse well in the local language with the villagers, this part of the research went on very smoothly. Questions regarding the quantity, quality, sufficiency of water and maintenance of the system etc. were asked. The list of questions asked to users, caretakers and VMC are attached as annex 3.2, 3.3, 3.4 respectively.

3.1.3 Mapping exercise

Mapping exercise has been carried out in addition to the sanitary inspection and interviews of the catchment area. This method was successful with the caretakers but not very successful with the users. A map of Lunten scheme drawn by the caretaker is in annex 3.5. Some of the users were reluctant/shy to draw maps of their water supply and the researcher could not persuade them to participate. The reason for this may be due to the researcher's limited knowledge of this methodology or not knowing the technique of this type of exercise and also the villagers not being familiar with this kind of exercise. Wherever not possible, this exercise had been compensated with interviews. The checklist used for mapping exercise is as per annex 3.6.

3.1.4 Sanitary Survey

A sanitary survey is defined as an on-site inspection and evaluation by qualified individuals of all conditions, facilities and practice in the water supply system that pose an actual or potential danger to the health and well being of the consumer. It is a fact-finding activity that should identify system deficiencies - not only sources of actual

contamination but also inadequacies and lack of integrity in the system that could lead to contamination (WHO, 1997).

The two principal activities are sanitary inspection and water quality analysis. It has been suggested by the WHO that sanitary inspection should take priority over the analysis, but the two should be done together wherever possible. A sanitary inspection is indispensable for the adequate interpretation of laboratory results. No analytical, bacteriological, or chemical survey, however carefully carried out, is a substitute for comprehensive knowledge of conditions at the water source and within the distribution system. A sanitary inspection thus provides essential information about immediate and ongoing possible hazards associated with a community water supply even in the absence of microbiological or chemical evidence of contamination (WHO, 1997).

The sanitary survey proved to be very useful in finding out the sanitary risks of the water source. It would have been even more useful if it had been carried out along with a bacteriological testing of the water at the source, tapstand, and where applicable, storage in the household. Bacteriological testing could not be carried out because, at that time the media for incubation was not available. The sanitary survey was carried out along with the help of the caretakers and a few users. The checklist for sanitary survey is as per annex 3.7.

3.1.5 Observation

Observation is a very powerful method for collecting data on physical conditions and behaviour patterns but behaviour patterns have not been observed during the survey as it was not included. This method provided valuable information on behaviour patterns like who collects the water, where, when, how. We can observe how people store their water at home and how it is used for various purposes. This method is also used to observe how the water supply components are maintained, and can be used to detect leakage in a tap, exposed pipeline, cracks in tanks, cleanliness of tanks, fencing around the intake and other structures etc. The checklist used for observation is shown in annex 3.8

3.1.6 Remarks

An important point to be looked at during data collection is the work schedule of the target area. For example, the first month of the data collection period coincided with the rice harvesting season, the busiest season of the year in the villages. All the villagers were busy in their fields and some were out in another village to help with the work. So the data collection took more time than required to get all the information.

3.2 THEMES AND INDICATORS

The various themes and indicators selected are described as follows (Visscher et al, 1997):

3.2.1 Organizational set-up

The following themes are selected to describe the existing organizational set-up at the central level and the district level in the rural water schemes in Bhutan.

Staffing

The indicators for staffing is the number of technical persons at the head office dealing with the design and estimate of new rural water supply schemes and also for the rehabilitation of old schemes. The persons of the head office involved in training of trainers (trainers are the district staff) and the district staff involved in the training of water caretaker and village maintenance committees.

The number of district engineers, section officers, work assistants, masons, plumbers etc. allocated in each district to implement and monitor the rural water supply schemes.

This information is collected from office files.

Training

Rural water supply schemes are managed by the community. Training is an important tool to improve the users knowledge in terms of technical and managerial aspects. The number of caretakers and village maintenance committees trained to look after the schemes and the different components included in the training course.

This information is obtained from training coordinator at the head office and also from progress reports and training manual.

Procedures and strategies

The procedures and strategies adopted by the department in relation to rural water supply schemes.
This information is collected from documents informal interviews of some persons in the PHES and the two districts.

The indicators used to assess the functioning of the scheme are as follows:

3.2.2 Quality of the system

The physical quality of the water supply scheme will reflect the quality of construction and the effectiveness of the caretakers in maintaining their schemes. Physical quality of the scheme means the cleanliness of the tanks, tapstands, leakages in the pipeline, fencing around the tanks etc.
In the research, the quality of the system was carried out by observation of the whole scheme with the help of a checklist (Annex 3.8).

3.2.3 Reliability

This refers to the number of supply hours per day and the continuity of the supply over the year. Continuity in the source means the reduction of flow at source in so many years.
This information is obtained from interviews and measuring at the source.

3.2.4 Quantity of water

This refers to the total volume of water collected per day. The indicator used is total quantity of water collected per day over the design quantity.

The method adopted for finding out the quantity of water used by each household was through interviews. It was found that the villagers use jerry cans or buckets to collect water from the tapstand. By finding out the number of times a household collects water in a day and multiplying it by the volume of the container used gives an approximate amount of water used per day by that household. This quantity divided by the number of persons in that household gives a rough amount in litres per capita per day. This method adopted for finding out the quantity of water used is not very accurate but still it gives a rough estimate of the average water used per person per day.

3.2.5 Sufficiency of water

This indicates whether the water supplied by the scheme is sufficient for domestic use or not. The indicator used is: Total volume of water used per day over the total volume of water produced at the source.
This information is obtained by interviews and measuring the flow at the source. The flow at the source had been measured by closing the outlet pipe, draining all the water through the washout pipe, then closing the washout pipe and the intake is filled with the incoming water. The time taken to fill the intake is noted and the volume of the intake is measured. The volume divided by the time it takes to fill gives the flow into the intake.

3.2.6 Quality of water

The quality of water supplied to the users. The indicator used are:

- Taste, smell and colour
- Risk of contamination: risk levels in the catchment, during transportation and storage in the house.

This information is collected by observation, interviews and sanitary inspection. To

determine the quality of water, the users attitude about the water they get in terms of taste, smell and turbidity were asked. Due to lack of instruments, turbidity could not be measured. Questions regarding storage and handling of water were asked. Together with the interviews, a sanitary risk survey of the catchment area was also carried out.

To find out the sanitary risks in the catchment area, users were interviewed and a mapping exercise of the catchment was carried out with help from the caretakers. In addition an observation of the catchment area was done.

3.2.7 Use of alternative sources

Normally alternative sources are used as an indicator for the acceptance of the system and the value users contribute to the system. In the research area, it was found that all the users fetch water from the scheme. Therefore, this indicator is used to find out if there are alternative sources available during breakdown of the water scheme, and to know whether the other source is of good quality. The information is collected through interviews.

3.2.8 Caretaker

After the construction, the rural water supply schemes are handed over to the community and is looked after by a caretaker wherever he/she is appointed. The indicators used to assess the efficiency and performance of the caretakers are the following:

- tools - the presence of a complete tool box
- spare parts - availability of spare parts
- training - training given to caretakers
- financial arrangements - incentives provided to the caretaker
- gender - any problems being a female caretaker

These information is obtained from interviews, mapping exercise and observation.

3.2.9 Village Maintenance Committee

Village Maintenance Committees are appointed in some of the rural water supply schemes in Bhutan to manage the operation and maintenance of the schemes. The functioning of the committees is assessed by the following indicators:

- revenue collection - the amount of money collected for operation and maintenance of the schemes.
- training
- record keeping
- decision making - the number of meetings held by the committees to discuss about the maintenance of the schemes and the decisions made by them.
- gender - female members being influential or not

These information is collected by interviewing the VMC members and caretakers.

4.0 RESULTS

This chapter describes the results obtained with the help of the various data collected that relate to the themes and indicators identified in chapter two. The findings on organisational set-up, the performance of caretakers and village maintenance committees and functioning of the schemes are stated here.

4.1 THE VILLAGES VISITED

The six villages that were visited have almost the same living style. There are no ethnic groups existing in these villages. Their main income is from agriculture. The main crop, rice, is grown for their own consumption and sometimes sold in the market. Other vegetables, especially potatoes and chilies, are also sold in the market. Many people keep cattle to make milk products and also to plough the fields.

The illiteracy in the villages visited is quite high among the adults but majority of the children are going to school.

Type of system

Only gravity fed piped water supply schemes are constructed in these rural areas. One scheme serves one village. None of the schemes have treatment plants. The main elements of a scheme are intake, reservoir, break pressure tank, tapstand and High Density Polyethylene pipe (HDPE) for the whole system. Galvanised iron (GI) pipes are used for stream and gully crossings. There are no house connections in any of the schemes.

The description of the schemes visited including the number of households served by each scheme, the construction year of each scheme and the source type of each scheme is given in table no. 4.1. The schemes of Bara, Isuna, Shinkana and Gepti belong to Paro district and the schemes of Lunten and Jushina belong to Thimphu district.

The description of the schemes visited is given in the table below.

Table 4.1

Scheme name	Constr-uction year	No. of household-olds served	Source type	Flow at the source lps	No. of tapsta-nds	No. of reservoirs	No. of break pressure tanks
Bara	1989	28	Spring	0.58	11	1 SM	-
Isuna	1991	31	Stream	2.00	4	-	1
Shikana	1991	26	Stream	0.57	8	1FCR	-
Gepti	1978	61	Spring	0.08	36	1 SM	5
Lunten	1991	21	Spring	1.60	10	-	2
Jushina	1990	36	Stream	0.88	7	1 FCR	

The Gepti scheme is rehabilitated in 1993
SM - Stone masonry
FCR - Ferrocement reservoir

Illegal Connections

There are different types of illegal connections prevailing in the villages. During the planning stage of a scheme, some households refuse to join in the new scheme because, they get their water from a private spring nearby or they don't like to contribute labour during construction. Thus they are not allotted a tapstand from the scheme. Later on, they change their mind and make a connection from the mainline by cutting the pipe.

In some villages, new houses are constructed after the implementation of a scheme and these houses get a water supply connection from the scheme by cutting the mainline and providing a T- joint. These connections which are made without the permission of the VMCs or water caretakers are known as illegal connections.

4.2 ORGANISATION

The implementation of a rural water supply scheme is shared between the Public Health Engineering (PHE) Section of the Public Works Division (PWD) and the District Engineering Units under the District Administration. The PHE is responsible for designing, estimating, extending technical and training support to the district staff, coordinating with sector donors/national bodies and monitoring the programme implementation and performance of the schemes. The district engineering units together with the rural communities survey and construct water supply schemes. The operation and maintenance thereafter is the responsibility of the community.

The organisation chart of the PHE is shown in annex 4.1

4.2.1 District level staff

PWD staff at district level has a wide range of other responsibilities and duties in the district. Their roles have expanded with the demands of decentralised organisation of works and additional projects managed at the district level. The PHE staff of the 20 districts are shown in annex 4.2

4.2.2 Policy on operation and maintenance

The O&M Policy describes the following procedures on VMC formation, maintenance responsibilities and caretaker selection.

Formation of VMC

The VMC for the RWS is established during the feasibility survey and comprises of a minimum of six members. These are:

Gup (village headman)	- chairman
Caretakers (2 nos)	- members
Village health worker	- member
Beneficiaries (minimum 2)	- members

The District Engineer/Section Officer (DE/SO) and representative from the health sector facilitate in the formation of the VMC. It takes place at an assembly of all beneficiaries under the guidance of the district administration. The officers will observe and confirm that fair procedures are adopted regarding the selection. While selecting members, consideration is given to general education levels and aptitude to social services. The VMC members are also given a 3 days orientation course. At present a total of 664 schemes have trained VMCs out of a total of 1800 rural water supply schemes.

The VMC's responsibility for maintenance of the scheme are:

- conflict solving
- arranging spare parts
- compensation of caretaker
- to convey health education and relation of health with safe water messages to the users

Maintenance responsibilities

After the completion of the scheme, it is formally handed over to the representative body of the beneficiaries called VMC for operation and maintenance and use. The VMC is thereby directly responsible for routine/regular operation and maintenance and minor repair of the schemes. The PHE will only assist the beneficiaries when the scheme needs major repair i.e. if the amount of repair is around Nu.2000/- (US$50) per head or if the scheme needs reconstruction. If the caretaker faces serious technical or complicated problems, he/she can seek help from the district staff. A request should be made by the VMC chairman to the district administration for assistance, then the district administration requests the PHES if it is rehabilitation of the scheme otherwise if only some technical help or some materials are required, the district will provide assistance.

Caretaker selection

From the beneficiary members, 2 persons (one male, one female) are selected as caretakers by the community with the help of the district staff, to be attached with government masons/plumbers during the construction phase. These two caretakers are further trained for 5 days. A tool box with a set of tools (namely: heating plate,

thermochrome crayons, teflon cover, blow lamp, wrenches, hacksaw, hacksaw blades, files, jute thread and grease) is also given to the caretaker after training. The responsibility of the caretaker is to perform preventive maintenance like cleaning of the tanks, the surrounding of the tanks, clearing of blockages, small repairs like plastering cracks in the tanks and tapstands, controlling the flow to all the taps etc. The system of formation of VMC and training of caretakers has been started only in 1991. Out of the total number of 1800 new rural water supply schemes, PHES now 1171 schemes with trained caretakers including schemes built before 1991.

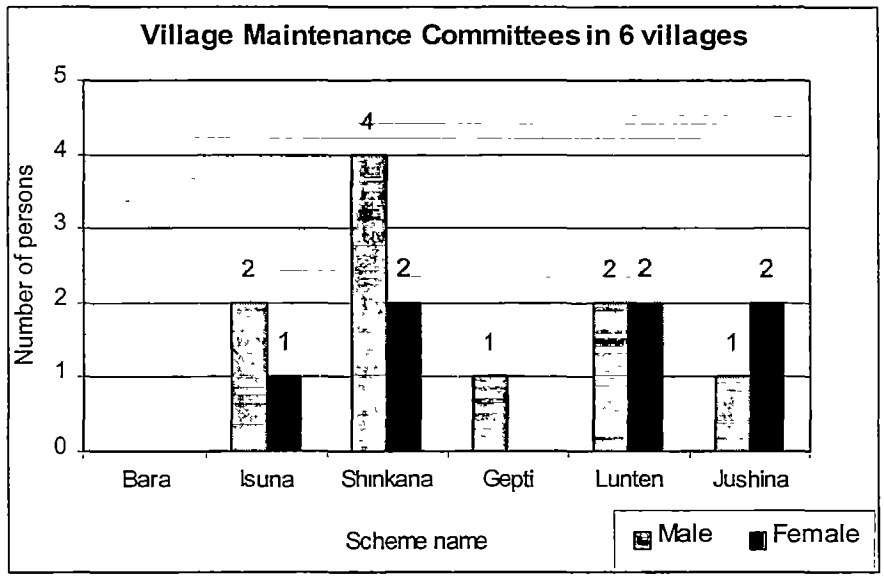
The responsibilities of the caretaker are the following:

- preventive maintenance like, cleaning of intake, reservoirs and break pressure tanks
- minor repairs like changing of bibcock or bibcock washer, plastering of walls of the tanks or tapstands etc.
- report to the district if major repair is required through VMC if present or directly.
- detection of leakage in the pipeline and joining the pipe if required
- adjusting of control valves to control flow in all the tapstands

4.3 VILLAGE MAINTENANCE COMMITTEE

The data obtained through interviews of the VMC members is presented in annex 4.3 and of the users is in annex 4.4(a&b). All the schemes visited have a village maintenance committee except for one scheme. The VMCs consist of male and female members. There are a total of 10 male and 7 female members in the six schemes visited. The five VMCs that were visited had a varying size as summarised in the following chart.

From the total members of the VMCs, 7 are females. Out of these 7 members, only 2 members of Lunten scheme feel that they are influential.



VMC members of four schemes have been selected by the community whereas the members of Jushina scheme have been selected by district staff and the community jointly.

4.3.1 Training of VMCs

Out of the five VMCs, four committees got a training of 3 days and one committee did not get training at all. All the members could explain their roles and responsibilities but sometimes they got confused with their roles and the caretakers roles. The Village Maintenance Committee members do not get any sort of remuneration.

Scheme name	Bara	Isuna	Shinkana	Gepti	Lunten	Jushina
VMC trained	-	Yes	No	Yes	Yes	Yes

Are the VMCs trained?		**Could VMCs explain their roles?**	
Yes	4 (total 11 members)	Yes	5 (total 17 members)
No	1 (total 6 members)	No	0

4.3.2 Revenue collection

The rural water supplies are constructed with UNICEF and a government grant, so there is no need for the users to pay for the capital cost except for the labour they provide during construction. Only the operation and maintenance cost have to be borne by the users. In the six schemes there is no regular system of collection of money for purchasing of spare parts. In three schemes i.e. Gepti, Lunten and Jushina a regular payment of the caretakers exists. In the schemes of Lunten and Jushina the VMCs had some activities like, whenever a spare part is to be bought, the VMCs collect money from the users and buy the spare part. In the schemes of Gepti, Shinkana and Isuna, the VMCs did not do any work, the users buy the spare parts themselves. In scheme Shinkana the villagers had collected money (Nu.3000) from the users who did not participate in the construction of the scheme and deposited it in the bank for O&M, but till now they have not used the money.

The VMC of Lunten scheme felt that there is no need to keep maintenance funds because the villagers are cooperative and there is no difficulty in collecting money whenever required. The VMC of Jushina said that keeping a maintenance fund will be appropriate and they are planning to have one in the future.

4.3.3 Record keeping

None of the VMCs have kept records of the money spent on operation and maintenance of the schemes. About the money spent on buying spare parts, only the VMC of Lunten could give a figure i.e. Nu.20/HH, after calculating in his memory. The rest could not remember how much was spent on repairs.

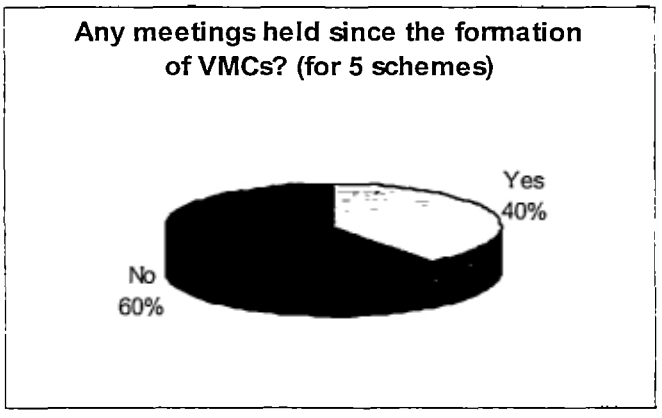
4.3.4 Meetings held by VMCs

So far none of the committees have conducted regular meetings. The committee of Lunten scheme conduct meetings whenever there is a problem related to the water supply. In Jushina scheme the committee have met only twice since their formation in 1991, to discuss the collection of funds for future maintenance. Other committees have

not held any meetings at all.

The summary on the VMC meetings held

Scheme name	Isuna	Shinkana	Gepti	Lunten	Jushina
Meetings held so far	No	No	No	Yes	Yes



Out of the five schemes with a VMC, only two VMCs held some sort of meetings and in these meetings they discussed the amount of money required for buying some spare parts. Then they collected the money from the beneficiaries.

Activities according to VMCs

The VMCs of Lunten and Jushina scheme said that they do some work. The VMC of Shinkana do not work because they are not trained and also do not get any incentives. The VMC of Gepti scheme does not get any cooperation from the users, therefore he does not work. The VMC of Isuna scheme do not work because the Gup feels that when the users can buy the spare parts, it is useless to have a VMC. They also pointed out that they do not get incentives.

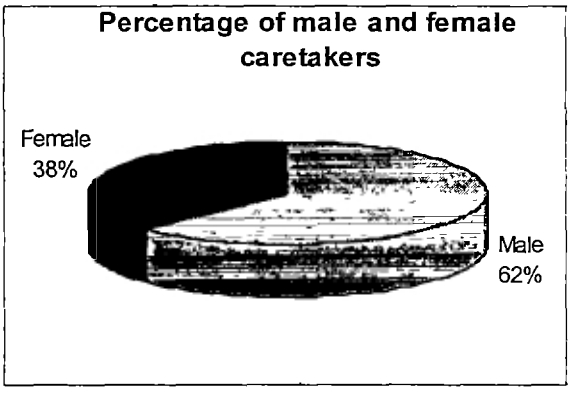
Functioning VMC: The VMC which assists the caretaker in the O&M of a scheme by keeping maintenance funds, buying spare parts, solving conflicts, etc. is regarded as functioning.

4.4 THE CARETAKER

The information collected through the interviews of the caretakers is presented in annex 4.5. All the six schemes visited had at least one caretaker. Two schemes have two caretakers (one male, one female), the other schemes have only one. Total number of caretakers for the six schemes is 8 out of which 3 are female. They were all selected by the community.

Among the 3 female caretakers, only one faces problems being a caretaker, the other two caretakers do not have any problems and are working well.

Scheme name	No. of caretakers
Bara	1 male
Isuna	1 male, 1 female
Shinkana	1 female
Gepti	1 male
Lunten	1 male
Jushina	1male, 1 female



During the visit, the caretaker of Gepti scheme was different from the one who was mentioned in the office record. As per office record, one male and female had been trained for that scheme but actually only one male caretaker was present and he was not trained. The caretakers who were ordinally trained resigned after working for one year because the male was not interested and the female got married and after having children she did not have time to look after the scheme. After their resignation, another man was appointed by the village but he worked for 2 years and resigned again. Again the village appointed the present caretaker and during the research, he had been working since 6 months.

4.4.1 Training

All the caretakers except one i.e of Gepti scheme have been trained by the district staff.

The caretaker training includes the following subjects:

- briefing on the different components of the scheme and the maintenance required for these components. The components are source, intake, reservoir, BPT and the tapstands.
- roles and responsibilities of the caretaker
- use of different tools in the tool box
- changing of washer in the bibcock and types of local materials that can be used as washer
- HDPE pipe welding and joining
- GI pipe joining
- adjusting of control valves
- detection of leakage/blockage in the pipeline
- visiting a scheme: cleaning devices and adjusting of valves are demonstrated on the scheme.

All these elements are first demonstrated by the district staff and later the caretakers have to repeat them.

Even with the training three caretakers found some difficulties in the operation and maintenance of the schemes, like not being able to detect a fault when there is no water in the taps.

In Isuna scheme, the overall structures were in good condition except for an exposed and leaking pipe behind one tapstand. The female caretaker saw there was no water in that tap and she assumed that the pipeline going to it was blocked. So, she cut the pipe to clear the blockage but there was no blockage. Later on she found that somebody had closed the control valve of the tap fully. Though she was trained, she could not join the HDPE pipe properly, it was wrapped by a cloth and kept leaking.

The caretaker of Shinkana scheme said that when the pipeline gets blocked, she is not able to detect it and therefore, she has to cut the pipe at many places to find the blockage.

The summary of training of caretakers and tool boxes issued.

Scheme name	With the training given, are you able to do all O&M works?	Is tool box present?	Is it complete?
Bara	Yes	Yes	No
Isuna	Yes-male, No-female	Yes	Yes
Shinkana	No-female	Yes	Yes
Gepti	No training	Yes	No
Lunten	Yes-male	Yes	Yes
Jushina	Yes-female, No-male	Yes	Yes

4.4.2 Tools

All the caretakers are provided with a tool box after their training, which is provided free of cost by the PHES. It is not issued to untrained caretaker. Only one tool box is issued per scheme. At the time of issue, the following tools are included in the tool set: heating plate, thermochrome crayons, teflon cover, blow lamp, wrenches, hacksaw, hacksaw blades and files. All tools were present in four schemes and in Gepti and Bara schemes some tools were missing. The caretaker of Gepti scheme faced problems due to the incomplete tool box.

4.4.3 Remuneration

Three out of the eight caretakers received money from the users and four were exempted from shaptolemi*. One got nothing from the users. The caretaker who did not receive any incentive is a female and she admitted that her male counterpart did most of the work, therefore, he is paid. Only during his absence she does some work.

*** The villagers are expected to contribute voluntary labour for community work, like the repair of a monastery, construction of a community school etc. as the most usual form of beneficiary participation i.e. 15 days per year per household. Such participation is called shaptolemi.**

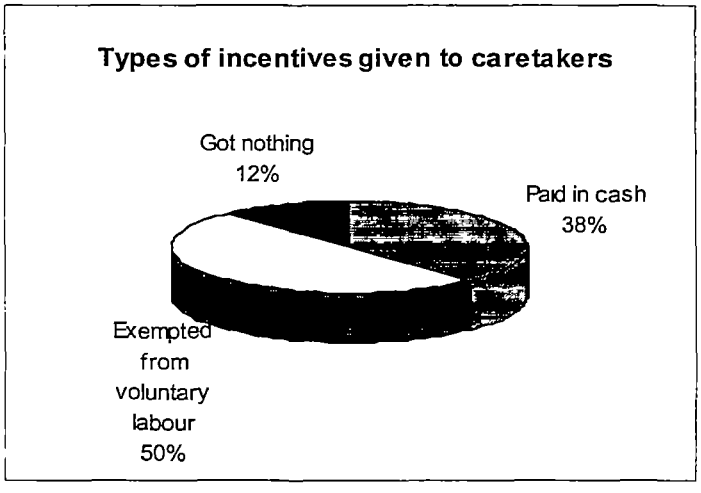
The remuneration for the caretakers has been decided by the village headman along with the villagers and the maintenance committees. The caretakers did not have a say in his/her preference of the type of remuneration.

The amount of money the caretakers got varied from village to village. Two of them received Nu.120 per household per year and the third one received Nu.50 per household per year. The caretakers were quite satisfied with the amount. The salary for the caretakers of Lunten and Jushina schemes are collected from the households by the VMCs every month. The caretaker of Gepti is being paid directly by the community every month. Those caretakers who were not paid in cash were not very happy.

Compensation for the caretakers

Scheme name	Bara	Isuna	Shinkana	Gepti	Lunten	Jushina
Caretakers	One	Two	One	One	One	Two
Type of compensa-tion	Exempted from shaptolemi	Exempted both from shaptolemi	Exempted from shaptolemi	Salary	Salary	Salary for the male only
Amount per caretaker	-	-	-	Nu.254/ month	Nu.210/ month	Nu.360/ month

The result is presented in the following chart.



4.4.4 Activities of the caretakers

A caretaker is responsible for routine maintenance, operation, monitoring/checking if there are any problems, cleaning of the structures and minor repairs of the water scheme in their village.

Activities according to caretakers

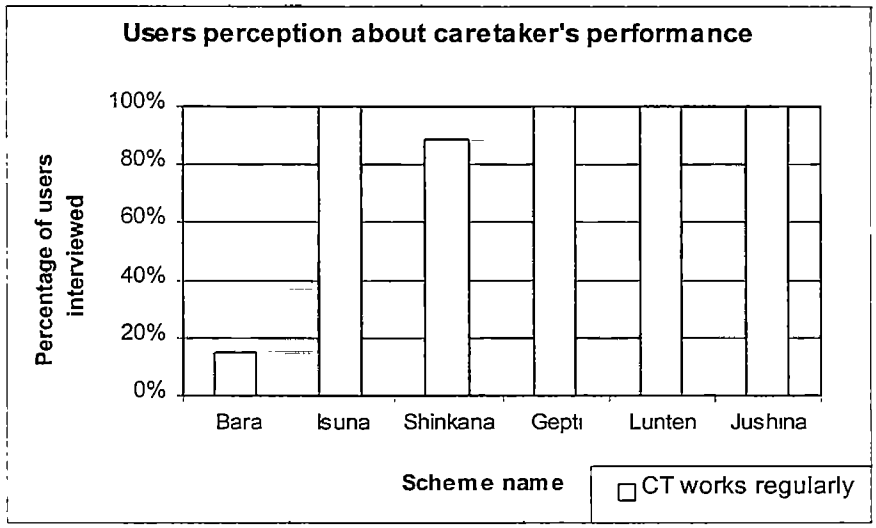
The caretakers of the research area do not work on the scheme on a daily basis. The caretaker of Bara scheme cleaned the tanks or did some repair only when asked by the villagers. The rest of the caretakers clean the intake and other tanks more frequently during monsoon season when debris blocks the intake. The frequency of cleaning is indicated in the following table:

Scheme name	Frequency of cleaning during monsoon	Frequency of cleaning during other seasons
Bara	Cleans only when asked by villagers	
Isuna	Once in 3 days	Once in a month when there is free time
Shinkana	Once in a week	Once in 3 weeks
Gepti	Whenever there is no water in tap	Once in 3 months
Lunten	Thrice a month	Once in a month
Jushina	Once a day	Once in 3 days

Activities of caretakers as perceived by the users

All users could identify the caretaker of their water supply scheme. Most of them said that their caretaker attend to their problems whenever there was no water in their taps. 17 out of 20 users of Bara scheme were not very happy with the water caretaker's performance and 2 out of 18 users of Shinkana also complained about the caretaker. Some of the users of these schemes have to clear blockages etc. in the intake if there is

no water in the tap. The interview is summarised in the following chart.



4.4.5 Cooperation from VMC

Bara scheme does not have a village maintenance committee. The rest of the schemes have VMCs. In more than half of the schemes the caretakers said that they do not get any cooperation from the VMCs. It can be seen from the following table.

Scheme name	Bara	Isuna	Shinkana	Gepti	Lunten	Jushina
Does the caretaker get cooperation fromVMC	No	No	No	No	Yes	Yes

4.5 QUALITY OF THE SYSTEM

The quality of the system is presented in the following sub topics.

4.5.1 Quality of construction

The result of the survey is presented in the following table.

Sanitary survey on the quality of the scheme

Scheme	Bara	Isuna	Shikana	Gepti	Lunten	Jushina
No fencing around source & intake	Yes	Only around intake	No	No	No	No
Grasses around intake & other tanks	Yes	Yes	Yes	Yes	No	No
Cracks in intake	Yes	No	No	No	No	No
Broken intake cover	Yes	No	No	No	No	No
Leaking pipeline	Yes	Yes	Yes	Yes	No	No
Exposed pipeline	Yes	Yes	Yes	Yes	Yes	No
No fencing around BPT/reservoir	Yes	No	No	No	No	No
Leaking reservoir	Yes	No	No	No	No	No
Broken cover on reservoir/BPT	Yes	No	No	Yes	No	No
Dirty tanks	Yes	No	No	No	No	No
Illegal connections	Yes	No	Yes	Yes	No	No
Leaking taps*	2/11	1/4	1/8	3/36	1/10	0/7
Dirty tapstand area*	6/11	1/4	4/8	16/36	2/10	1/7
Low pressure in tap**	Yes	No	No	Yes	No	Yes

* The numerator refers to the number of taps leaking or dirty and the denominator refers to the total number of taps.

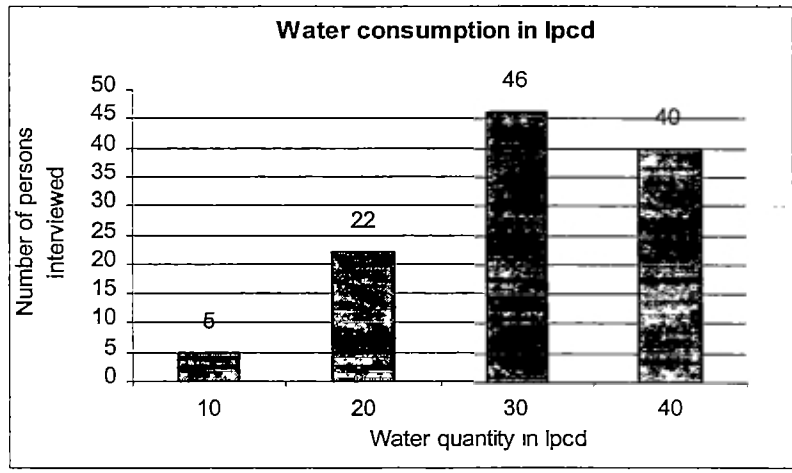
** The pressure is related to flow i.e pressure is considered low when the flow in the tap is small

Cracks in intake structure or broken covers were not very common in the schemes visited. Leaking taps and tapstands with dirty surroundings were observed in almost all the schemes. Exposed and leaking pipeline were observed in four schemes. Some reservoirs and BPTs were surrounded with grasses.

4.5.2 Water Consumption

In total 113 households were interviewed. They indicated that they used the water from the tapstand for cooking, washing, cleaning of dishes and for cattle. Majority of the households collect the same quantity of water every day.

The average water used per person in the schemes visited is shown in the chart.



4.5.3 Quantity supplied

The indicator selected for the sufficiency of water was total volume of water used per day over total volume of water produced per day. This can be summarised in the following table:

Scheme name	Bara	Isuna	Shinkana	Gepti	Lunten	Jushina
Intake flow in lps	0.58	2.00	0.57	0.08	1.60	0.88
Volume produced in litres per day (i.e.)	50112	172800	49248	6912	138240	76032
Population	224	248	208	488	168	288
Average water use in lpcd	30	30	40	40	20	30
Water used per day (ii)	6720	7440	8320	19520	3360	8640
Sufficiency = (ii)/(i.e.)	**0.13**	**0.04**	**0.17**	**2.82**	**0.02**	**0.11**

The formula used to calculate sufficiency of water in the table on the previous page indicates that when the figure is 1, the water is just sufficient , when the figure is less than 1, the water is more than sufficient and when the figure is greater than 1, the water is not sufficient for the village. It is clear from the table that only Gepti village is not getting sufficient water.

The six schemes that have been reviewed vary considerably in production. The flow at the source at the time of the visit varied from 0.08 to 2 litres per second (table above). The table also indicates the population drawing water from these schemes that vary from 168 to 488 inhabitants. The volume of use that is indicated in the schemes varies between 20 to 40 lpcd. This volume had been measured from the number of times each household collects water in containers per day and therefore, the quantity is rather rough. In two schemes Bara and Gepti, the community living at the end of the scheme complained that they do not get water most of the time.

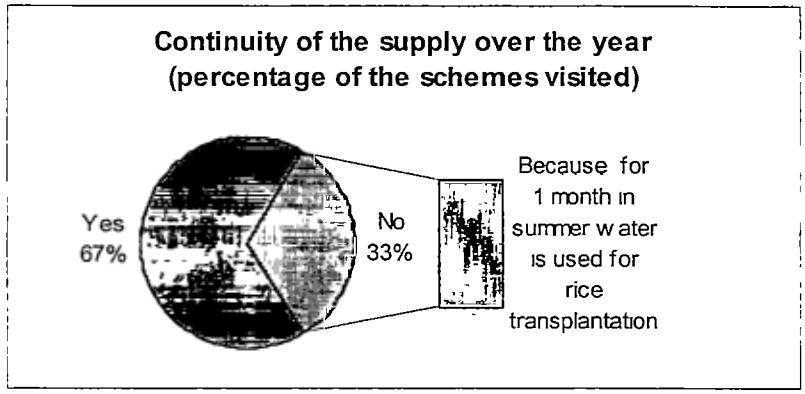
4.5.4 Reliability

In all the schemes visited, the supply is continuous over the day i.e 24 hours service. In the schemes of Bara and Gepti the water from the sources are diverted to supply the rice fields during the rice transplanting season leading to reduced flow. The other schemes had only temporary discontinuity in the source during the rainy and autumn seasons when the leaves and debris block the pipeline. But this situation lasts only for some hours or a day because it is reported to the caretaker and cleaned immediately.

The result is summarised in the following table.

Scheme	Bara	Isuna	Shinkana	Gepti	Lunten	Jushina
Continuity over the day	Yes	Yes	Yes	Yes	Yes	Yes
Continuity over the year	No	Yes	Yes	No	Yes	Yes

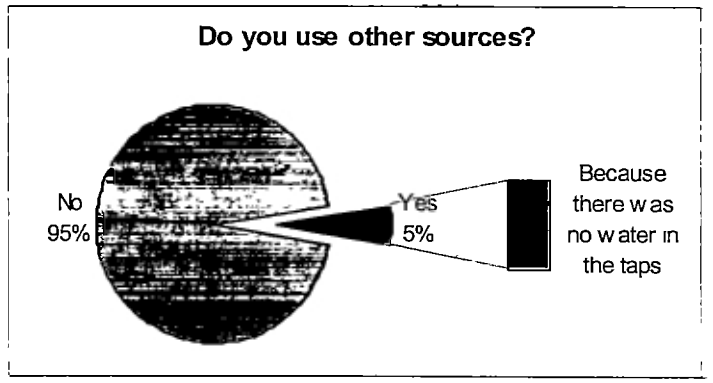
The result of the survey is presented in the following pie chart



4.5.5 Use of Alternative Sources

All the users interviewed accept the water supply scheme provided to them. None of them use other sources except six households of Bara scheme due to the non availability of water in the taps. These households collect water from a nearby irrigation channel.

Scheme name	Do you use other sources?
Bara	Yes(6), No(14)
Isuna	No (8)
Shikana	No (18)
Gepti	No (33)
Lunten	No (20)
Jushina	No (14)



The figure between brackets indicate the number of persons interviewed.
Most of the villages had an alternative sources but the sources were either a dirty stream or an irrigation channel.

4.5.6 Water Quality

The users interviewed said that the quality of water is good, the taste is good and that there is no bad smell. The turbidity was not measured but the majority of the users interviewed said that the water is turbid during the monsoon season which lasts for about three months. Due to the rains the water becomes muddy. Some people of Shinkana village complained that in summer, a gang of wild boars get into their water source area in search of food and make the water muddy. Bara, Gepti and Lunten villagers said that sometimes frogs get into the pipeline and block the water supply.

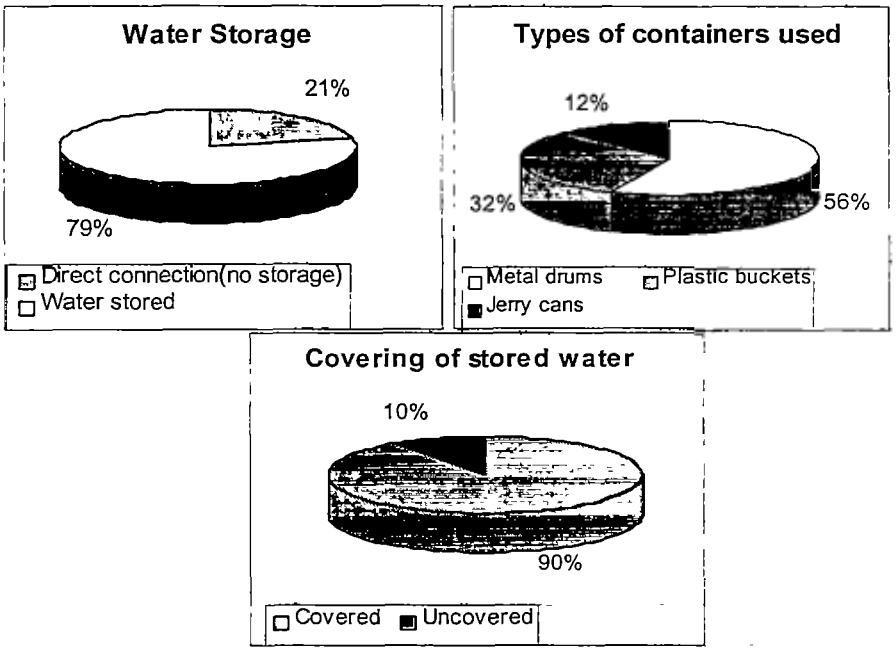
The summary of the interview on the quality of water can be seen in the following table.

Summary of the interviews on quality of water

Scheme name	Bara	Isuna	Shikana	Gepti	Lunten	Jushina
Taste	Good	Good	Good	Good	Good	Good
Smelly	No	No	No	No	No	No
Turbid in monsoon	Yes	Yes	Yes	Yes	Yes	Yes
Frogs in pipes	Yes	No	No	Yes	Yes	No

Most of the villagers store water in containers for a maximum of 3 days in their houses.. About 21% of the users interviewed make a direct connection by themselves from the tapstands whenever required. Water is stored in metal containers, plastic buckets, jerry cans etc. of varying sizes. Where water is stored, about 90% of the households keep the containers covered. Metal ladles and plastic jugs are used to handle the water. These are kept either hanging on the wall or on the top of the containers.

This can be clearly seen in the following pie charts



4.5.7 Risk of contamination in catchment area

The catchment area is defined as the area that surrounds the source and slopes towards the source. All the villagers know the catchment area very well, since they have participated in the construction of the scheme. Even in the mapping exercise, the caretakers indicated all the activities like deforestation, erosion, cattle etc. in the catchment area. The catchment area map drawn by the caretaker of Shinkana is in annex 4.6. In scheme Lunten, there was a vegetable garden on the slopes upstream of the source grown by people of another area living near the source.

The activities occurring in the catchment area are given in the table on the next page. A rating for instance, 1 point is given for every yes. The points are summed up and the scheme having higher point will be categorised in the high risk etc.

The result from sanitary survey and mapping exercise

Scheme name	Bara	Isuna	Shinkana	Gepti	Lunten	Jushina
Houses in catchment area	No	No	No	No	No	No
Latrines in catchment area	No	No	No	No	No	No
Cattle in the area	Yes	No	No	Yes	Yes	Yes
Deforestation	Yes	No	Yes	Yes	Yes	Yes
Agriculture	No	No	No	No	Yes	No
Erosion	No	No	Yes	No	Yes	No
Rating score	2	0	2	2	4	2

From the table above, it is indicates that Isuna scheme gets zero score which implies that there is no risk of contamination in the water related to the catchment area. The schemes of Bara, Shinkana, Gepti and Jushina are in low risk group whereas Lunten scheme has the highest risk

4.6 OWNERSHIP

The ownership of the schemes as perceived by the users and the Village Maintenance Committees are as follows:

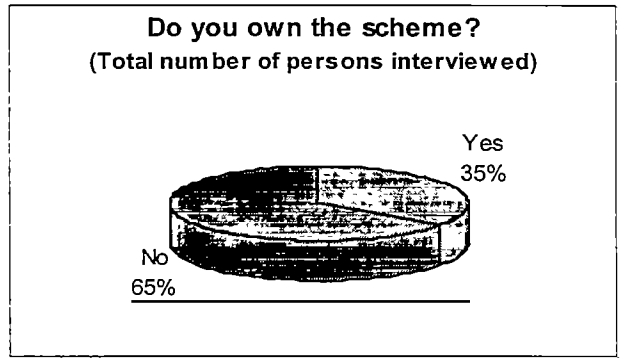
4.6.1 Ownership feeling by the users

Less than half of the users interviewed feel that they own the scheme. Among those who did not have any ownership feeling, the majority of them said that the scheme has been granted by the government, so it should be the property of the government only. One person said that the tapstand is being shared with other households, so he cannot feel that he owns it.

The ownership feelings about the six schemes expressed by the interviewed users has

been illustrated in the following chart.

Scheme name	Own the scheme?	
	Yes	No
Bara	7	13
Isuna	3	5
Shinkana	6	12
Gepti	10	23
Lunten	7	13
Jushina	6	8

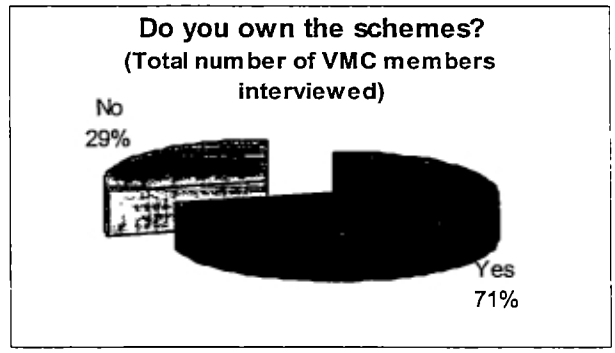


4.6.7 Ownership feeling by VMC

Most of the VMC members felt that they owned the schemes. Only some of them were not sure about the ownership and said that since the government provided the materials and built the schemes, it should be government's property only. Out of the 17 members interviewed, 12 of them said that they own the schemes whereas 5 members denied the ownership of the schemes.

This is summarised in the following table and pie chart.

Scheme name	Own the scheme	
	Yes	No
Isuna	2	1
Shinkana	4	2
Gepti	0	1
Lunten	3	1
Jushina	3	0



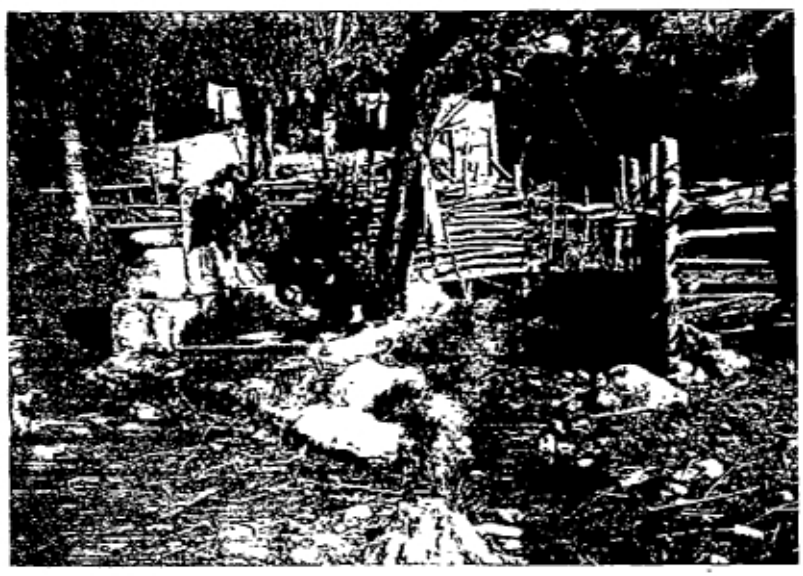
Caretaker of Isuna scheme cleaning the intake, intake surrounded with grasses

Intake of Jushina scheme

Trenchline digging by the community

Cleaning of ferrocement tank by the caretakers

Tapstand with a clean surrounding



Tapstand with dirty surrounding

5.0 DISCUSSIONS/CONCLUSIONS

This chapter outlines detailed discussions and conclusions of the different topics presented in the results. By looking at the data presented, some interesting linkages between different aspects can be found which are stated here. Also we can compare the performance of operation and maintenance systems of the rural water supply schemes in Bhutan with findings in the literature.

5.1 SAMPLE SIZE

For the research, two districts in the western part of Bhutan were selected. Bhutan as a whole consists of mainly three ethnic groups i.e the Ngalops in the west, the Sharchops in the east and the Nepalis in the south. The living style is quite different and the use of water also differs. The surveyed village consists of Ngalops only. So, the present sample size may not be a true representation of the whole country. Therefore, this study can be representative of the two western districts.

5.2 STRENGTH OF DISTRICT STAFF

In the two districts visited, the staff appointed by PHE for the rural water supply sector is as shown in the following table:

District	District Engineer (DE)	Junior Engineer (JE)	Section Officer (SO)	Work Assistant (WA)	Plumber	Mason
Paro	1	1	2	-	5	5
Thimphu	1	-	4	1	3	3

In general, most of the other districts have almost the same pattern of staff except for a few districts which have been operating with very basic levels of staffing - there are examples of district with only 1 district engineer, 1 section officer, 1 plumber and 1 mason. The staff unit in the two districts exceeds the theoretical unit of 1 DE, 1SO,

2WA, 3 masons and 2 plumbers.

The above mentioned staff are appointed for the rural water supply sector, but they are involved in a wide range of responsibilities in the district like housing, roads, irrigation etc. It can be concluded that with the sharing of different activities by the district staff, they cannot devote their full time in the construction of water supply schemes which will eventually affect the O&M of the schemes.

Improper supervision during construction may lead to the poor quality of the scheme and even with a good maintenance system, the scheme may not function well. Also the with the wide range of activities to look after by the PHE district staff/shortage of staff at the district will hamper the training activities for the caretakers and VMC members which will directly affect the O&M of the schemes.

Therefore, it is felt that even the above mentioned strength staff in the 2 districts (though it exceeds the theoretical unit) will not be sufficient in the districts since they have to perform a variety of works.

5.2.1 Caretaker and VMC training

Out of the 1800 rural water supply schemes in Bhutan, 1171 schemes have trained caretaker/s and 664 schemes have trained VMCs. Still 35% of the schemes need a trained caretaker and 63% schemes need a trained VMC for the sustainability of the schemes.

5.3 THE VMC

In the six villages surveyed, five schemes have some sort of Village Maintenance Committee formed.

5.3.1 Formation and composition

The policy stipulates that a health worker should be present in the VMC formation

meeting. However, these are the procedures stated in the documents only, in reality a health worker is not always present during the formation of a VMC. Also village health workers are not selected as members of the VMC. In the six schemes, none of the VMC members is a village health worker.

The size of the committees as indicated on page 46 do not meet the criteria set by the department's policy. As per the policy, the committee should have a minimum of 6 members, whereas the size of the Village Maintenance Committees of the six schemes varied from one member to six members. Therefore, the requirements on composition are not met. In Gepti scheme there is only one member in the VMC. The VMC does not work because he did not get any cooperation from the users. Being the only member, he might not be recognised by the users. A similar situation occurred in a village in Cameroon where one person dominated or monopolised the maintenance set-up and the users did not like it. Their decision to set up a new maintenance committee made him angry and that very night the motors of the pumps were stolen which led to complications in the supply and there no water in the village for 3 months.

It can be concluded that the composition also affects the proper functioning of the VMC.

5.3.2 Training/ Revenue collection/ Record Keeping

Even the trained committees except Lunten and Jushina VMCs are not doing any work. They are well aware about their roles but do not know how to put it into practise. Only the VMCs of Lunten and Jushina collect money whenever required for buying spare parts and to pay the caretakers. None of the committees keep any record of the activities that have been carried out for the maintenance of the schemes.

The review of literature stated that the reason for poor performance of many water supplies is that the need for technical training is usually recognised, but the need for training in management skills is often overlooked. This can be a problem for the performance of the rural water supplies in Bhutan too because the VMC and caretaker training include all technical aspects of maintenance but management skills such as bookkeeping, water quality control, reporting, communication and administration is

neglected.

One of the problems of maintenance systems is inadequate revenue collection as stated in the literature. This is also a problem found in the six schemes visited.

5.3.3 Performance of the VMCs

The committee members were able to state their responsibilities when they were asked but majority of them like the committees of Gepti, Shinkana and Isuna schemes do not put it into practice. All of them could explain their roles as coordinator between the caretakers, villagers and district staff. Even the untrained members could explain their responsibilities because they had been briefed by the village headman at the time of selection. Sometimes they became a little bit confused about their role with caretaker's role, for example some of the members stated that their role was to control the flow in the taps which is actually the job of the caretaker.

Two schemes i.e Lunten and Jushina out of the five schemes with VMCs are somehow active. They collect money to pay the caretakers and collect money whenever required to buy spare parts. The caretaker of Lunten scheme takes all the committee members with him whenever he goes for any repair work. He said that they are also trained, so they should work with him.

As found out during the survey, these two committees do not hold regular meetings or make any decisions. There is no fixed system of collecting money for maintenance fund, money is collected whenever a spare part is required. The committees are also not aware of keeping a record for maintenance activities.

The non functioning of the VMCs have some specific reasons as well. The VMC of Isuna scheme was not functioning because the village headman found it unnecessary. Another reason is for not getting any incentives unlike the caretaker. The VMC of Shinkana scheme do not work because they do not get any incentives.

It is stated in the results that functioning VMC should assist the caretaker in the O&M of a scheme by keeping maintenance funds, buying spare parts, solving conflicts,

making decisions etc. By taking these criteria into consideration, it can be concluded that none of the VMCs are functioning properly except for two VMCs which have some activities.

5.4 THE CARETAKER

The various issues concerning the caretaker is discussed as follows:

5.4.1 Appointment and composition

The policy is to have two caretakers, one male and one female, for each scheme which should be trained. Even in the literature it is stated that it may be advisable to train more than one operator so that prolonged absence does not lead to complications (Ketcham, 1970; Matango and Mayerle, 1971). Kreysler (1970) also pointed at the importance of preventing any monopoly. The criteria of appointing two caretakers was not found to be applied in the research villages. Only two schemes have two trained caretakers and the other four schemes have only one caretaker.

Also the policy states that the caretakers should be selected during the construction phase. Practically this does not always happen. The caretakers of all the six schemes were selected after the construction of the schemes.

The presence of only one caretaker instead of two in some villages visited is due to the unwillingness of the villagers to volunteer. Two caretakers for one scheme is found more convenient because, when one of them is engaged in his/her work, the other one can look after the scheme. Also the schemes with two caretakers are found to be in better condition than the schemes with one caretaker as it can be seen in table 5.1.

The reasons for the frequent resigning of the caretakers of Gepti scheme is due to non payment of the previous caretakers by the users and the caretakers were not selected in a voluntary way.

5.4.2 Training and tool box

All the caretakers appointed for the schemes are trained for a duration of 5 days and one caretaker got a refresher training of 3 days. But still, 3 out of 8 trained caretakers faced problems with detecting blockages in pipelines. This may be due to the variety of technical subjects taught in a short duration of time or due to the refresher course not given to them. The caretaker of Gepti faces problems because of being untrained and also due to incomplete tool box.

5.4.3 Remuneration

The nature and amount of remuneration for the caretakers is decided by the beneficiaries but not all caretakers are compensated for their work. Where there is some form of compensation, the mode and amount of remuneration (kind/cash, exemption from free labour contribution) varies from scheme to scheme and district to district.

In Isuna scheme both the caretakers are exempted from shaptolemi and both are working alternatively. The caretaker of Shinkana is also exempted from shaptolemi. Whereas in Jushina scheme only the male caretaker is paid and the female gets nothing. The female works very rarely only during her counterpart's absence because she is not being paid. The users of Bara scheme are not happy with the caretaker and he is not paid.

Those caretakers who are paid, especially the caretakers of Lunten and Jushina schemes are working well. This was also observed in the field with the schemes being well maintained as it is clear in table 5.1.

From the results of the survey, it can be concluded that remuneration of the caretakers plays a vital role in their performance.

5.4.4 Performance

From the table on page 53, it can be seen that the caretakers do not work regularly. The caretaker of Bara scheme seems to be not interested in his work. This can be due to the

lack of salary for the caretaker, lack of interest or due to the absence of a VMC. All these factors have resulted in the non availability of water in some taps of the scheme.

The payment and composition of caretaker, the presence of VMC, the presence of tool box, training etc. which in a way or the other affects the performance of the caretakers and the relation between all these aspects can be seen from the table below.

Table 5.1

Scheme name	Condition of scheme	Condition of maintenance	No. of CT	VMC active	Users pay O&M cost?	Users pay caretaker
Bara	Bad	Bad	1	No	No	No
Isuna	Good	Good	2	No	No	No
Shikana	Fair	Fair	1	No	No	No
Gepti	Fair	Fair	1	No	No	Yes
Lunten	Good	Good	1	Yes	Yes	Yes
Jushina	Good	Good	2	Yes	Yes	Yes

CT- Caretaker

The above table shows that in two schemes Lunten and Jushina where there is an active VMC, the payment for the caretaker is prevailing and the schemes are also running in a good condition. During survey it was observed that the schemes are maintained well which shows the activeness of the caretakers.

Isuna scheme is well maintained and in good condition. Shinkana scheme is maintained well and in fairly good condition. These schemes are performing good even though the VMC is not functioning and the users do not pay for O&M costs. Not a single spare part has been bought till the time of survey. The good condition of the schemes is due to the preventive maintenance carried out by the caretakers. The caretakers are exempted only from "shaptolemi". But in the long run the non payment of O&M costs may affect the sustainability of the schemes. Both the schemes have village maintenance committees but they are not active.

The maintenance of Gepti scheme was not very good and the condition of the scheme is also fair. The caretaker is being paid because previous to him three caretakers had resigned, one of the reasons being not getting any incentives, so the community decided to pay the present one to get a longer service from him. Perhaps the condition of the scheme is fair because they had so many problems with the earlier caretakers.

In the badly maintained scheme like Bara scheme, the users do not pay for the caretaker and the caretaker does not do any maintenance work. The caretaker is exempted from shaptolemi. The caretaker had been selected by the community but not in a voluntary way, no other person was willing to be a caretaker. Users have cut the mainline at many places, this shows a lack of unity among the villagers and the lack of a village maintenance committee.

5.5 QUALITY OF THE SCHEMES

In general, the researcher feels that the six schemes visited are in good condition. This can be discussed in separate topics for the individual schemes as follows:

5.5.1 Quality of construction

The four schemes Isuna, Shinkana, Lunten and Jushina built in 1990-91 are in better condition than those built prior to that. The intakes and reservoirs of the earlier schemes i.e Bara and Gepti, built out of stone masonry were found to be leaking (which is a very common problem in stone masonry tanks) and without proper cover. The reservoir and BPTs built of ferrocement of the later schemes are in better condition. These tanks were built with the help of the district staff. This can be due to improved technology used, better quality of construction and better maintenance systems.

The exposed and leaking pipeline was mainly due to the cutting of pipes by some people and making illegal connections. In the case of Bara scheme, some users have cut the main pipeline to get water because there was no water coming from the tapstand. Some users get a direct connection from the tapstand instead of walking to the tap and fetching water. Some houses are located at a higher level than the tapstand. Therefore, to get a direct connection to the house, these people cut the part of the mainline which

is at a higher level than the house. Whenever they want water they pull out the main pipeline and plug it into their private pipeline. These portions of the pipeline are kept exposed and due to the temporary joining leakage occurs. This scheme does not have a VMC.

In two schemes, Bara and Gepti, villagers complained that the people living nearer to the intake (new households) that do not have a tapstand cut the main line to make direct connections from the mainline to their house. As a result, the people living at the end of the scheme do not get water. In one scheme, Isuna there was one private connection which did not affect the flow of the other taps because the connection was through the overflow of the break pressure tank.

5.5.2 Water consumption and quantity supplied

The graph on water consumption on page shows that most of the people use 30 to 40 litres per day which is well below the design flow i.e. 45 lpcd.

The table on sufficiency on page 56, shows that all the six schemes supply sufficient water except for Gepti scheme. Some users of two schemes, Bara and Gepti, were complaining about not getting sufficient water most of the time. It is quite interesting for Bara scheme because as calculated and shown in the table, the flow is 3 times more than the demand. On the other hand, the people living at the end of the scheme are complaining and in fact they are collecting water from other sources. Since a lot of exposed and cut pipes were observed, the water must be leaking along the pipeline. This also reflects that the caretaker does not do any work and the users have indeed complained about the caretaker.

The complaints of the users of Gepti scheme about the insufficient amount of water is quite understandable from the table, as the flow at the source is less than the demand. The flow at the source had decreased compared to the flow measured during construction of the scheme. Due to this problem, 19 tapstands of this scheme had been connected to another source. The cause of the decrease may be due to the improper location of the spring or due to the seasonal spring.

5.5.3 Reliability

The water for four schemes is quite reliable over the day and over the year but Bara and Gepti schemes are unreliable in the harvesting season i.e May - June when the water from the source is diverted to the fields.

5.5.4 Water quality

The water of the six schemes do not have problems regarding taste and smell but the turbidity during rainy season can pose a problem. This may be due to a technical fault in the capping of the springs. It is observed that the problem of frogs getting into the pipeline is due to uncovered intakes without strainers, uncovered reservoir tanks and gaps between the roof of the tank. If these problems are occurring regularly, it can impose a risk of contaminating the water.

If the springs are capped at the right place, the water is probably free of faecal contamination. In the research area, the springs are capped at a place further away from the source which causes a risk of contamination which was also stated in the literature that insufficient spring box causes maintenance problems. The muddy water the users get in the rainy season may be due to this problem. The prevalence of cattle grazing, deforestation and gardening around the source may cause contamination. The flow at the source may reduce due to deforestation. The invasion by wild boars can be also a risk of contamination to the water. Since the water sources are located far away from the village, there are no human settlements in the catchment area and therefore, the risk of contamination by humans is not present.

Improper storage and handling of water can be a source of contamination. In 10% of the households the water is found to be kept uncovered, which implies a risk of contamination by flies, people sneezing nearby or mishandling by children. Some of the containers can be reached by children. Furthermore, all users handle the water with ladle or jugs which are kept on the containers or on the wall. Flies and dust are very common in the rural houses.

The protection of catchment areas and the preservation of water quantity and quality are

increasing problems and as such are recognised by the community. But activities in this respect are limited only to source protection by providing fencing around the source.

5.5.5 Use of Alternative sources

The users of all the six schemes accept the water system provided to them and they do not use any other water source except when there is no water in the tapstands.

5.6 OWNERSHIP

Ownership of the schemes is an important factor for the proper operation and maintenance of the schemes by the community in the long run. The ownership felt by the users and the maintenance committees is discussed below:

5.6.1 Ownership of users

It is felt that involving the community right from the planning stage, construction to the operation and maintenance improves the sustainability of water supply schemes. In Bhutan, some sort of community participation prevails. The community requests for a water supply scheme, they are involved in the selection of the source and tapstand location, they provide labour during construction, and finally the scheme is handed over to the village after construction.

Though the community is involved to some extent in water supply schemes, more than half (65%) of those interviewed of the six schemes still feel that the water schemes are government property. This may be the reason for the cutting of pipes and making illegal connections as explained in the results.

5.6.2 Ownership of VMC

On the other hand, contrary to the users view on the ownership of the schemes, about 71% of the Village Maintenance Committee members feel that they own the scheme. This may be an effect of the training given to the committees, because in the VMC

training, the members are briefed about the ownership and responsibility of the schemes.

The majority of VMC members of Isuna and Shinkana schemes feel that they own the schemes, but very interestingly, on the other hand they are not active. This is due the lack of incentives to the VMCs as stated by themselves.

5.7 General conclusion

The six schemes visited are in good condition but there are some problems with the maintenance systems and some caretakers. In general the caretakers are working quite well but still their efficiency can be improved. The composition and way of selection of caretakers, types of incentives, training and presence of a maintenance committee plays a vital role in the performance of the caretakers.

None of the VMCs are functioning properly. Two VMCs are somewhat active by collecting money for spare parts whenever required and also paying the caretakers. But they do not have a proper way of collection of money, they rarely hold meetings and they are not aware of book keeping as was prevailing in a rural scheme in Nepal which is explained in the literature study.

O&M cannot be achieved overnight, there are many forces and people involved with a range of agendas. However by remaining firm on principles and through participation of all, a real chance exists for O&M to be secured.

6.0 RECOMMENDATIONS

By conducting the survey in the six villages and analysing the findings, the performance of the water caretaker and the village maintenance committee, the policy procedures and functioning of the schemes with the help of the maintenance systems are discussed and concluded in chapter five. With the help of the review of literature, various aspects found lacking in O&M of rural schemes which are felt to be useful in improving the present system of maintenance are stated here:

i Since the present sample size is quite small, it is recommended to carry a similar type of study on a wider area i.e covering all the districts so that it can be representative of the whole country

ii After handing over the schemes to the community, the operation and maintenance is their responsibility but there should be some guidance and monitoring by the district staff or PHE. This is to facilitate the community in managing their own schemes

iii The district staff appointed for water supply should be responsible for water supply construction and training only rather than being involved in a variety of works

iv At the moment, the O&M Policy is only at PWD level, it needs to be recognised at the ministerial level. The policy should give some guidance on remuneration of the caretakers too

v In general not every scheme has a VMC and a caretaker, therefore PHE and district should put more emphasis on the training of VMCs and caretakers

vi In the Policy there should be some clear instructions to distinguish between the water source for irrigation and for drinking purpose and also on illegal connections

vii The VMCs are not yet fully operational and some of their roles and

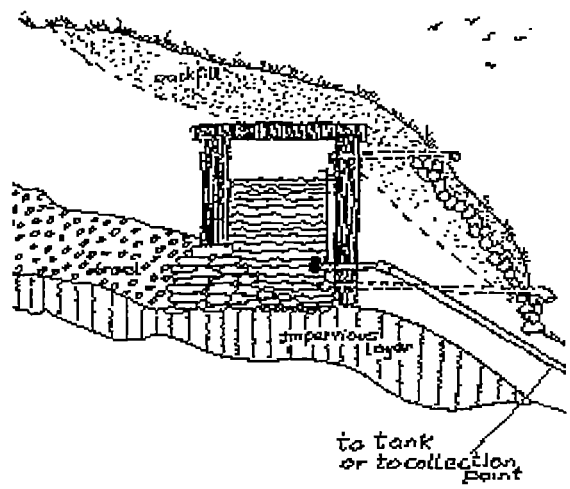
responsibilities need to be more clearly defined and also more support is required

viii Training of the VMCs and caretakers should not be purely of technical nature but it should include management skills as well, such as revenue collection, record keeping, water source protection and monitoring through sanitary survey etc. The duration of training needs to be increased

ix There should be regular coordination between the Health Ministry and the PHE to monitor the quality of the rural water supply schemes. To lessen the risk of contamination of water during transportation, storage and handling in the house, hygiene education must be given to the users

x The spring sources should be capped at the point of origin to avoid contamination

An example is given here:
The main parts of a spring captation are a drain under the lowest natural water level, a protective structure providing stability and a seal to prevent surface water from leaking in. The drain usually is placed in a gravel pack covered with sand and may lead to a conduit or a reservoir. The protective structure may be made of puddled clay and sometimes plastic. A screened overflow pipe guarantees that the water can flow freely out of the spring at all times. To prevent contamination from infiltrating from the surface, a ditch, known as the interceptor drain, diverts surface water away from the spring box and a fence keeps animals out of the spring area. (IRC/WHO, 1997)



xi Provision of sedimentation tanks may be advisable to reduce the turbidity in the monsoon season..

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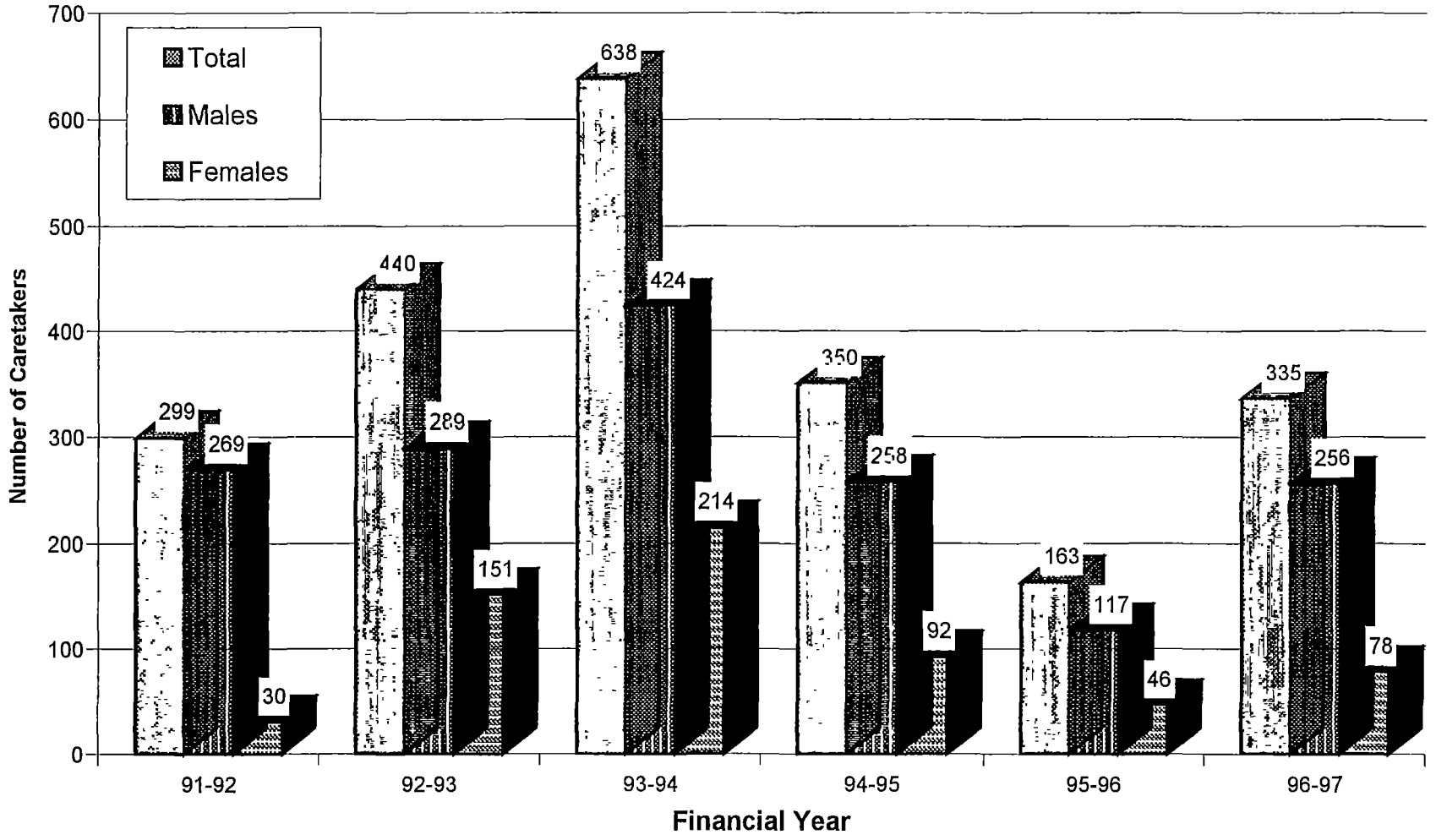
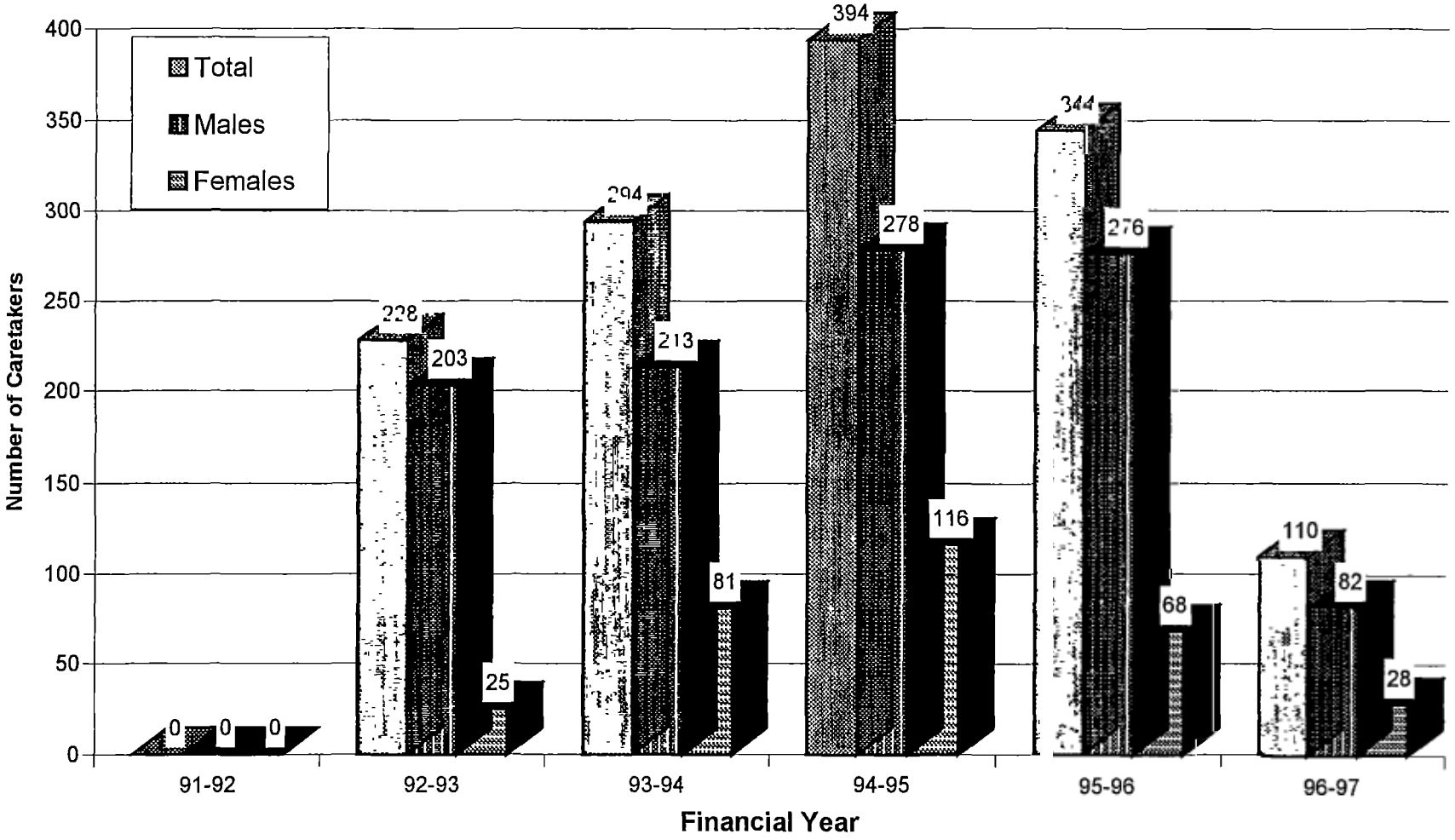
Number of caretakers trained



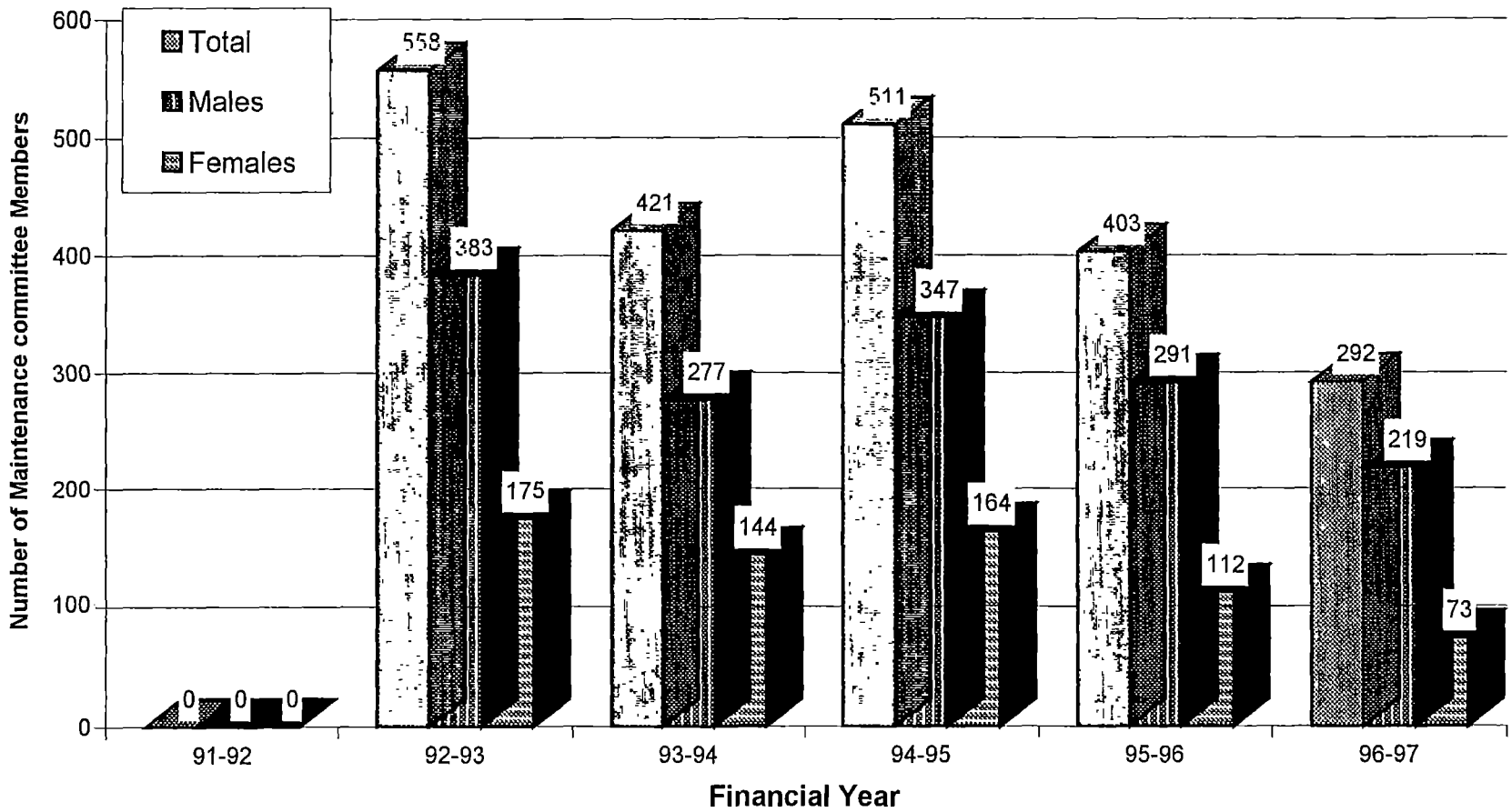
(source: Training Coordinator, PHE, 1997)

Number of caretakers trained in a Refresher Course



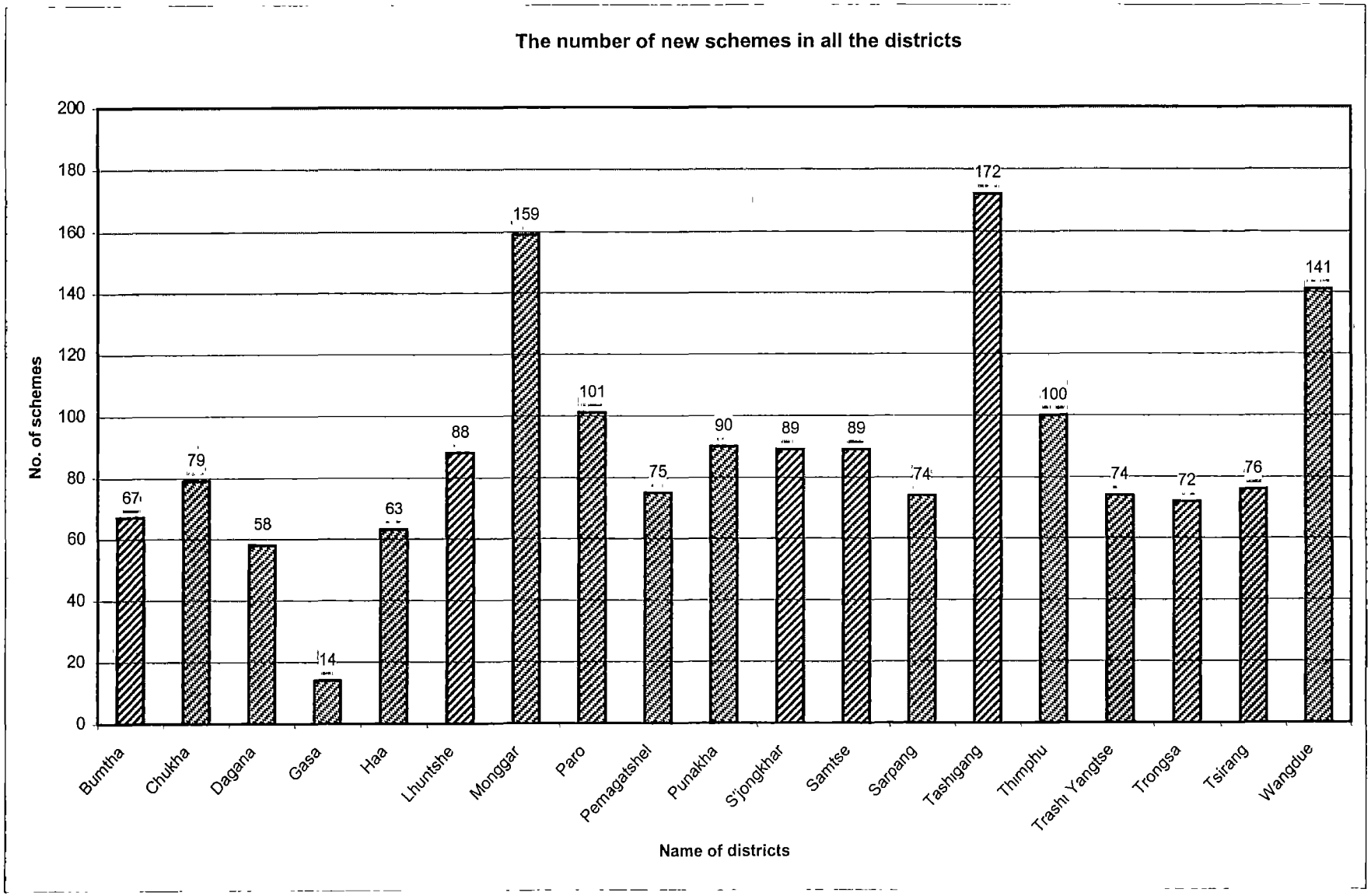
(Source Training Coordinator, PHE, 1997)

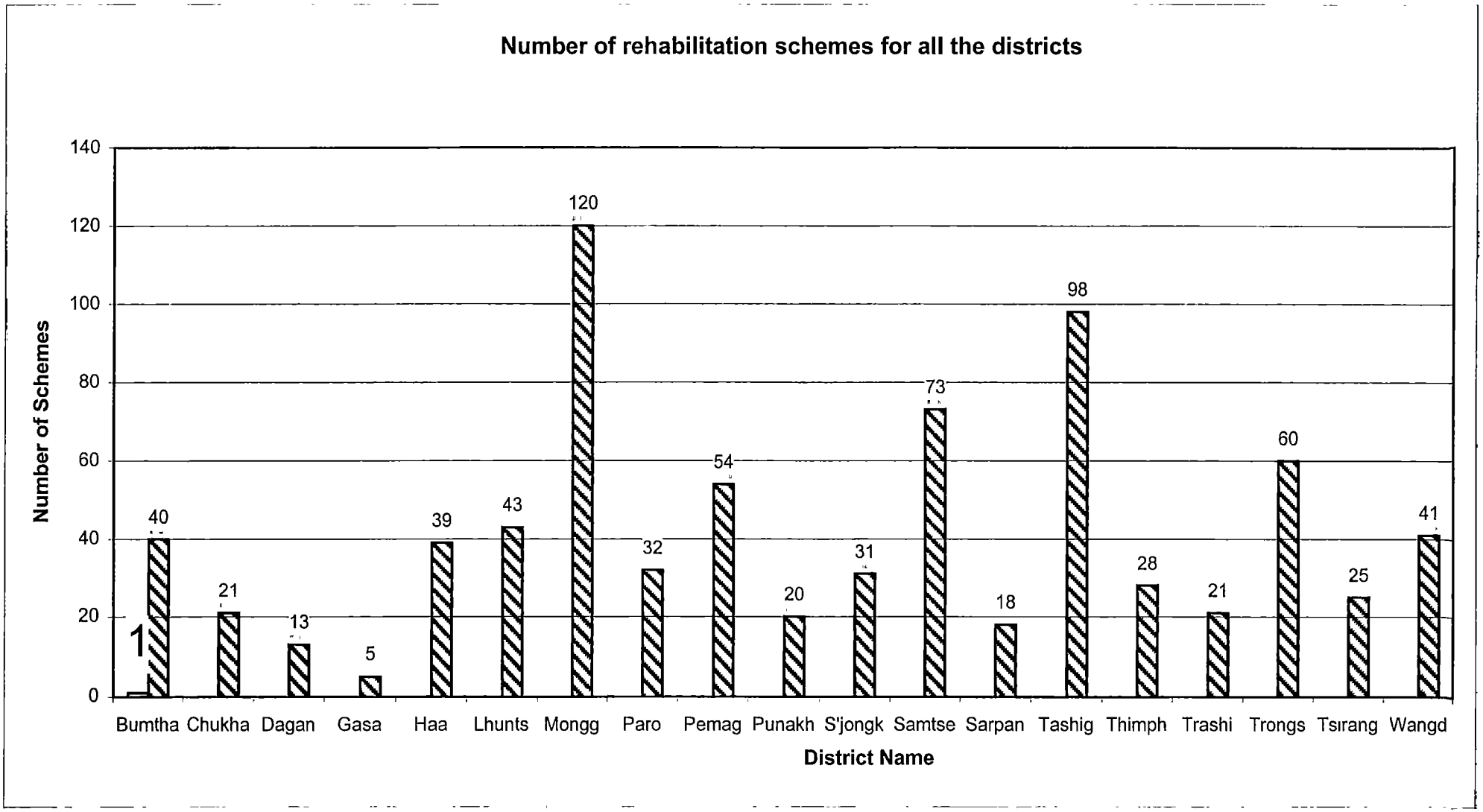
Number of Maintenance Committee Members trained



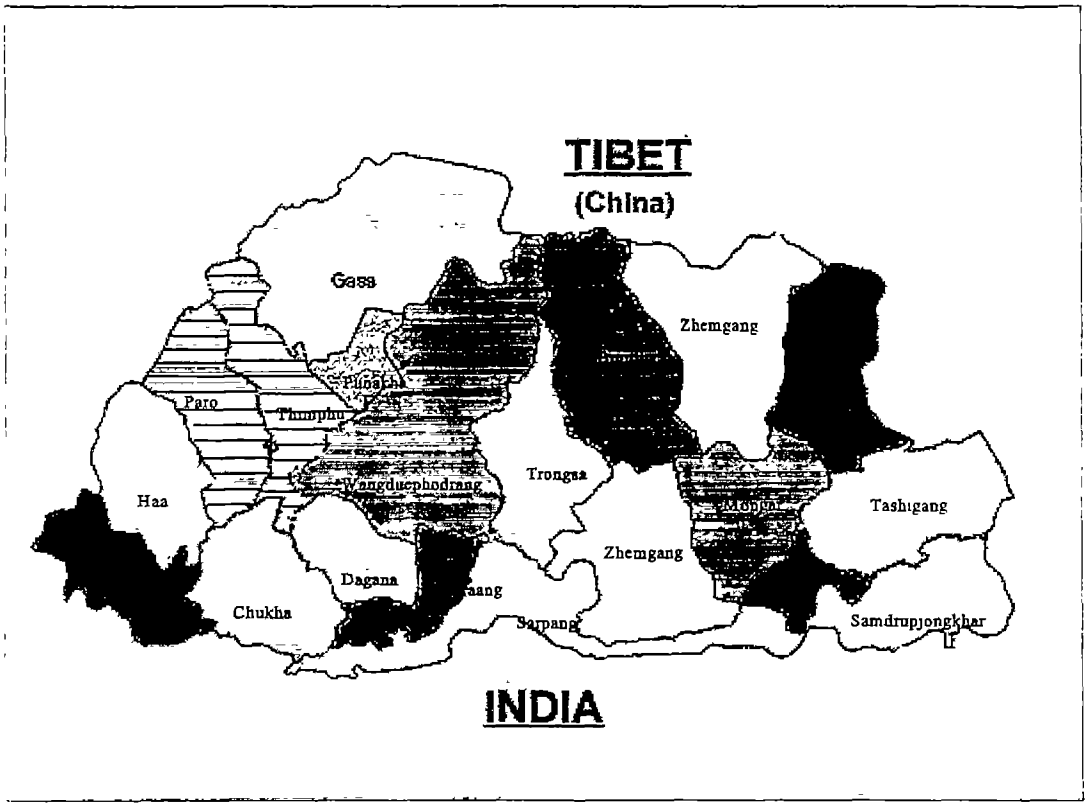
(Source: Training Coordinator, PHE, 1997)

Annex 1.4


The number of new schemes in all the districts
No. of schemes
200
180
160
140
120
100
80
60
40
20
0
67
79
58
14
63
88
159
101
75
90
89
89
74
172
100
74
72
76
141
Bumtha
Chukha
Dagana
Gasa
Haa
Lhuntshe
Monggar
Paro
Pemagatshel
Punakha
S'jongkhar
Samtse
Sarpang
Tashigang
Thimphu
Trashi Yangtse
Trongsa
Tsirang
Wangdue
Name of districts


Number of rehabilitation schemes for all the districts
Number of Schemes
140
120
100
80
60
40
20
0
1
40
21
13
5
39
43
120
32
54
20
31
73
18
98
28
21
60
25
41
Bumtha
Chukha
Dagan
Gasa
Haa
Lhunts
Mongg
Paro
Pemag
Punakh
S'jongk
Samtse
Sarpan
Tashig
Thimph
Trashi
Trongs
Tsirang
Wangd
District Name

Annex 3.1



Map showing the 20 districts of Bhutan

The shaded portion are the two research districts

Questionaries to the villagers **Annex 3.2**

1. Do you take water from the water supply scheme?

   If yes, how much water are you collecting from the tap per day?

2. Do you collect the same quantity every day?

3. Do you have to wait for sometimes (summer/winter)?

4. Is the quality of water good?

5. Do you like the taste?

6. Is the water clear throughout the year? If not, when is it turbid?

7. Does the water have other problems like smell or colour? If yes, which and when?

8. Do you receive sufficient water?

9. Is the water continuous over the day and year?

   If not, when is the shortage time?

10. Has the volume been decreasing over the years?

11. Has the quality changed over the years?

    If yes, in what way?

12. Do you know who maintains the scheme?

13. Do you pay O&M costs and how much?

14. Do you use other alternative sources?

15. Did you participate in the construction of the scheme?

16. Do you feel that you own the scheme?

17. Is your water caretaker doing his job regularly?

18. Do you know the area above the water source?

19. What activities take place in that area?

20. What changes have occurred in this area over the last 5 to 10 years?

21. Are there other better water sources available?

22. How is the water stored in the house? Is it covered?

23. How do you handle the water in the house?

Annex 3.3

Questionaries to caretaker

1. How were you selected for this job?
2. How long are you maintaining the scheme?
3. Have you undergone training regarding O&M of the scheme?
4. If yes, duration of training ....., frequency.....
5. With the training, do you face difficulties in O&M?
6. Do you get cooperation from VMC and the users?
7. Are you paid for your work?

   If yes, how much.....
8. How frequently do you maintain the scheme?
9. Are there any illegal connections in the scheme?

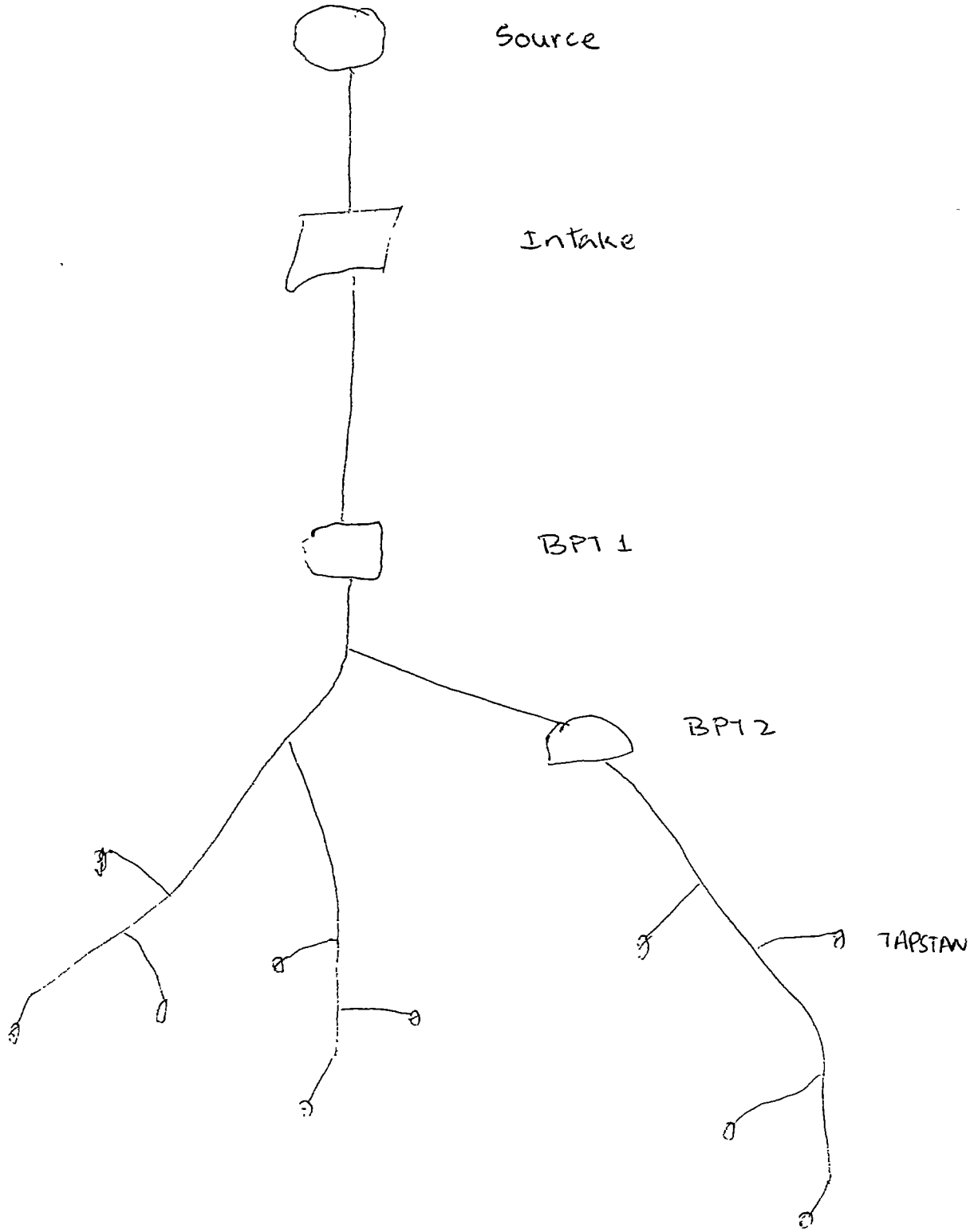
   If yes, do the people ask you to make the connections?
10. Are you capable of making a new connection?
11. Do you perform different tasks ? (female)
12. DO you face any problems being a caretaker? (female)

Annex 3.4

Questionaries to the village maintenance committee

1. How is the committee formed?
2. How many members in the committee? (men....., women.....)
3. What are the objectives of the VMC?
4. What are your duties for O&M?
5. How are the financial arrangements made?
6. How do you purchase spare parts and other materials?
7. How much money is spent on maintenance per month?
8. Do you keep records?
9. How many meetings held per month?
10. What are your contacts with caretaker?
11. What types of decisions do you make?
12. Any problems with users ?
13. Being on VMC, do you feel influential? (female)

Annex 35



Map of Lurlen scheme drawn by the caretake

Annex 3.6

Checklist for the information to be included in mapping of catchment area

* The location of the intake for the drinking water supply system and its catchment area
* All surface waters (standing and flowing)
* Types of soil
* Types of vegetation and vegetation cover
* All land uses upstream of the intake of the scheme draining into catchment area
* All water uses upstream of the intake of the scheme draining into catchment area
* All human settlements with sanitary facilities and those without
* Existing water supply infrastructure both for drinking water and irrigation

Annex 3.7

Sanitary risks of catchment area

1. Are there houses in catchment upstream of the intake?
   If yes, how many:.....
2. Is open field used for defecation?
3. Are there any latrines upstream (above) the source?
4. Are there cattle upstream of the intake? (> 5 refers to cattle)
5. Is there visible erosion?
6. Is there deforestation?

Annex 3.8

Sanitary survey form for quality of the system

1. Is there any point of pipe leakage between the source and the reservoir/BPT?
2. Is the cover o reservoirs or BPT tanks insanitary?
3. Are there any cracks in the intake structure?
4. Is the reservoir/BPT cracked?
5. Is the reservoir dirty?
6. Are there any visible leaks in any part of the distribution system?
7. Is the pressure low in any part of the system?
8. Is the tapstand area stagnant with water?

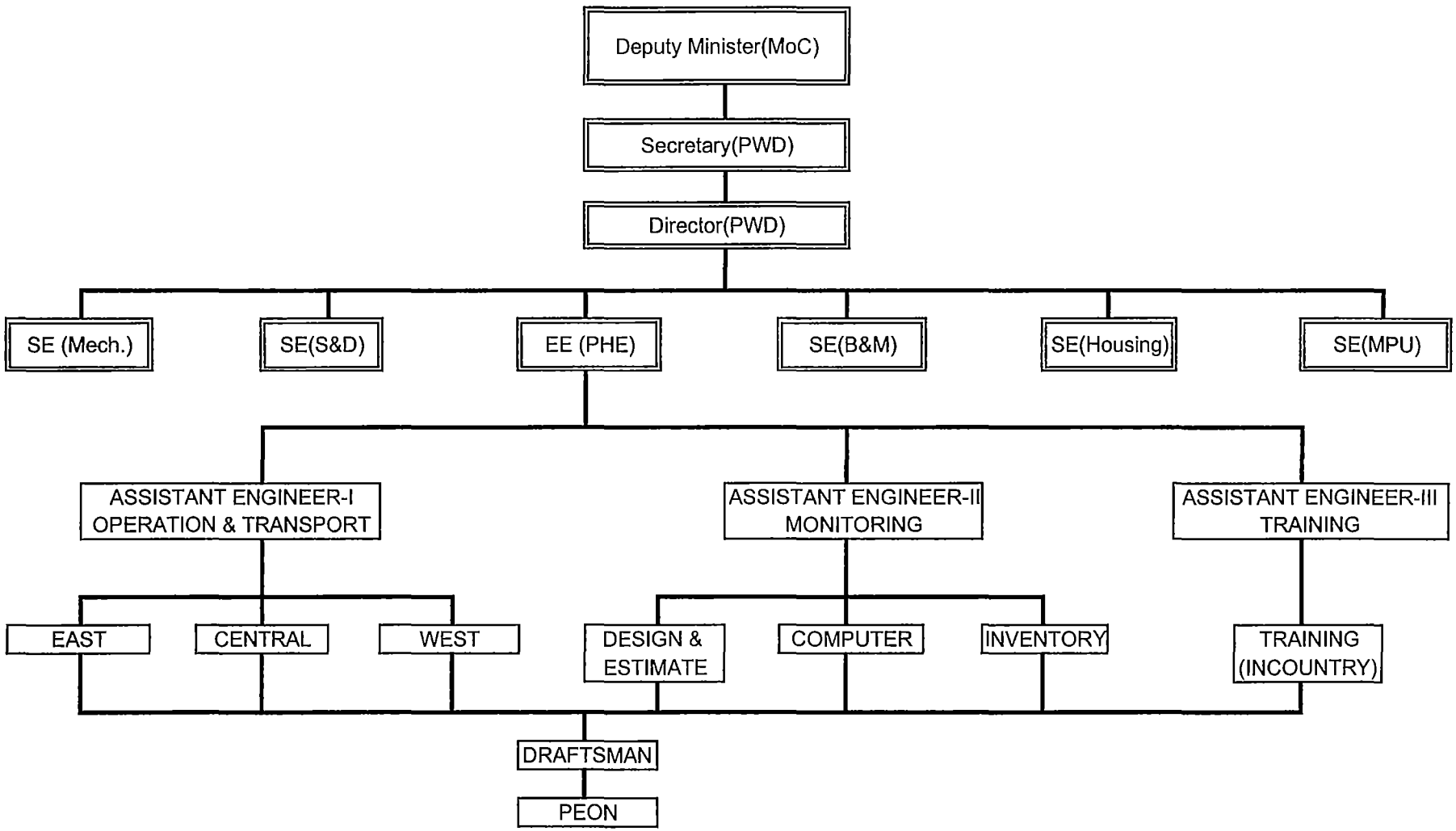
Technical inspection sheet for spring intake

1. Is the masonry protecting the spring source faulty?
2. Is there an insanitary cover over the spring protection work?
3. Is the spring lacking a surface diversion ditch above it?
4. Is there erosion of the soil in the area?

Organisation Chart

Annex 4.1

Public Health Engineering Section : (PWD)



PHE staff in the 20 districts **Annex 4.2**

Districts	District Engineer	Junior Engineer	Section Officer	Work Assistant	Plumber	Mason
Bumtha	1	-	1	2	2	3
Chukha	1	-	1	2	2	4
Dagana	1	-	1	1	2	1
Gasa	1	-	1	-	1	1
Haa	1	1	2	-	1	1
Lhuntse	1	-	2	1	2	3
Mongar	1	-	2	1	3	4
P/Gatsel	1	-	3	2	2	4
Paro	1	1	2	-	5	5
Punakha	1	1	2	2	2	4
S/Jongkhar	1	1	3	1	4	2
Samtse	1	1	2	-	1	1
Sarpang	1	-	5	-	3	1
T/Yangtse	1	-	4	-	2	3
Tashigang	1	1	4	1	4	6
Thimphu	1	-	4	1	3	3
Trongsa	1	-	3	2	4	5
Tsirang	1	-	2	-	1	-
Wangdue	1	-	3	2	4	3
Zhemgang	1	-	4	3	4	1

Data collected from the village maintenance committees **Annex 4.3**

Scheme name	Isuna	Shinkana	Gepti	Lunten	Jushina
Members	2 male, 1 female	4 male, 2 female	1 male	2 male, 2 female	1 male, 2 female
Selected by	Community	Community	Community	Community	Department & community
Objective	Coordinate with the CT to look after the functioning of the scheme	Coordinate with the district and village	Coordinate with the village and district	To help the CT, to check if there is water in the village	Coordinate with CT and villagers for the proper functioning of the scheme
Duties in O&M	To check if there is water in the tap, collection of maintenance fund	Conduct meetings, collect money, buy spareparts, report to district if scheme breaks down	Conduct meetings, collect money for spare parts	To check cutting of pipes, disturbance in the flow, broken pipellnes, collect money to buy spareparts	Collect money for maintenance, control the flow, assist plumber and buying of spareparts
Financial arrangements	Non	Money collected from those who did not participate in construction and deposited in bank to be used for O&M	The users pay directly to the CT	Collects money whenever required	Money to buy spareparts is collected whenever asked by the CT
Purchase of spareparts	Not done	Not done	Not done	From hardware shop 4 km away	From hardware shop 5km away
Money spent on maintenance	No record	No record	No record for repairs, total Nu.1525 for CT salary	Nu.420 on repairs, Nu.10,080 on CT's salary	No record for repairs, Nu.21,600 on CT's salary
Contacts with caretaker	Non	Non	Non	Good	Good
No. of meetings held/month	Non	Non	Non	Whenever there is some problem with the scheme	Twice till date
Any problems with users	Yes	No	Yes	No	No
Do you feel influential(female)	No	No		Yes	No

Interview to users **Annex 4.4a**

	Scheme name Questions	Bara		Isuna		Shinkana		Gepti		Lunten		Jushina		Yes	No
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No		
Quantity	Use of W/S scheme	14	6	8		18		33		20		14		**107**	**6**
	Average used	30	lpcd	30	lpcd	40	lpcd	40	lpcd	20	lpcd	30	lpcd	**32**	
	Same qty. everyday	20		8		18		24	9	20		10	4	**100**	**13**
	Shortage	16	4		8	5	13	33		1	19	14		**69**	**44**
	Sufficiency	16	4	8		18		7	26	20		11	3	**80**	**33**
	Continuity over the year		20	8		18			33	20		14		**60**	**53**
	Decrease in volume	18	2		8	13	5	33			20	13	1	**77**	**36**
Quality	Is quality good	20		8		18		33		20		14		**113**	
	Is the taste good	20		8		18		33		20		14		**113**	
	Clear throughout	4	16		8	2	16		33		20	2	12	**8**	**105**
	Any smell	20		8		18		33		20		14		**113**	
	Has it changed		20		8		18		33		20		14		**113**
	Good alternative source		20		8		18		33		20		14		**113**
O & M	Knows the caretaker	20		8		18		33		20		14		**113**	
	Pay for O & M costs		20		8		18	33		20		14		**67**	**46**
	CT works	3	17	8		16	2	33		20		14		**94**	**19**
	Own the scheme	7	13	3	5	6	12	10	23	7	13	6	8	**39**	**74**

Interview and observation data (users interviewed) **Annex 4.4b**

Scheme name	Bara	Isuna	Shinkana	Gepti	Lunten	Jushina
Activities in the catchment area	Deforestration, cattle grazing	None	Deforestration earlier but now it is stopped	Cattle grazing	Cattle grazing, deforestration, vegetable gardens	Cattle grazing, deforestration, forest fire once
Changes in the catchment over the last 10 years	Cattle grazing,	None	Erosion	Cattle grazing	Landslide, Cattle, deforestration, garden	Forest fire
Storage of water	No storage(4), storage(16)	Storage(all)	No storage(4), storage(14)	No storage(7), storage(26)	No storage(6), storage(14)	No storage(3), storage for about 3 days(11)
Types of containers used	Metal containers(8), jerry cans(2), buckets(6)	Metal containers(5), jerry cans(2), buckets(1)	Metal containers(7), buckets(5), jerrycans(2)	Metal drums(15), buckets(8), jerrycans(3)	Metal drums(6), buckets(6), jerrycans(2)	Metal drums(9), buckets(2)
Uncovered containers	14	8	13	24	13	9
Covered containers	2	0	1	2	1	2
Handling of water	Jugs and ladle	Ladles and jugs	Ladle and jugs	By jugs and ladle	By ladle	By ladle

Data collected from caretakers **Annex 4.5**

Scheme name	Bara	Isuna	Shinkana	Gepti	Lunten	Jushina
No. of caretakers	1 male	1 male, 1 female	1 female	1 male	1 male	1 male, 1 female
Selected by	Community	Community	Community	Community	Community	Community
No. of years of service	6	6	3	1/2	4	5
Trained	Yes	Yes	Yes	No	Yes	Yes
No. of days of training	5	5	5	-	5 & 3 (refresher course)	5
Was the training understandable	Yes	Yes(1), No(1)	No	-	Yes	Yes(1), No(1)
Any difficulties faced	No	Yes(1), No(1)	Yes	Yes	Yes	No
Cooperation from VMC		No	No	No	Yes	Yes
Cooperation from users	No	Yes	Yes	No	Yes	Yes
Are you paid	No	No	No	Yes	Yes	Yes
Exemption from voluntary labour	Yes	Yes	Yes	No	No	No
Frequency of maintenance	When asked by users	Once in 3 days during monsoon, once a month in other seasons	Once a week in monsoon, once in 3 weeks in other season	Whenever there is no water in tap in monsoon, once in 3 months in other seasons	3 times a month in monsoon, once a month in other season	Once a day in monsoon, once in 3 days in other season
Any illegal connections	Yes	No	Yes	Yes	No	No
Capable of making a new connection	Yes	Yes	Yes	Yes	Yes	Yes
Do you perform different tasks(female)		No	No			Yes
Any problems (female)		No	No			Yes

Annex 4.6

Map of catchment area drawn by caretaker of Shinkan