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EVALUATION OF FUNCTIONING OF INDIA MARK-II AND MARK-III HANDPUMPS IN THE STATE OF UTTAR PRADESH, INDIA.

Master of Science Thesis,

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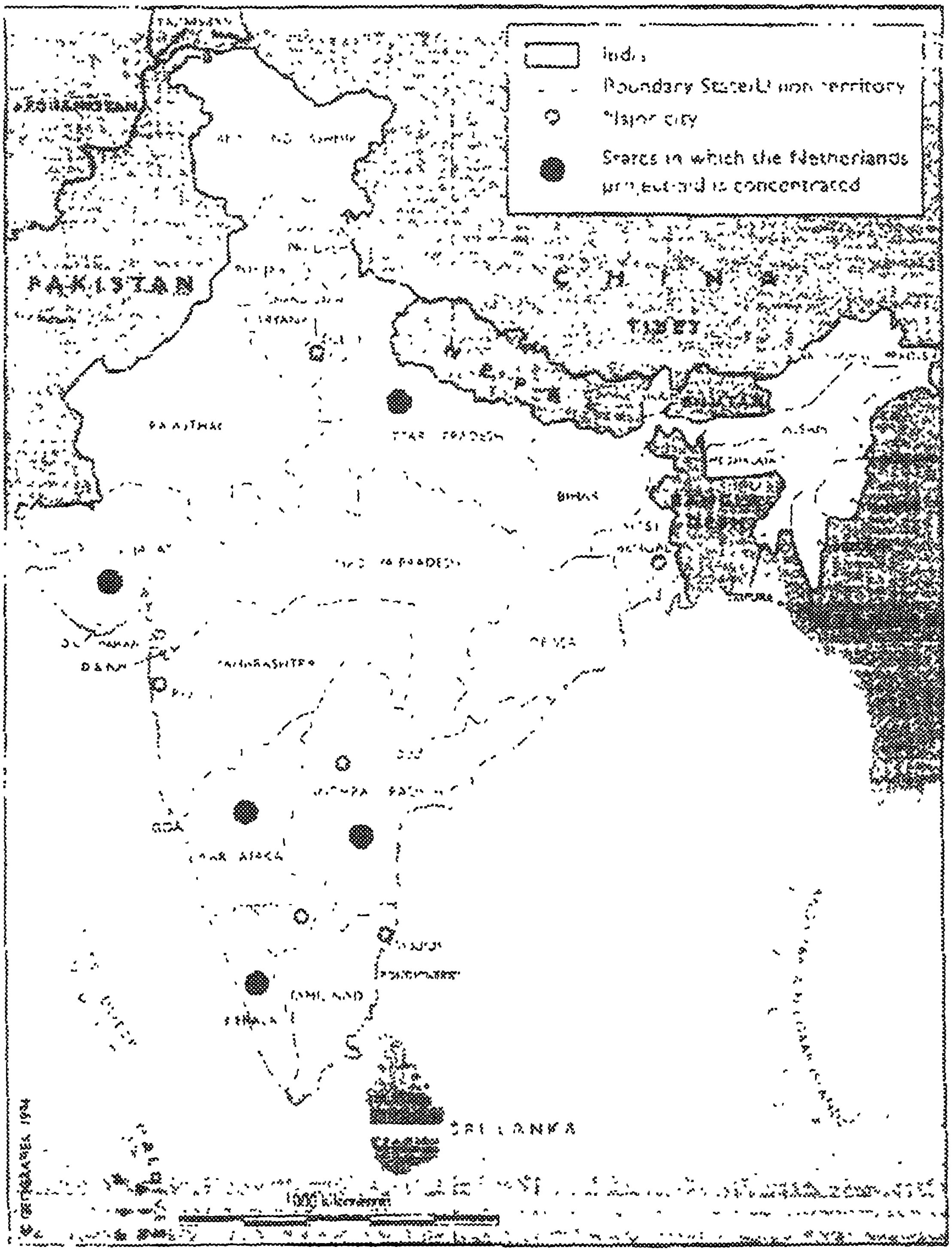
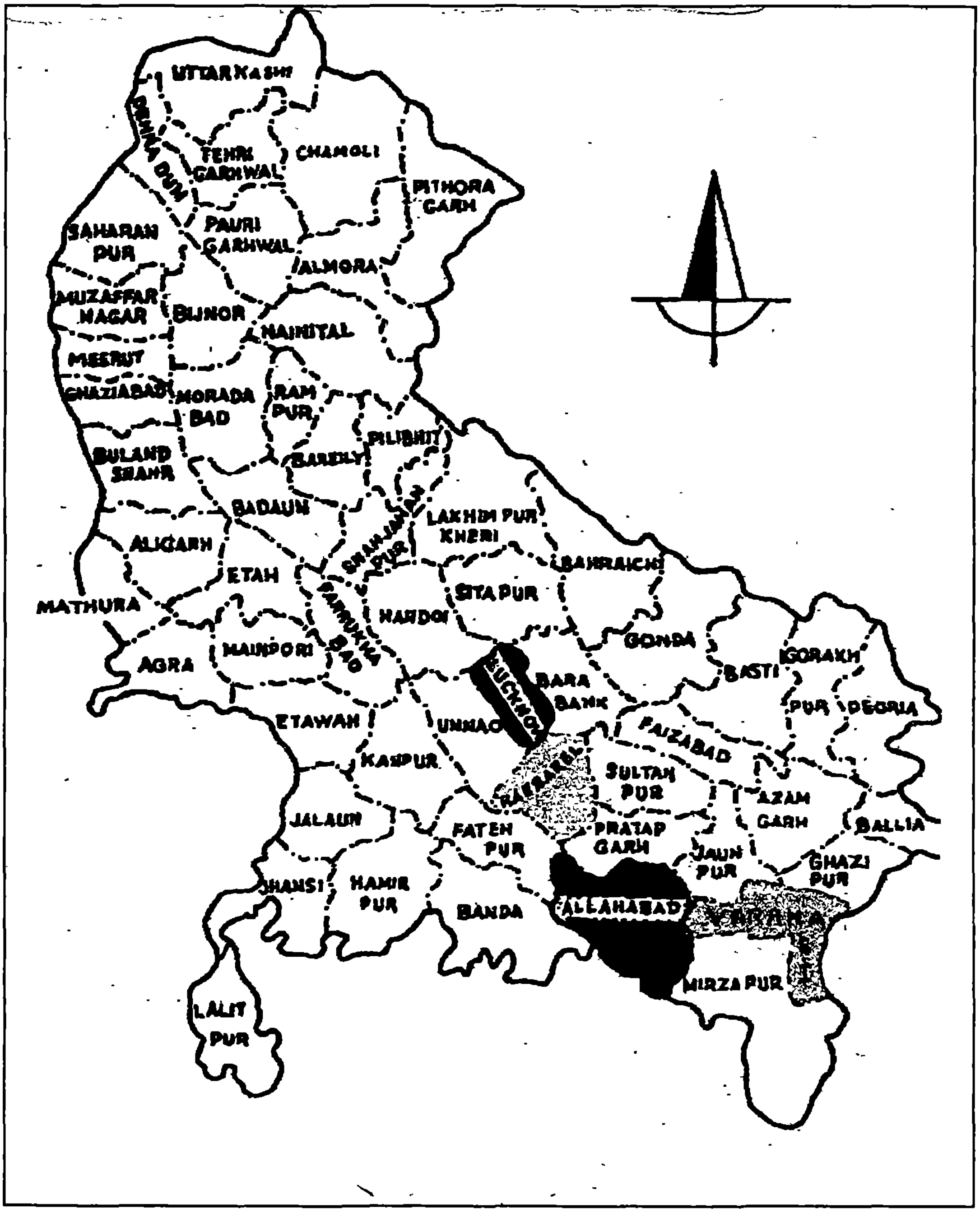
DELFT

MAP OF INDIA



- Based upon Survey of India Outline Map printed in 1987
- The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line
- The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act 1971, but has yet to be verified
- Responsibility for correctness of internal details shown on the map rests with the publisher

MAP OF UTTAR PRADESH



--Selected Districts for Study

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Chandra H.

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The Netherlands.

Summary

"Water and Sanitation for All" was the main objective of the United Nations declaration of water Decade (IDWSSD, 1981-1990). The rural population, all over the developing countries, was almost unserved before the water decade. The low-cost option found to be the only viable means for the achievement of this paramount goal of the decade. The miracle combination of borehole mounted with handpump, has proved to be a single means of water supply to the rural people, where there the ground water is readily available. In India, over 500 millions of population have been covered with India Mark-II/Mark-III handpump water supply system. In the state of Uttar Pradesh(UP), over 600,000 of handpumps have been installed and most of the villages are covered with water supply. Maintenance of such a large numbers of handpumps, offers a major problem to the agency, the UP Jal Nigam, which is also responsible for implementing the handpump project. The early effort of transferring maintenance of India Mark-II handpumps in the hands of community, the *Gram Panchayats* (elected body by villagers), found not successful. India Mark-III handpump was developed to make it maintainable at the village level with minimal skills and spare parts available locally. The simple maintainability of India mark-III handpump was anticipated to induce community participation in maintenance or the community based management of handpump programme. But the installation of India Mark-III handpumps could not pick-up gear in the state of Uttar Pradesh and India Mark-II handpumps are being installed at a large scale. Centralised maintenance system is still being continued in the state by the agency concerned. Out of best efforts, a large numbers of handpumps are found out of order at any point of time and also few thousands of pumps are permanently defunct.

This study have been conducted with the objectives of evaluation of functioning of India Mark-II and India Mark-III handpumps installed in the state and to find out solution for improvements in the functioning of handpump water supply system. The methodology adopted is the literature study, relevant to handpump water supply and field observations over the installed handpumps in past years. Literature review was done at the library of IRC, The Hague and IHE, Delft in the Netherlands and at the UPJN &PSU foundation at Lucknow in India. The field observation was conducted in two districts of state, Lucknow and Allahabad, where there, both types of handpumps were installed. In all 40 handpumps, 20 of each were inspected to evaluate functioning in the ten number of villages of different blocks of the districts. About 300 handpump users were interviewed to obtain actual situation of handpumps in the villages. The agency officials and personnel involved in handpump maintenance were approached to know the present maintenance procedure followed in the state.

The literature study reveals that India Mark-III handpums should function better and be more reliable as compared to India Mark-II. In the study area only caretakers were nominated for India Mark-III handpumps but village level maintenance system was not developed. As a result both types of handpumps were maintained under centralised maintenance system by the agency. The field observations reveal that both types of handpumps are functioning equally well in the field conditions. India Mark-III may prove more reliable only when the village level maintenance system is adopted. India Mark-II

handpump was also found maintainable at the village level in the study area. Most of the people were using handpump water barring few exceptions those who have their own source of water. Traditional sources of water are used only where there the handpumps are inaccessible, ignoring the water quality. Lack of water quality awareness and sense of ownership of handpumps was observed in the villages.

The study recommends to ensure the preventive maintenance for improving the functioning and thereby the service life of handpumps. Involvement of community for village level maintenance of India Mark-II handpumps be also started. Caretakers be trained for complete repair of handpumps and promoted with some incentives. Community also be involved in platform construction to some extent so as to develop a sense of ownership among them. India Mark-III handpumps can be installed only when community is held responsible for maintenance. Cost reduction of India Mark-III is necessary by making major design changes to compete with India Mark-II. For the future hand pump programme, the study recommends to integrate the handpump water supply with the rural sanitation programme. Individual yard handpumps be provided with sanitation facility to those well being villagers who can afford it. Further handpumps to weaker sections of villages be provided only when the community takes the full responsibility regarding maintenance of the handpumps.

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Abbreviations:

AD	-	Anno Domini
AE	-	Assistant Engineer
ARP	-	Accelerated Rural Programme
ARWSP	-	Accelerated Rural Water Supply Programme
BC	-	Before Christ
BIS	-	Bure au of Indian Standards
CE	-	Chief Engineer
CGWB	-	Central Ground Water Board, India
CWRDM	-	Central Water Resources Development
C&DS	-	Consultancy and Design Services
DTH	-	Down The Hole
EE	-	Executive Engineer
EPA	-	Environmental Protection Agency, USA.
GDP	-	Gross Domestic Product
GoI	-	Government of India
GP	-	Gram Panchayat
Govt.	-	Governments
HRD	-	Human Resource Development
IRC	-	International Reference Centre
ISS	-	Indian Standard Specifications
IDWSSD	-	International Drinking Water and Sanitation Decade
IHE	-	International Institute for Infrastructural, hydraulics and Environmental Engineering, The Netherlands.
JE	-	Junior Engineer
MNP	-	Minimum Need Programme
NGO	-	Non-Governmental Organisation
O&M	-	Operation and Maintenance
PHED	-	Public Health Engineering Department
RGNDWM	-	Rajiva Gandhi National Drinking Water Mission
Rs.	-	Indian Rupees (currency)
SE	-	Superintending Engineer
UNDP	-	United Nations Development Programme
UNICEF	-	United Nations Children's Fund
VLOM	-	Village Level Operation and Maintenance
WHO	-	World Health Organisation

1.1 Overview :-

Significance of Water:

Water, air and food are the three basic needs for the life. Safe and potable water is vital for human beings. Every person takes water in his own way, city dwellers may use tap water, rural people may take water from wells or streams or other traditional sources. Not only human being, but also all creatures depend on water in one way or other. A neat, clean and hygienic environment is equally important for the good health of people. A healthy community is essential for putting hard labour and working efficiency, adding strength to the nation. This can be achieved by providing safe and adequate quantity of water, suitable sewerage system and a proper solid waste disposal system to every person of the country (UNICEF, publications).

Availability of water:

Water is in abundance on the earth but very less (about 3%) is available as fresh water for domestic usage of human beings. It is available on land, in lakes, streams, ponds, reservoirs, rivers and most commonly under the ground. The water available from different sources may not always be safe and perennial throughout the year. Comparatively, no water is cleaner, cooler, less polluted or less contaminated than the water which exists under the ground (UNICEF, publications).

Means of supply:

There are several means of water supply to the community. The sophisticated piped water system has been the conventional method of supply since past. For the rural area, borewells with handpumps are found more viable means in the present time. It had been estimated that ground water supplies through handpumps will be an appropriate technology choice for more than half of the 1,800 millions people in rural and urban fringe areas of developing countries who need improved water supply by the end of century (World Bank- 1987). Yet there are many parts of the world where as many as half of the handpumps, which have been installed, are out of action at any particular time. If full advantage is to be taken, potential simplicity, low-cost dependability of handpump ground water and important lesson have to be taken from past successes and failures (IRC-1988, technical paper series-25).

Programmes:

The International Drinking Water Supply and Sanitation Decade (1981-1990); set out with a great aim, "water supply and sanitation for all". The underlying rationale for the declaration of the target was the worldwide improvement in overall health and quality of life and the specific reduction of water and dirt related sources of diseases that would accompany its achievements. Water and sanitation services are regarded as one of the essential components of primary health care. The decade goal was one of the targets established in 1978 by the Alma Alta International Health Conference, sponsored by WHO and UNICEF with the aim of reaching "Health for all by 2000". The most of the countries of the world included water supply and sanitation programme in their national agenda and the water-sanitation sector geared up with several national and international projects(Black M.–1990).

Technology options:
Arlosoroff(1984) mentioned the various options for rural areas. The possible technological options included dug wells, borewell/tubewell with handpumps and pumped schemes with standposts. At a cost reduction of 60 to 80 percent, handpump based water supply can provide a wider coverage and greater reliability than that can be achieved with more sophisticated systems which offer higher level of services. A handpumps installed in dug wells or bore wells in areas where ground water is readily available, provide one of the simplest and least costly methods of supplying rural population with drinking water.(Arlosoroff,et.al. –1984).

Gaurishankar Ghosh(1995) also advocates the adoption of handpumps for rural and urban fringe areas. Handpumps installed in wells, where ground water is readily available; provide the simplest, safest and least costly method of supplying drinking water to rural and urban fringe area. Because of budget limitations, it is apparent that only such a low cost option can lead to wide coverage of improved water supply
(Ghosh et.al.-1995).

O&M Aspects:
Inspite of repeated statements resulting from international meetings and general recognition's of need to improve operation and maintenance of existing and planned water supply and sanitation systems, progress in establishing viable and successful operation and maintenance programme is discouragingly slow. It is estimated that more than 50% systems are not reliable, not sustainable and inefficient as a result of poor operation and maintenance in rural and urban area.
(Proceedings of meeting, Working Group – 1991)

1.2 Problems in Rural Water Supply Sector:-

As and when the need of safe drinking water got international recognition, it was thought to be a technical matter only. The handpump option was recognised as an affordable and viable option regardless to a long-term solution, to community water needs. In 1987, the World Bank (technical paper no. 29 – 1987) mentioned serious problems with poor performance and short working life of most of the handpumps used for community water supply. The problems were lying with the handpump design, quality of manufacture some rooted in the users' attitudes and behaviour with handpumps. And the organisation of handpump installation and maintenance programmes were responsible for these problems. After review of several projects, the following causes of failure were attributed to the problems:

1- lack of infrastructure, *proper maintenance*, spare parts, trained personnel and appropriate budget.
2- pumps which were not designed for continuos use by entire community nor for *repair and maintenance* by villagers.
3- Improper design and construction of bore holes.

(World Bank –1987)

Arlosorroff mentioned six key elements, as a core of success of handpump system of water supply – the community, the handpump, the aquifer, the well, *the maintenance system,* the pump and the finance. Out of these is the arrangement of routine operation and maintenance was found the most predominant in the several schemes
(Arlosoroff et.al.-1987)

During the decade (1981-90), it was experienced that even prominent water agencies could not operate and maintain the water systems efficiently in the developing countries. The prime reason behind that was the lack of community involvement. Though the agency made best of it but some other constraints like staff and finances were limited which caused the failure of systems (IRC-1983).

The maintenance problem was first recognised by Pacy(1977). He analysed the problem on the basis of several publications on handpump maintenance. Falken Mark argues that the reliability of handpump system has left much to be desired in the past. A large percentage of failures (about 80%), due to lack of maintenance, draw the attention and need to be done in this regard.(Buitenhuis-1993). WHO recognised it as a major problem and advocates the systems to be constructed with due consideration of maintenance. Even the donor agencies were ready to finance the constructional cost of the project but no commitment for long-term support towards the maintenance cost was acceptable. (WHO-1986).

Ground water quality is also an important feature in the selection of handpump. Aggressive water may result in corrosion of below ground components like rising mains, pump rod and cylinder assembly. Hence corrosion resistant material, like stainless steel which is more expensive than non-corrosion resistant material like galvanised iron, should be used in the areas with aggressive water (IRC-1988).

The need of operation and maintenance is inevitable. Any new facility provided to the users, must fulfil its commitments throughout the design life i.e. be sustainable; otherwise the investment are gone to waste and the real benefits are lost. Operation and maintenance are the two separate activities that make the system run. Operation comprises of the day to day activities required the system to function. Whereas the maintenance involves a set of activities which ensures the system to keep fit for operation. Handpumps are considered to be a simple mechanical device to operate. Therefore the operation lies normally in the hands of users. For maintenance, there is usually a dependence on external expertise. Even it may be possible at village level also under which condition where there are sufficient spares and training.

1.3 O&M Problem in India and in the state of Uttar Pradesh:-

Wierema(1987) mentions the following general definition of maintenance, *"Maintenance comprises of those activities, meant either to keep the object* over *which an actor disposes, in condition, or bring them back in condition demanded necessary for facilitating the function as desired by the actor "* Whereas Bron(1985) has called the maintenance *" headache of the decade"* not aiming at the problems for installation of the handpumps, but in their maintenance (Buitenhuis-1993).

During the International Water Supply and Sanitation decade(1981-1990), millions of handpumps were installed all over the India. A national workshop on handpumps was organised in the year 1990 at New Delhi. As per summary of the workshop, it was reflected that India has largest water supply programme in the world. At that time, over 1.5 millions of handpumps were installed, serving an approximate population of over 2.6 millions. Several thousands of India Mark-II handpumps are serving rural communities in many parts of Africa, Latin America and Asia.

(workshop on IM-II handpump – 1990).

In India, recently a national workshop on O&M of rural water supply and sanitation was held at New Delhi in September 1996. Representatives of various states of the country participated in the workshop and a numbers of papers were presented there. Beside papers, some case studies were also presented by consultants and well known institutions or organisations. The workshop papers reflected the overall scenario of O&M throughout the country. The following problems have been summarised from the different papers compiled in workshop.

The theme paper of Sagane and Patwardhan, shows that only 89.2% handpumps were found in functioning order in the year 1994. It means that 10.8% handpumps were becoming defunct every year. Many constraints were listed out for improper functioning of rural water supplies. The cost recovery and inadequate financial provision for O&M were main reasons. A very little per capita cost was worked out which could be easily affordable by the community (theme paper by Sagane, R.M. and Patwardhan,S.S.-1996).

UNICEF, (Hyderabad) defined the present maintenance system as a purely *breakdown* maintenance; that means the repair is done only when the handpump has totally stopped the *functioning*. It was recommended that the community ownership and upkeep maintenance were important key elements for a sustainable maintenance system(UNICEF-1996).

Though the large coverage is achieved through safe water sources but still there exists the problem of water born diseases, which were said to be the single most important cause of morbidity and mortality. There are evidences of recurrent epidemic of enteric and other gastro-instentinal diseases are found all over the country. It is indicated that water quality problems are still persisting predominantly in India.

(approach paper on community based water quality survillance-1996)

Another paper also reflects the thrust on water quality issue. It is stated that even being very strong institutions, PHED's are not able to do justice in terms of water quality in many areas. That leads to crippling and lethal diseases such as fluorisis and arsenical dermoeteris.

The PSU foundation Lucknow, reported the O&M situations in the state of Uttar Pradesh. Various problems causing inefficient operation and maintenance systems, are listed out as prevailing in water supply projects, Indo-Dutch Credit programme in particular. Main problems are: insufficient fund flow, lack of proper O&M schedule, directions and plans, focus on construction, consumers appreciation and involvement, cost recovery, political interference in revenue collection etc. The foundation concludes that O&M situation can not be improved without unanimity on the strategy and certain back up support from government.

The theme paper presented on behalf of RGNDWM (GoI), highlights the success of handpump programme 'handpump has become a living symbol of resurgence in rural India'. This paper finds various systems of maintenance in vogue throughout the country and summarises the problems encountered in various states of the country. The main problems observed in the state of Uttar Pradesh in particular are enlisted below.

The main problems observed in the state of Uttar Pradesh in particular are enlisted below.

(a) The maintenance staff is far away from the users of handpumps. Accessibility to villages becomes too difficult in the rainy season, even by jeep.
(b) Many of the villages are without post offices, therefore breakdown report sending to the agency is itself a problem.
(c) Shortage of man power at all level of maintenance of handpumps.
(d) Non-availability of funds is a major problem.
(e) Lack of co-ordination between Jal Nigam and Jal Sansthans.

By this time over 2.6 millions of India Mark-II deepwell handpumps have been installed all over the country and thus a massive investment incurred in the financial terms. But all the handpumps are not found in functioning order at any time. Water supply coverage has reached to around 82% to that of about 692 millions of rural people. Now there is a question of sustainability of installed facilities to ensure long-lasting benefits of huge investments. Since more impetus was given towards creation of new sources without thinking of a sustainable O&M system. The centralised maintenance system is found in heavy pressure as a result of that only breakdown repairs can be carried out to keep the facility in *functioning* order. Under these circumstances, the 'functioning' of the handpumps becomes an important issue.

In the state of Uttar Pradesh, over 600,000 numbers of India Mark-II and India Mark-III handpumps have been installed by this year. The UP Jal Nigam, being the implementing as well as maintaining agency in the state. As per monthly repair statement of last year end, about 17% handpumps were found out of order, including around 4% permanently defunct.

1.4 Relevance of Study:-

All the villages in the state of Uttar Pradesh have safe drinking water supply system, mostly through handpumps and some via piped water supply. The maintenance, at present, is in the hands of U P Jal Nigam, which is the implementing body also. A large numbers of handpumps (above 600,000) have been installed which is largest figure in India and so in the world. Out of the best effort of the agency, the present failure level is quite higher. The main problem encountered in maintenance is acute budget allocation and lack of community involvement at any level.

Therefore in the plight of above mentioned problems, it is important to evaluate the installed India Mark-II and Mark-III handpumps. Secondly the installation of India Mark-III handpumps, out of being more reliable VLOM version of India Mark-II, is not enthusiastically accepted by the agency. This is also important to be looked-into by comparing the functioning of the both types of handpumps.

1.5 Research Objectives:-

This study is intended to evaluate the functioning of India Mark-II and Mark-III handpumps, installed by U P Jal Nigam in the state of Uttar Pradesh.

"The overall objective of the research will be to investigate why some of India Mark-II/Mark-III handpumps not function well and also some go out of order at the early stage of installation."

Following are the specific objectives of this study;

1:- To evaluate the functioning of India Mark-II and Mark-III handpumps.

2:- To evaluate the water use and water quality.

3:- To compare the performance of India mark-II and Mark-III handpumps and suggest improvements for better functioning.

Hence under above prevailing conditions, it is imperative to look into the roots of the problems. A review of present day conditions and evaluation of those handpumps which were installed some years back, may be able to suggest some improvements and solutions for future betterment. The study may help the planners, policy makers and designers to identify the root causes and viable solutions for future application.

1.6 Structure of Report:-

The report constitutes of seven chapters in all. The second chapter deals with the background information about the country and state. After that the various literatures relevant to the topic of study are reviewed in the third chapter. Chapter four is devoted to the methodology adopted in this study and the fifth chapter presents the results and findings from the analysis of field data. In he sixth chapter, the results obtained are discussed in the light of functioning of handpumps. And at the last the report ends with conclusions and some recommendations.

This chapter deals with the country and state background of this study. It provides some overview of general features of the India and also that the state of Uttar Pradesh. The progress made in the water supply sector is also presented here. First in section 2.1, the general Indian features like demography and geography, Governmental set-up and water resources are displayed and the same issues are discussed for the state section 2.2. The section 2.3 provides the phases of rural water supply development in India. And lastly, in section 2.4, the structure, activities of the water agency involved in the massive programme of water supply through handpumps, have been provided.

2.1 India :-

India, a union of states, is Sovereign Socialist Democratic Republic with parliamentary system of government. The Republic is governed by a constitution, adopted by constituent assembly. It is the largest democracy in the world; the geographical area is about 3.3 million square kilometres, measuring 3200 kms. North to South and 3000 kms. East to west. It can be located on the globe between the parallels of latitudes of 8^0 $4'$ and 37^0 $6'$ North and longitudes of 68^0 $7'$ and 97^0 $25'$ East.

2.1.1 General Features :-

India is the second largest populous country in the world. Its' population as per the 1991 census is approximately 846.3 millions people residing in about 3500 towns and around 600,000 villages. The annual population growth rate in last decade was 2.1% per year. Roughly seventy five percent people live in rural areas. The rate of population growth is more in urban areas than rural. It increased from 19% in 1965 to 27% in 1990 and most of the increase is encountered by the migration from rural to urban towns as a reflection of rapid urbanisation phase. There are twenty cities with more than one million population and six more prominent towns with population more than 4 millions. Those are; Bombay (12.6 millions), Calcutta (10.9 millions), New Delhi (8.4millions), Hyderabad (4.3 millions) and Banglore (4.10 millions).

The country constitutes of 25 states and seven Union Territories Country's 43% area is fertile and good for agriculture and 20% forest. The socio-economical conditions, language culture & religion and traditions also show a wide variation. Most of population is constituted of Hindus, Muslims, Sikhs, Buddhists and Christians. Physiologically it can be divided in seven regions: 1- Northern mountains, 2- Great plains, 3- Central high lands, 4- Peninsular plateau, 5- East coastal belt, 6- West coastal belt, 7- Islands. (Ghosh et. al. –1995). The country has varied climatic zones with considerable regional variations, including well irrigated areas in the North west, deserts in the West, Himalayas in the North, the hill tract in East the Gangatic plain, the semi-arid Deccan plateau and the tropical coastal area in the South.

Though India is a poor country, it is a major industrial power also, ranking among the top twenty in the world. The main economics is shared by agriculture 30%, industries 30% and services 40%. Agriculture has been the main occupation of most of the people since past and the production is increased considerably with advanced irrigation and fertilisers availability. The country is much advanced in the field of defence, space technology, electronics, petrochemical industries and nuclear power technology. The country has a large export potential also of various products. (Economic review- 1994).

2.1.2 Governmental Set-up :-

The constitution of India empowers the Governments; there are two levels of public administration, one at the centre of country and other at each state level. The central Government is constituted of two houses, the Parliament (*Lok Sabha, 545 seats)* and Council of States (*Rajya Sabha, 245 seats).* The parliament members are directly elected by the people of country and Council of States members are indirectly elected by the state assemblies. The constitutional head of the Government is The President of India who is elected by the members of the Parliaments and the state legislative assemblies. The party with the majority of members selects its leader in the house and normally the leader of biggest party is called for formulating the Government and then prove his clear majority at the floor of house. The leader of the party in majority is appointed as the Prime Minister and he constitutes a cabinet for disposal of the duties of Government.

The states also follow the same democratic procedure as above, but the head of state is the Governor, a nominee of President of India. The leader of legislative assembly is called as Chief Minister of the state and also assisted by a cabinet of several ministers. The Chief Minister is responsible for disposal of commitments of central Government to the people of the state. The states have created several departments to provide different services, security and justice to the people.

The Union Territories, e.g. the Andaman Nicobar, lakshdwip, Pondichery ctc. all seven numbers are ruled directly by the Central Government through an administrator, known as Lieutenant Governor, appointed by President of India on the advice of cabinet.

2.1.3 Water Resources and Utilisation: -

India is blessed by the heavy rainfall throughout the country. The total replenishable ground water resources, in the country are estimated to 45.34 m ha. Out of this 6.83 m ha is reserved for drinking, industrial and other uses leaving 38. 51 m ha for irrigation. The stage of ground water development is about 30% of the utilisable ground water. (CGWB, India). The rainfall in the country is abundant but with a large variation in the entire region due to prevailing meteorological conditions and varied geography. Average annual rainfall is found 112 cms. in the plain areas the maximum rainfall is recorded in the state of Assam to a order of 200cms. Roughly seventy five percent of rain falls in the monsoon season from July –September every year. Besides there occur rains in the winter also in some parts of the country.

Surface water and ground water are the two main sources in India. The major contribution is that of surface mainly in the rivers. The country has a good river systems of four groups; the Himalayan snow fed rivers, the Deccan rain fed rivers, the Coastal rivers and the rivers of inland drainage basin with an ephemeral character. (Ghosh et. al. – 1995)

The major ground water source in the country are the borewells. Also millions of dug wells are constructed though the country since the past to meet the domestic and irrigation demands. A study conducted by the central water commission reveals that by the end of Vth five year plan, there were 8.7 million irrigation dug wells, 0.336 millions private tube wells and 0.046 millions state tubewells in the country.

2.2 State of Uttar Pradesh :-

Uttar Pradesh, the most populous state of India is situated in the northern part of the country. It covers an area of about 294,441 square kilometres which is about 9% of the entire area of the country . Its capital town is Lucknow and the principal languages are Hindi and Urdu. Its position on the globe is between the parallels of latitudes 25^0 & 31^0 N and longitudes of 78^0 & 81^0 E.

2.2.1 Historical Background :-

The history of Uttar Pradesh is very ancient and interesting. It is recognised in later Vedic Ages as *Brahmarshi Desa or Madhya Desa.* Many great sages of the time like Bhardwaj, Yagyavalkya, Vashishtha, Vishwamitra and Valmiki appeared to have flourished in U P. Several sacred books of Aryans were also composed here. Two great epics of India, *the Ramayana and Mahabharata,* appeared to have inspired in UP. *Ramayana* features the royal family of *Koshala* and *Mahabharata* centres around the royal family at *Hastinapur*, both located in Uttar Pradesh.

In the sixth century BC, Uttar Pradesh was associated with two new religions, *Buddhism and Jainism.* Mahavira, the founder of Jainism is said to have his last breath at Doora in UP. It was at Sarnath that Buddha, preached his first sermon and laid the foundation of his order. UP had been a learning centre since the past. In the medival period it passed through moghul rule and led to a new synthesis of Hindu and Islamic culture and many intellectuals born of Hindi and Urdu languages.

UP preserved its intellectual leadership even under the British Administration. The British combined the Agara and Oudh provinces into one and called it as United Province of 'Agara & Oudh' later shortened to United Province in 1935. After Independemce in January 1950, the United Province was renamed as *Uttar Pradesh.* UP is bounded by Tibet and Nepal in its North, Himanchal Pradesh in North-West, Hariyana in the West, Rajasthan in south-west, Madhya pradesh in South and Bihar in East. (source:India- 1996).

2.2.2 Demogrophical Features :-

The population of Uttar Pradesh is 139,112,287 persons as per the1991 census records. There are 681 numbers of towns and 112,566 revenue villages in the state. About 71% people live in rural areas. The population increase in last decade was 2.29% per year. Literacy rate is only 41.6% percent which is less than national figure of 51.4%.

2.2.3 Geology and Climatology :-

The Indo-Gangatic alluvial plains with the Yamuna as western most river, forms the entire Uttar Pradesh. The alluvial sediments, debris of Himalayan mountains, which formed the plains, were deposited in the Gangatic trough or geosyncline. The depth of the trough varies, highest at northern limit from which the floor slopes upwards to its Southern edge where merged with Vindhyan uplands of Deccan high lands. The floor of the Gangatic plain is corrugated by inequalities and buried ridges which being more or less impervious.

Uttar Pradesh has a sub-tropical monsoonal climate. Max. temp. in plains varies between 43° to 47° in May-June while the minimum ranges between 3° to 4° in January. High summer temperature is responsible for high rate of evaporation and consequent rains. Most of rainfall is from South-West monsoon in the months of July-August. Rainfall varies from 600 mm in plain to 2000 mm in hilly areas, in plains it also varies from 600mm to 1400mm at different places.

2.2.4 Water Resources :-

The state has got a natural gift as the large Ganga-river system. There are number of perennial rivers, originating in high Himalayan mountains, traversing through the state and ultimately emerging in Ganga, which finds its way through Bihar, West Bengal and also Bangladesh; to the Bay of Bengal. These rivers carry huge amount of water for utilisation in irrigation and drinking purpose (after treatment). There is a big network of canal irrigation system throughout the state. Some of the rivers originate from Southern Vindhyan ranges also that carry water all the year and benefit the state.

The state is overlying a vast reservoir of underground fresh water, the Indo-Gangatic alluvium (one of the biggest reservoir of fresh sweet water, Raghunath – 1987). The groundwater occurs in primary porosity of course sand, gravel and boulders of variable thickness of 3 to 60 metres. Shallow aquifers are confined whereas deeper aquifers are semi-confined or confined. The groundwater recharge is through rainfall and through a huge network of irrigation canals throughout the state. Water utilisation is through a large numbers of public and private tubewells. There exists a vast potential for success of handpumps in rural water supplies.

2.2.5 Administrative Set-up of the State :-

The state is divided in thirteen *mandals* (divisions) and eighty three districts.The districts, administered by a district magistrate is again sub-divided in four to six tehsils according to the area of district. Tehsils are again divided in numbers of development blocks which are constituted of hundreds of revenue villages. The smallest unit village is headed by a village pradhan who is elected democratically by the people of that village and popularly known as *Gram Pradhan.*

2.3 Development of Rural Water Supply in India :-

2.3.1 Evolution :-

The importance of safe drinking water was first recognised by the Bhore Committee in the year 1944. The recommendations were followed by some of the state Governments and later the Union Government appointed an Environmental Hygyene Committee in 1948-49; to assess the hygienic problems in the country. The committee recommended to provide safe drinking water and sanitation to 90% of the country population within a period of forty years. During the period of first five year plan

(1951-56), the Union Government announced their National Water Supply and Sanitation Programme as a part of health scheme in September 1954. The initial thrust was to provide drinking water through dugwells, either by new construction or by renovation and shallow handpumps. The programme could not get momentum due to shortage of resources till late sixties (Ghosh et.al.-1995).

By the end of 1970, the total coverage was only 5.7% out of investment of Rs.1286.7 millions. The state Governments through their PHED's were responsible for implementation of schemes with contribution/cost sharing from local bodies and communities. The systems provided were supposed to be maintained by the users. (Bishwas et.al.-1996, issue paper).

2.3.2 Emergence through Emergency :-

The severe drought in late sixties in the northern states and increasing epidemics due to faecal contamination of drinking water sources, forced the central Government to drive a major break through in rural water supply sector. The centrally aided, Accelerated Rural Water Supply Programme (ARWSP) was launched in 1972 to cover the problem villages(refer to 2.3.5) as identified in 1971-72. The sector got a place in 20 pint programme in 1975 which is a massive National Development Programme still continuing through the country.

2.3.3 Revolution through Hnadpumps:-

In the late sixties there was severe drought in the state of UP and Bihar. As a drought relief programme, number of handpumps of different local make, were installed with the help of UNICEF and some other external agencies. But after few year, those handpumps were just turned to useless hole in the ground. The whole investment and the anticipated benefit gone to waste. Thus the lesson learnt from the failure of drought relief handpumps programme in late sixties provided a driving force for the development of India Mark-II handpump. The pump developed during 1976-77, made a solid foundation for achieving the goals of International Drinking Water and Sanitation Decade (1981-90). It played a revolutionary role in providing 'water for all' out of United Nations declarations.(Black, M.-1990).

2.3.4 National Drinking Water Mission ;-

Earlier to 1985, the rural water supply and sanitation was under the Urban Development Ministry and it was transferred to Rural Development Ministry for gearing up the progress, integrated with other rural development programmes. In 1986, the National Drinking Water Mission was launched as one of the five social missions started by the Government of India. Later it was renamed as the Rajiv Gandhi National Drinking Water Mission (RGNDWM). The GoI continued to give highest priority to rural water sector through the activities of the mission and ARWSP. It also forms a part of state funded Minimum Need Programme and point no. 7 of the 20 point programme-1986.

2.3.5 Strategies and Priorities :-

The GoI formulated the strategy to identify the problem villages, which is mentioned below.

→ Those village which do not have a water point within 1.6 km distance or a water depth within 15 m below ground level in plain areas. For the hilly area, no source available at an elevation difference of 100m .

Recently this norm has been modified to 500 m distance in plain and 15 m elevation difference in hills.

→ Those villages with chemically unfit water i.e. having excessive salinity, iron and fluorides etc.

→ Water contaminated by guinea worms or other epidemic disease.

The following norms were adopted for providing safe drinking water to rural population:

(a) 40 litres of drinking water per capita per day for human beings.

(b) 30 litres additional for cattle in desert areas.

(c) One handpump for every 250 persons. (recently revised to 150 persons).

(d) Mini protected water supply schemes for villages of population of 1000 to 1500.

(e) Protected water supply scheme for villages of population more than 1500.

(f) Public standposts; for every 200 population.

The following priorities were adopted to cover those difficult areas, in seventh plan, which were not touched earlier.

1- To cover sixth plan spill over problem villages.

2- To cover all villages with no water source (1985 list)

3- To cover no source problem villages, surveyed or identified subsequently.

4- To cover all villages with contaminated water(both, chemically and biologically).

5- To cover all villages with per capita supply less than 40 lpcd to bring the service level up to norm level.

6- To cover hamlets and habitations.

(source: RGNDWM –1993)

2.3.6 Coverage through Water Supply :-

Out of the massive water supply programme in the last decade, there have been substantial progress in covering the rural population with drinking water. According to Bishwah (1996) it was 5.7% in the year 1971 and now attained 82% by the year 1996. Following table presents the achievement figures.

Table 2.1: coverage of rural population; population in millions

Financial year	Rural population	Population served	%age coverage
1951	299	6	2.0
1961	360	14	3.90
1971	439	26	5.9
1981	525	162	30.8
1991	627	463	73.8
1996	692	564	81.5

(source: Bishwas et.al. –1996, issue paper)

Further programme is to cover unserved habitations which were not identified during mission survey. Up to April 1996; a total of 911,000 habitations were fully covered and 331,648 habitations were partially covered where as 75,582 habitations is still to be covered by safe drinking water source. Water quality of the sources developed is first tested in laboratories and only safe water is allowed for public use. Most of the coverage is thorough India mark-II handpumps which are functioning well. It is targeted that all such habitations will be covered by the end of year 2000.

(workshop papers –1996)

2.3.7 Operation and Maintenance Issue :-

The speedy coverage of rural population was the result of extensive thrust given to creating new sources without finding solution to the problem of sustainability and O&M of sources. The entire programme of water supply was based on 'supply driven approach' with 100% subsidy. The O&M issue caught importance in the Global Consulation held at New Delhi in September- 1990; under the auspices of GoI and United Nations. The New Delhi declaration was later adopted by the UN General Assembly as a strategy for 1990's. Under the eighth five year plan (1990-96) the O&M issue got a place following the two declarations made in New Delhi.

(a) Institutional reforms promoting an integrated approach, including changes in procedures, attitudes and behaviour and full participation of women at all level.

(b) Involving local institutions in implementing and sustaining water and sanitation programmes. (source : RGNDWM- 1993)

Initially the states Public Health Engineering Departments were using 10% of their plan budget for maintenance of schemes under MNP and later on ARP schemes were also allowed for the same. As an estimate about Rs. 9000 millions per year are required for operation and maintenance of schemes created in the last two decades as against the allocation of Rs. 2250 millions only. At present O&M issue under the transition stage of transferring the responsibility to the respective *Gram Panchayats* as a decentralisation step of the maintenance system.

(source: Workshop papers- 1996)

2.4 Rural water Supply in the State of Uttar Pradesh :-

2.4.1 About the Water Supply Agency (UP Jal Nigam):-

For providing water supply and sanitation to the state a Public Health Engineering Department (PHED) was established in the year 1927. It was renamed as Local Self Government Engineering Department (LSGED) in 1949. Again it was transformed to *Uttar Pradesh Jal Nigam* in 1975, herein after called as Nigam, a semi-autonomous body and serving the state till now.

2.4.2 Administration of Agency :-

The water supply agency is under the control of Urban Development Ministry of the state Government. The overall governing authority of the Nigam is a board of directors, constituted of eleven members, headed by a chairman who also holds the post of chairman of the Nigam. The chairman of the Nigam is a senior administrative officers of the state, appointed by the state Government. Managing Director is the executive head of Nigam, is an experienced engineer selected by Government from within the top officials working since years in the Nigam. A finance director is also appointed who is the head of financial management. These three are the permanent members of the board and other eight are the nominated secretaries of different ministries of Government (refer to organisationogram, Annexure-I).

2.4.3 Activities and Aims :-

Following are the main activities and responsibilities of Uttar Pradesh Jal Nigam.

1- To prepare the project of water supply and sewerage and to execute, promote and finance.

2- To provide all services of water supply and sewerage to the state as well as to private concerned on request.

3- To prepare master plans of water supply and sewerage on the directions of state government.

4- To review the tax and tariff structures of Jal Sansthans and other local bodies under the agreement of article 46 of the Act.

5- To determine the material requirement and management of procurement as well as utilisation.

6- To prepare standards for water supply and sewerage for the state.

7- To discharge all the duties of earst while LSGED which are not covered here.

8- Annual inspection of water works and sewerage systems of Jal Sansthans and local bodies on technical, financial and other considerations which fall under section 46 of the Act.

9- To review and monitor the technical, financial and economic issues of each water supply and sewerage system of the state.

10- To implement, operate and maintain the water supply and sewerage schemes on the direction of state Government for the directed terms and conditions.

11- To generate the man power and train them for services of water supply and sewerage in the state.

12- To provide constancy services for efficient functioning of Jal Sansthans or Nigam itself.

13- Any other activity under the purview of Act or evolved by Act, to dispose off.

14- To perform any activity under the Guzzett Notification of the state Government.

2.4.3 Structure of UP Jal Nigam :-

The main activity; execution of water supply and sewerage projects, of the Nigam are implemented through its circles and divisions. The divisions are headed by the Executive Engineers and are the smallest unit of the department. The circles are constituted of 4 or 6 divisions and headed by a Superintending Engineer. At present there are 177 divisional units and 40 circles in the department scattered all over the state. The whole state is further divided in seven zones, headed by Chief Engineers (level-II). The headquarter of Nigam is at Lucknow, the capital of state and headed by the Managing Director and assisted by two Chief Engineers (level-I) and a numbers of Superintending Engineers, looking the works of administration, management, monitoring, planning, project appraisal, inspection and all other technical activities. The financial section is headed by the finance director and assisted by the number of account officers (source: UPJN activities and roles- 1997).

2.5 Water Supply Status in the State :-

The Uttar Pradesh Jal Nigam is involved providing water supply and sanitation to entire urban and rural population of the state. Here only the details of rural water project through handpumps is presented in the forthcoming paras.

2.5.1 Handpump Programme :-

The UP Jal Nigam bears the responsibility of providing the water supply in the rural areas of the entire state. There are in all 112,566 revenue villages in the state .Out of that 78,050 were found problem villages with respect to water supply, under the criteria laid down by the GoI. The coverage status of rural villages through water supply up to the year March 1995 is given as follows.

Table 2.2: status of villages in the state.

Particulars	Numbers of villages		
	Plains	Hills	Total
Problem villages	66,408	15,044	78,050
All villages	97,522	15,044	112,566

Coverage of villages by safe water supply is shown in following table.

Table 2.3; water supply coverage status of villages

Particulars	Plains	Hills	Total
Problem villages	66,408	11,553	77,961
Other villages	27,927	3,390	31,287
All villages	94,335	14,943	109,287

Thus the coverage status stands at 99.99% for the problem villages and 97.09% overall the whole state. In the early eighties it was decided to cover all the problem villages by installing only two handpumps, one for socially/economically weaker sections and other for general habitation. Afterwards the villages were saturated by providing requisite numbers of handpumps for each 250 persons. Presently each habitation, having a population of only 10, is also considered a single unit from water supply point of view. In all 274,641 of such habitations have been identified and they are supposed to be covered by the end of year 2000. By the end of March 1997, about eighty three percent of these habitations have already been covered through handpump water supply (source: UPJN- activities and role-1997).

2.5.2 Piped Water Supply Programme :-

Beside handpumps there are in all 1860 numbers of piped water supply schemes in the state. Some of the schemes were started in the late seventies, before adoption of the India Mark-II handpumps. Most of the schemes have been completed and being maintained by the Nigam and mostly not functioning well, to the expectations of users. Hence few handpumps are also installed in such villages which were earlier covered under piped water supply. Presently piped water supply schemes are being constructed to only those villages where ground water is chemically unfit for drinking like excessive fluorides, iron or salinity. As a survey report under RGNDWM , there are 1072 village affected by excessive fluorides, 3720 villages with iron and 4426 by excessive salinity. The piped water supply schemes for these villages are under construction/consideration with financial assistance of central or state Governments.

2.5.3 Dutch Assisted Programme :-

Under Indo-Dutch Co-operation, there are numbers of piped water supply, handpump and sanitation programmes, being executed or maintained in different districts of the state. There are 36 piped water supply schemes and two handpump scheme under different sub-projects, covering above 5000 villages. About 40, 000 India Mark-II handpumps have been installed till now under this co-operation. As an estimated cost of different projects, an aid amounting to Rs. 86,449.2 millions were expected to be received from the Government of Netherlands.

2.5.4 Operation and Maintenance of Rural Water Supplies:-

The O&M of rural water supplies and handpumps installed in the plain are as is in the hands of UP Jal Nigam. Regional Jal Sasthans are constituted for the maintenance of all water supply schemes falling in the hilly areas. Following norms, fixed by the GoI, are being followed for O&M of the water supply by the Nigam.

1- Handpumps : Rs. 400-500 per handpump per year.

2- Piped water supplies: 5% of the estimated cost of the schemes(excluding electrical expenditures).

3- Gravity schemes: 7.5% of estimated cost of the scheme (in hilly area).

On the basis of above norms, a total of Rs. 706 millions are required every year for the maintenance of all rural water supply schemes in the state. Where as only Rs. 500 millions are allocated for the year 1996-97 by the Government. Thus there is a financial deficit of Rs. 200 millions per year in the maintenance budget. Water tax is collected from the private house connections in case of piped water supply which is insufficient to meetout the maintenance expenses of the scheme. For the handpumps users do not contribute any more. The deficit in budget is reflected in terms of poor functioning of the water supply schemes.

2.5.6 Maintenance Procedure :-

Following procedure is being adopted for the maintenance of handpumps installed in the rural areas.

(a) For obtaining the handpump failure information, self-addressed and self-stamped post cards, are distributed among the Gram Pradhans, responsible persons in the villages. It is expected that the villagers will post the card whenever breakdown occurs, duly marked the expected defects.

(b) A register have been kept at each block development office to lodge the failure complain by the people.

(c) The Junior engineers of the department are instructed to attend the meetings of the block development committees.

(d) Junior Engineers are also instructed to maintain a register of each handpump repaired.

It is proposed to post a block mechanic at every block, equipped with necessary tools and few spare parts. A mobile team is also proposed at each tehsil level and a responsible officer is supposed to monitor the maintenance of handpumps at the district level.

There is no separate set-up for the maintenance of the rural water supply schemes, within the structure of Nigam. All of the divisional units situated in different districts of state are entrusted the job of maintenance falling within their area of work. The staff engaged in execution work, is responsible to carry out maintenance in his block along with other works Only centralised maintenance is being done by the Nigam. The maintenance system, as above mentioned, is proposed to be improved by creating mobile team.(also refer to chapter –5, para 5.2.1).

(source: UPJN activities and roles-1997)

This chapter deals with the study of literatures relevant to that on hand pumps and mainly focused on the functioning. It is constituted of mainly two sections; one dealing with historical and developmental phase of handpumps and other with its functioning and technical details. Para 3.1 and 3.2 describe the first section whereas 3.3 to 3.6 discuss the factors effecting its functioning and lastly the water usage and water quality.

3.1 Evolution of handpump water supply system :-

Earlier to the decade of sixty, single family and their live stocks primarily used the handpumps in single farms. Handpumps were connected to windmills and tanks.(Mc Junkin- 1977). A survey of World Health Organisation, in the early seventies (WHO-73) indicate that over one thousand millions of people living in rural areas of developing countries lacked reasonable access to safe drinking water. Unsafe or contaminated water is found as a principal cause of some disastrous epidemics like cholera, bacillary dysentery and many other diarrhoeal diseases. As an estimate, around 30,000 people were dying every day, many of them diseases attributed to lack of safe water or adequate sanitation facilities(World Bank –1987).

As and when the importance of safe drinking water supply for all, was recognised in the year 1977 by the United Nations Water Conference at Mar Del Plata and subsequent proclamation of International Drinking Water Supply and Sanitation Decade (water decade 1981-1990), it pressurised the countries to achieve the target within the decade. To achieve the massive target; simple as well as low-cost means of community water supply was looked into the hand pumps by many countries. "A world bank report (1987) estimated that the ground water supplies through hand pumps will be an appropriate technological choice for more than half of the, 1800 millions people in rural and urban fringe areas of developing countries who need improved water supply" (IRC- 1988)

The handpump installed in wells, where ground water is readily available, provide one of the simplest and least expensive methods of supplying rural communities with water (Kalyan- 1997). In the present day situation, the handpump water supply system have almost taken over the conventional piped water supply system in the rural areas except where good quality ground water is not available. Now, not only in rural areas but in big urban towns also, there is an increasing demand of handpumps due to unreliability of power dependent or intermittent piped supply systems in countries like India.

3.1.1 Handpumps Through Ages :-

"The origin of reciprocating pump is not clear but is sometimes attributed to Ctestbius, Cira 275 B C" (Mc Junkin-1977). That pump seemed to be a twin cylinder, lift type with external valves and without packing between plunger and cylinder wall. The purpose of this pump was fire fighting. This type of handpump was also known to some other historians, Hero (2nd century BC) and Vitruvius (Ist century BC). Archaeological excavations in Europe from the late Roman times, finds the existence of reciprocating pumps. According to Ewbank, wooden pumps were in use as a ship's pump in the early Greek Roman navies(Mc Junkin-1977).

"One of the best documented early examples of wooden pumps using metal flap valves, from Saxony, was recorded by Agricola in sixteen century" (Kalyan- 1997). In England, reciprocating pumps were made of wood or lead-using leather packed plunger, sometimes in 17th century. By the middle of 19th century, the Industrial Revolution facilitated the major break through in mass production of metallic handpumps for a wider use. During and the end of 19th and early 20th century, there was a tremendous production of various models of handpumps. Some 42 millions of handpumps are estimated to have been made in USA alone by the year 1920, when the electric pumps began to replace them.The basic working principle of all pumps was the same(Mc Junkin-1977).

Although the basic design of reciprocating handpumps has not changed much in the 20th century, its use certainly has. The smaller European backyard handpumps got good market value as an individual family pump for a use at small scale. But when those pumps were introduced in developing countries, under different operating conditions and put to extensive use by hundreds of villagers for long hours, frequent breakdowns were observed (Arlosoroff – 1987).

3.1.2 Handpump Water Supply in India:-

The rural water supply, through handpumps in India was born out of an emergency relief programme in late sixties (Maggie Black- 1990). It grew out of a grooming water scarcity in hard rock areas. The technological challenges of providing "problem villages" with a reliable bore hole, gave the programme its driving force. The boreholes fitted with handpumps proved to be only a reliable source of water as an immediate relief during drought period.

In the early summer of 1967, the states of Uttar Pradesh and Bihar of Northern India, faced a severe drought. In response to drought stricken plight of villagers, some of the first DTH (down the hole) hammer pneumatic drilling rigs for water boreholes were introduced in India by relief agencies. Within a short time, over 250 villages were put to relief by bringing water penetrating rock and soil. Out of this emergency relief option; grew a National Programme, which by this time has transformed the picture of rural water supplies through the Indian sub-continent.

The majority of the handpumps was installed in hard rock area, which were drought-prone villages. Bores were drilled by rig machines, donated by UNICEF until the late sixties. The hard rock terrain was classified as "technically difficult". Much of that was drought-prone and disease-epidemic. Rivers were seasonal, dwindling to streams in dry seasons. The ground water was limited and deep and it was gradually dropping and depleting. At this stage the handpumps were adopted as drought relief measures and not as an appropriate technology to community water supplies (Maggie B-1990).

3.2 Innovation of Handpumps in India:-

Since the last sixties, UNICEF has been a close collaborator to the Indian rural water supply programme. The effort was to bring clean domestic water supplies and improved environmental sanitation to the inhabitants of villages in India. In the year 1974, a major problem threatened to ruin the entire programme. The UNICEF carried out spot surveys in the states of Tamil Nadu and Maharashtra to assess the performance of previously installed handpumps. It was found that about 75% of handpumps were out of order. It appeared that millions of investment in drilling and supplying water to thousands of villages, had disappeared just in a hole in the ground. The handpumps were supposed to be maintained in the village ownership. This presumption proved to a complete failure due to many reasons, viz; lack of a comprehensive system of spare parts, mechanics and training. Another major problem was old design of handpumps following that of European or American models. Also it was more a social problem than technical.

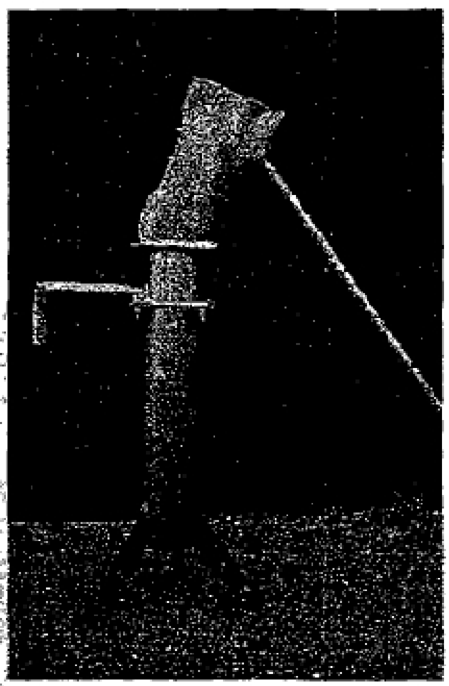
"The first voluntary organisation to replace old cast-iron handpumps was the Church of Scottland Mission at Jalana in Maharastra. During the late 1960's, what was known as "Jalana"pump came into being; the brain-child of a self-taught Indian driller. The design was well advanced over the cast-iron pumps. Another voluntary agency at Walda also developed the same type with some improvements named as the "Jalwad". Most of the design efforts continued to focus on rendering the above ground mechanism, less subject to breakdowns from heavy or careless use. In early the seventies, the Solapur Well Service came up with the 'Solapur' pump, which was considerably advanced over 'Jalana' and 'jalwad'. By 1974, several thousands of these three types of handpumps were installed in Maharastra. In 1975, UNICEF purchased 5000 of Solapur units and used them as conversion head of old existing cast-iron pedestal. Their performance was convincing."(Maggie Black-1990).

Figure –1 Handpumps in India earlier to seventies:

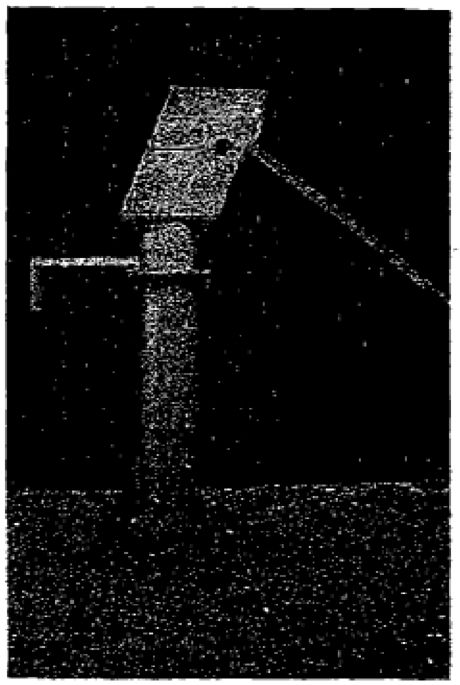
TYPE OF HANDPUMPS USED IN INDIA (YEAR 1960-1970)

DOUBLE GUIDE HANDPUMP

JALNA CONVERSION HEAD



SHOLAPUR HANDPUMP



SHOLAPUR MODIFIED HANDPUMP

The failure of the then deep well handpumps, installed for community water supply, initiated action in co-operation with state Governments, World Health Organisation(WHO), United Nations Children Fund (UNICEF),Mechanical Engineering Research and Development Organisation(MIRADO) and Richardson and Cruddas(1972) Ltd.(a Government of India undertaking), for the development of a dependable handpump. In 1975, a national workshop was organised, in which the Solapur handpump was used as a basis for new handpump design criteria. UNICEF took a co-ordinating and facilitating role in pump development, working with others. From this joint endeavour, emerged the India Mark-II handpump. The name, 'India Mark-II' was just a given name out of the efforts initiated in India. "*What happened to India Mark-I ?*" This is aquestion generally asked by newcomers to the handpump scene in India. The answer is that there was a Jalana pump, a Jalwad pump, a Sholapur pump, and a short development (orMark-I) phase, but there was no India mark-I. If one was to draw India Mark-II handpump linkage as accurately as possible, the Sholapur pump of the early 1970s must be regarded as its closest preceding kin (Mudgal, A.K.-1996).

3.2.1 India Mark-II deepwell Handpump:-

The present day India Mark-II handpump has its origin in the 'Solapur' pump locally produced in the state of Maharastra. Most of the features are derived from it. The additional design modifications were to make it feasible for mass production and increase the simplicity of its maintenance. The other design requirements were: its indigenous production in small scale industrial factories with available Indian raw materials, ex-factory cost to be within US$200, be sturdy and safe and had to function at least for one year without breakdown and without any maintenance. Some more design elements were introduced for aesthetic and practical reasons; its pedestal base was intended to fit over the casing pipe of well, the handle was replaced by solid bar in place of a pipe handle, weight of connecting rod was counterbalanced by long handle bar for smooth and lighter pumping.

Field-testing was conducted on twelve numbers of such produced handpumps first in Coimbatore in the year 1976-77. Some modifications were made as per the field report and the mass production was started in 1977-78. Richardson and Cruddas was the pioneering company to produce 600 of handpumps per month. Manufacturing license was issued to others also for fast growth. Quality control of the product was in the hands of the Government. The first Indian National Standard specifications for the India Mark-II deepwell handpump was issued in 1979 as IS-9301, 1979. It was also included in the global/international laboratory and field testing project initiated in the early eighties. The Coimbatore handpump field-testing project (1983-88), formed the part of a global project and efforts were made to further develop the India Mark-II handpumps. During a period of four and a half years of field testing, improvements were carried out which were proved very useful in field trials. Out of these improvements, the Indian Standard Specifications was revised three times and the last in 1990. The salient features of this handpump are as follows.

SECTIONAL DETAILS OF INDIA MARK II HAND PUMP SYSTEM ASSEMBLY

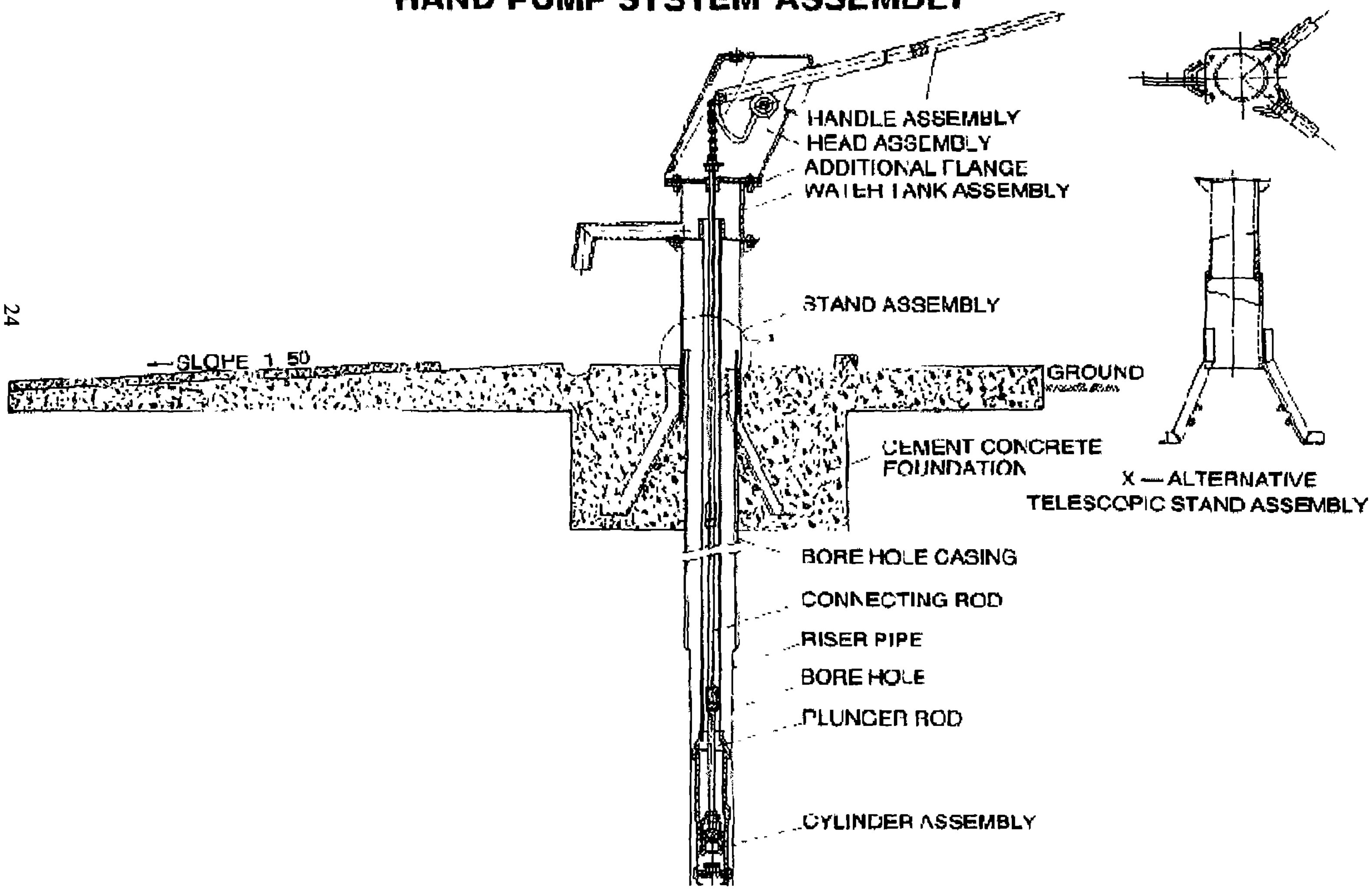


Figure –2 India Mark-II Handpump: (sectional details)

Salient features of India Mark-II handpump:

(I) Pump head assembly:- It is a fabricated steel structure, fully hot galvanised. It consists of head with handle, water tank, pump stand (pedestal). Figure-2 shows the pump head details.

(II) Cylinder assembly:- It is the main pumping unit, made of cast iron body, inside fitted with seamless brass liner of smooth surface. Gunmetal foot valves and plungers are made as per IS318-1981 with nitrile pump buckets and sealing rings.

(III) Connecting rods:- Theses are 12 mm dia. Electro-galvanised, mild steel bright bars of three meters length along with hexagonal coupling and locking nuts.

(IV) Riser pipes:- these are 32-mm nominal bore galvanised iron medium class pipes in three meters length with coupling sockets.

The performance of the India Mark-II handpumps turned out to be its own best advertisement. Some Engineering departments offered resistance in its immediate use for community water supply. As they were used to conventional piped water supply system as in city water supplies. UNICEF put considerable energy into advocating the viability of India Mark-II handpump in hard rock areas. Within a short time ten key states of the country accepted it application to rural water supply projects. The production was standardised and an efficient quality control was ensured by GOI. The production capacity was increased to 200, 000 per year by 43 listed companies and the pump was exported to Africa and Latin America. "It is today's best known handpump in rural water supply business world-wide." (Maggie black-1990)

Operation and Maintenance aspects:

Though the development of India Mark-II handpump was a major break through in terms of reliability and ease of operation. As per a report (GoI) the number of handpumps operating at any point of time rose from a dismal 25% to an impressive figure of 85%. However, this pump relies heavily on centralised maintenance system. The extensive field and laboratory testing have demonstrated that this handpump is very durable, but it is not so easy to maintain because of the high skills, special tools and a motorised van needed to service the below ground components. A mobile team consists of a van with special tools and a crew of 4-5 semi-skilled workers, is needed to provide specialised maintenance. This system is expensive and difficult to sustain. Alternative models of decentralised maintenance systems have been tried out with limited success.(Report- GOI-1990).

If a conservative estimate of handpump maintenance cost of Rs. 800, per handpump per year (conservative cost in comparison to the present provision of Rs. 600 taken by UNICEF, 1995) is used, the all India cost of maintenance totals to Rs. 20 millions per year. This real value of handpump maintenance cost would come to almost 15% of the total Government expenditure on rural water supply in 1994-95. Another indication of the handpump maintenance programme is the fact that, currently for Rs. 100 spent on new handpumps by the state Governments, about an additional Rs. 50 is spent on spare, i.e.

one third of the value of the domestic production of handpumps in India is for spare parts. This cost of maintenance is now, or soon will be an unacceptable burden on Government resources. (UNICEF- 1995)

3.2.2: Why was the India Mark-III Handpump Developed:-

Undoubtedly the development of India Mark-II handpump proved to be very sturdy one and most suitable to Indian rural conditions. At the same time, a careful and skilled maintenance need was left behind. The initial intention to develop a new generation handpump; designed specifically to be durable in developing countries, was only part of the solution to performance problems of handpump projects (Arlosoroff et.al. – 1987). The maintenance difficulties not only pertain to technical fallout, but also arise more from institutional or financial shortcomings. Pumps may be remaining idle because mechanics, tools or spare parts are not readily available or want of funds to carryout repairs (Paecy et.al.-1977).

The field trials and data gathered from number of different countries on maintenance, made clear that greater involvement of the community itself in maintenance, would bring both, lower cost and better reliability. This conclusion gave birth to a new concept of VLOM(Village Level Operation and Maintenance) in the early 1980's.
(Arlosoroff et.al.–1987).

"For long term sustainability of deepwell handpump programme it is necessary that most the repairs must be carried out at village level itself with minimal outside support. In the Indian context it is the essence of VLOM concept as enough local manufacturing capacity exists in this country." (Mudgal A.K.- 1990, paper presented in workshop)

The fore mentioned VLOM concept was put to field trial at the Coimbatore project for the further improvement of India Mark-II and its VLOM version. The research and development efforts were continued for more than four years and the outcome was a VLOM derivative of India Mark-II, which was named as the India Mark-III deepwell handpump. The design features of this pump are that the repair of below ground components has been simplified substantially. Maintaining the robustness of India Mark-II handpump, the ease of repair was improved such that the Mark-III could be repaired at village level with fewer tools and minimal skills. In a true sense, the India Mark-III is not a very different handpump from the India Mark-II except in ease of maintenance. The only difference lies in the design of cylinder assembly and size of riser pipe. The cylinder of Mark-III is rather a open top cylinder (OTC) which facilitates the extraction of plunger valve and foot valve assembly without dismantling of riser pipes.This improvement was too vital for the community –based maintenance system that is being introduced in some of the hand pump projects (Report,GOI – 1990).

Design Features of India Mark-III Handpump:-
The main design features of India Mark-III handpump are given as below. Figure –3 also shows the details of India Mark-III handpump:

(i) The piston and foot valve can be extracted without lifting the rising main.

(ii) When the piston assembly is screwed on the foot valve body, the push rod lifts the valve guide. This helps in dewatering the water column as soon as the foot valve is lifted. This ensures the easier lifting of rod along with valves.

Figure –3; Sectional details of India Mark-III handpump:

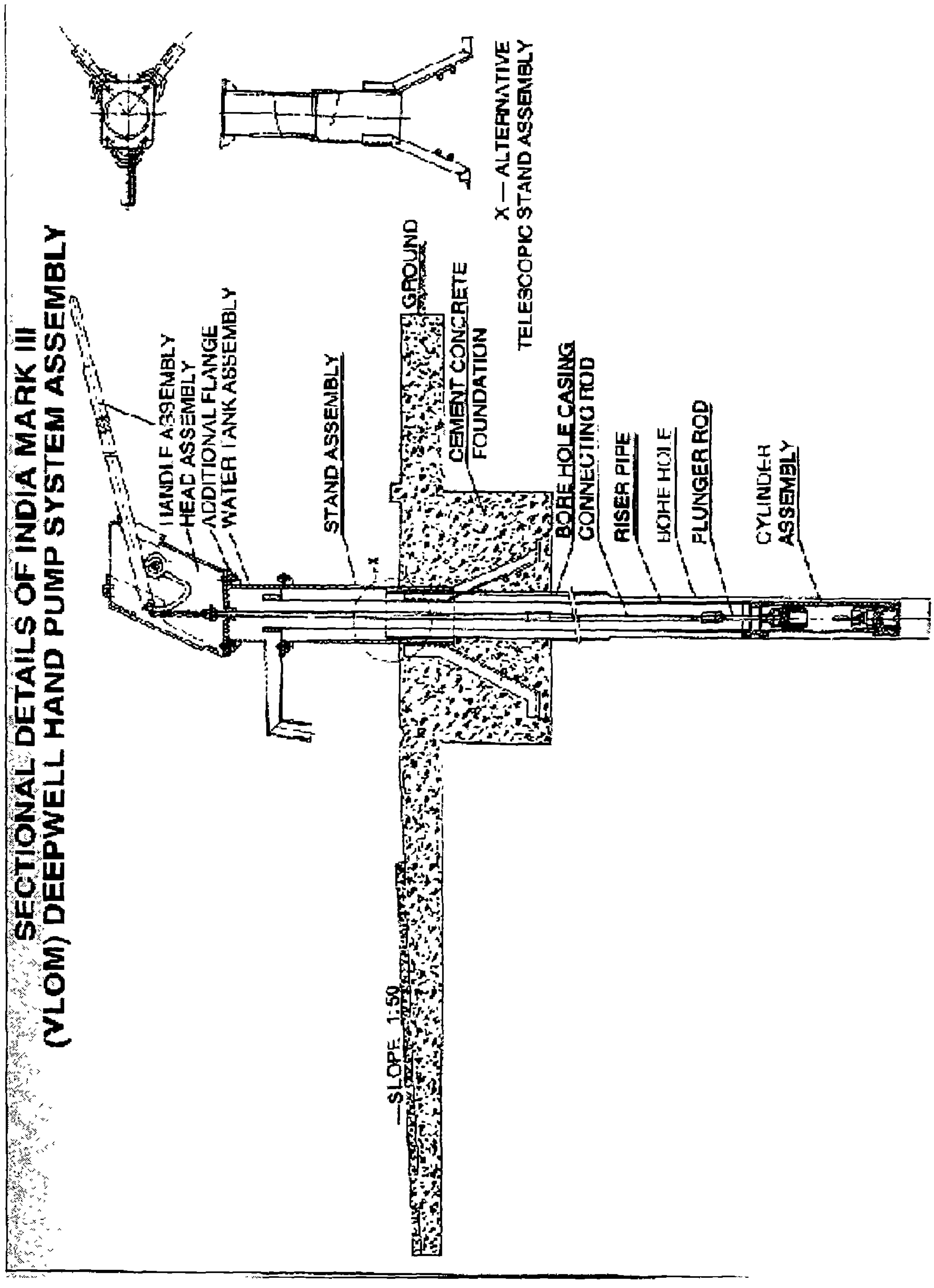
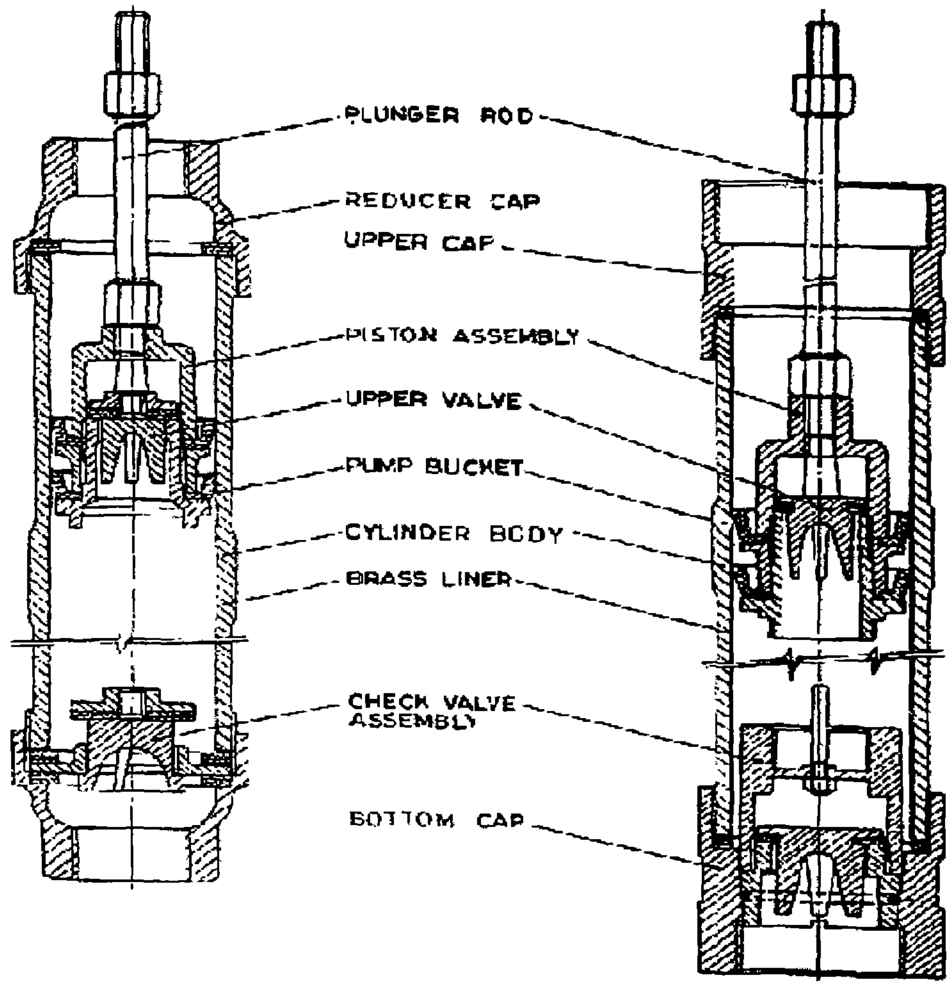


Figure –4; Main difference between Mark-II and Mark-III:



INDIA MARK II
CYLINDER - YEAR 1979

INDIA MARK III
CYLINDER - YEAR 1990

(iii) The foot valve is placed in a conical receiver and sealed by o-rings.
(iv) Nitrile rubber piston seals are used instead of leather seals.
(v) The two piece upper valve eliminates failure due to disconnection of the threaded joint.
(vi) An additional flange known as intermediate plate is placed between the head flange and water tank top flange. This facilitates the removal of head assembly without removal of handle assembly. This improves the access to chain assembly and simplifies the maintenance of above ground mechanism.
(vii) A square bearing housing instead of round bearing housing ensures higher rigidity and less distortion of housing due welding. This improves quality of bearing housing and enhance the life of bearing and handle assembly.
(viii) The increased window opening (handle slit) reduces the hitting (banging) on the bracket bottom stop.
(ix) The height of water tank assembly was increased to eliminate the splashing of water during fast pumping operation. The overall height of stand assembly was reduced by 75 mm to bring the operating end of handle close to platform footrest. This reduces the banging of handle on bracket bottom stop and makes repair more convenient.

3.3 Comparative Study of India Mark-II and Mark-III Handpumps :-

It was recognised in the National Workshop on handpumps in 1990 at New Delhi, India that the India Mark-II is a very robust handpump. The extensive field and laboratory testing also reveal that it is a very reliable and sturdy deepwell handpump. But its maintenance or repair was said beyond the capacity of villagers. Therefore further improvement in its reliability and maintainability was felt essential. Different bilateral and multilateral agencies were entrusted to carryout research on request of the Government of India (GoI).

The Coimbatore Handpump Project was under taken, out of this collaborative effort in the year 1983. The Major role player in this project were Tamilnadu Water Supply and Drainage Board, UNDP/World Bank, UNICEF and Rechardson and Cruddas (1972, a GoI undertaking). The then National Drinking Water Mission (GoI) co-ordinated the project (source: workshop papers – 1990).

The project was aimed at to resolving the two dominant issues: the maintenance difficulties and the maintenance cost lying with India Mark-II deepwell handpump. Testing project continued for a period of four and half years under the field conditions of heavy use and deep static water level. Two types of designs were tested; first intended for design improvement to increase Mean Time Before Failure (MTBF) and second to simplify the maintenance so as to a villager could repair it with minimal tools. In all about eighty pumps were tested, some of them were fitted with 65 mm diameter G I riser pipe to facilitate the extraction of foot valves without dismantling it . A sample of standard India Mark-II handpumps, provided the baseline information and by that the performance of experimental variations was compared.

The final outcome from the analysis of field data, are these two distinct handpumps: India Mark-II (modified) and India Mark-III. The reliability and serviceability was improved considerably. The test results show that average frequency of service (by mobile team) ; reduced by 89% per year and mean effective repair time to 67% as in case of India Mark-III handpumps. In reality, 90% of repairs were possible for a single village mechanic moving on bicycle with fewer tools and assisted by the users. In case of India Mark-II handpumps, a little modification was done to above ground mechanism. That facilitated the quick and easy removal for access to below ground repairs. Besides, nitrile rubber cupseals in place of leather, a two piece upper valve instead of three pieces and a modified spacer were also introduced.

The changes due to design improvements caused some increase in production cost of the handpumps. This increase in cost was assessed to be offset within 3-4 years with that of less repair expenditures. The increase in reliability (even up to 100%) and ease of repair were considered to be additional benefits. The additional cost of production of India Mark-III handpump, at that time was worked out to Rs. 1320 only which expected to be fully offset by lower maintenance cost within three years time.

The Coimbatore field testing project report recommendations are as follows.

1:- Design improvements to India Mark-II handpumps be incorporated into the national standard specifications.
2:- The existing 1.3 million India Mark-II handpumps be modified for substantial increase of MTBF.
3:- The India Mark-III handpumps be installed on a large scale in all the states presently using India Mark-II handpumps and a village-based maintenance system be developed which needs minimal support from a mobile team.
4:- A national standard be prepared for the India Mark-III handpump.
5:- A study on national level be conducted to evaluate the strength and weaknesses of the various existing maintenance systems and to suggest ways to create village level capacity to repair deepwell handpmps.
6:- Further research and development should be undertaken to simplify maintenance requirements that will encourage the users themselves to carryout maintenance.

(source: GoI Coimbatore field testing report- 1990).

Advantages of I M-III over I M-II handpumps:

The India Mark-III handpump offers following substantial benefits over India Mark-II. As extracted from Coimbotare field testing repor (Kalyan –1997).

(1) **Improved Serviceability:** For the routine maintenance of I M-III handpump, a set of fewer and lighter tools and lesser labour is needed to change the parts, which require frequent replacement. These parts are; piston seals, valves, valves seats, other above ground parts and occasionally the connecting rods. As compared to mean active repair time by components of I M-II versus I M-III, is observed that 67% less time was spent on I M-III, for similar repair of both.

Another important feature is that for all below ground repairs, a mobile van needed for I M-II whereas for I M-III it can be carried out by a mechanic with the help of a handpump caretaker or even user. The dependence of mobile team is 0.16 times per pump per year for I M-III against 1.44 times in case of I M-II.

(2) **Frequency and cost of replacement of parts:** When compared the average frequency of the parts replacement such as axle, handle assembly, chain assembly, bolts and nuts etc. and the maintenance cost for consumption of spare parts (based on data collected during the Coimbatore project) it is observed that the mean annual frequency of the parts replacement is 9.15 parts per I M-II pump as compared to 4.49 parts per I M-III. And the annual cost of part replacement was Rs.228 per I M-III against Rs.423 per I M-II; i.e. the cost of parts replacement was 46% less in case of I M-III handpumps.

(3) **Maintenance cost:** The maintenance cost for I M-II and I M-III have been worked out based on the assumptions made on the density of handpumps and travel distance. The data were collected during the Coimbatore project on consumption of spare parts, active repair time and manpower needed to carry out various repairs.
The following table gives the comparative cost of maintenance.

Table 3.1 : maintenance cost per pump per year

Particulars	I M-II	I M-III
	Cost (in Rs.)	Cost (in Rs.)
Caretaker	40.0	40.0
Block mechanic	18.61	42.25
Mobile team	392.1	228.2
Spare parts	423. 5	228.2
Total	874.21	381.11

As shown above, the total annual maintenance cost for I M-II is Rs. 874.21 as against Rs. 381.11 for I M-III. Thus there is saving of Rs. 493.10 per year per handpump. It is a substantial saving and it can be more if the village level mechanics are trained to carryout most of the repairs at village level itself and an efficient spare parts distribution system established.

(4) **Break-even point on cash basis:** It is estimated that extra expenditure of Rs. 1350, on the capital cost of I M-III will be offset in 3 – 5 years time due to lower maintenance cost.

(5) **Lower down time:** In case of I M-III, 90% of repairs can be carried out by a mechanic (using a two wheeler) with the help of users. This mechanic will be easily accessible and will therefore cut down the communication delays and reduce the response time and thus the downtime. The financial and economical benefits accruing due to lower down time will be far in excess of savings in the maintenance cost. (Kalyan –1997).

Limitations of I M-III handpumps:

The India Mark-III handpumps has some disadvantages, which are as follows;

1:- It is a fact that I M-III (including cost of riser pipe) is approximately 25% more expensive than I M-II. While studies show that converting to I M-III over a long term results in large programme budget savings in O&M.

2;- Another disadvantage is related to the heavy, 65 mm diameter, riser pipe used with the pump. There have been reported cases from a couple of states where the riser mains have failed (broken off at the top) in deeper installations.

3:- Due to non-verticality of bores, there have been some problems reported in mounting the India Mark-III handpumps on boreholes less than 125-mm dia.

Remedies to above limitations (using PVC riser pipes):

The Coimbatore project also conducted trial with PVC riser pipes to get rid of above limitations. The PVC pipes are light weight , low cost compared to G I, corrosion proof and also easy to handle during installation. The project tested fifteen numbers of handpumps fitted with 75-mm outer dia. 5-mm wall thickness PVC pipes and various types of joints used as riser pipe. The following observations were recorded in this field trial.

1:- the use of pump rod centraliser with PVC riser pipes was found essential. However, its use , even with G I riser pipe will reduce damage to inner surface of riser pipe due abrasion. Further development is needed on this problem.

2:- the rubber compression fittings used in experimental pumps, to hold the PVC riser pipe in the water tank assembly performed extremely well. No failure was noticed during three years of testing.

3:- The PVC riser pipes are found not suitable for installation in unlined borewell. The abrasion from out side causes premature failure of riser pipe. The threaded PVC joints in the riser pipe worked satisfactorily for two years. Further development and field-testing will be necessary to develop a system compatible with unlined borewells.

There are some examples of successful performance of PVC riser pipes used in I M-III hand pumps in Ranga Reddy district of Andhra pradesh. The pumps with PVC riser pipes were installed in the year 1994-95 and were found working satisfactorily without any complain up to the year 199 (Kalyan- 1997).

3.4; Technological Background of Handpumps:-

The handpumps installed in sixties or early seventies in the developing countries like India, were more or less the copies of European models. The technology involved was almost empirical and revolutionary modified over centuries. Though the concept of the operating principle was known, the scientific analysis of basic reciprocating cycle was presented in the technical paper series no. 10 of International Reference Centre for water supply and sanitation, The Hague in 1977, by Mc Junkinn. Over an effort of years, a handbook on handpumps was consolidated including the mathematical analysis of fundamental hydraulics, structural and energy requirements of various component parts of a handpump. Later on, a mathematical model of the working cycle was given by Goh Sing Yau in the year 1985 (IDRC-TS). This included the dynamic effects of fluid friction, pressure resistance due to fluid flow, valve delays and leakage past through piston seals.

The handbook established a theoretical relationship between the rate of discharge to that of cylinder dimensions and pumping speed. The discharge of any pump can be worked by the expression ($Q= \pi/4\ D^2NS$). Junkin also developed a nomograph, with the help of that discharge can directly be worked out for a given cylinder diameter, stroke length and number of strokes per unit time. He defined the differences between actual discharge to that of theoretical, by introducing the factors of leakage and slippage through piston and valves. The active forces during pumping were analysed and a relationship between hydraulic forces and static head of pumping was established which enabled the economical design of various component parts of a handpump. The term of mechanical advantage was able to utilise the suitable design of handle for human operation.

(Source: Mc. Junkin-1977).

The mathematical model of Yau; introduced the concept of volumetric and mechanical efficiencies in handpump design. He presented the rigorous mechanics involved in the pumping operation. His analysis and experimental investigations established that the leakage past through the piston rings, friction between piston ring seals and pump cylinder, valve closure delays and pressure drops across the piston and foot valve have a pronounced effect on the functioning of handpumps. The above dynamic affects have potential influence on the volumetric and mechanical efficiencies of a handpump. A mathematical expression was also derived in this regard. With the help of these analytical approaches; the optimal design of cylinder assembly head assembly could be possible. A computer simulation programme of handpump performance was also possible using those mathematical models and experimental investigations.

(Source: Goh Sing Yau-1985).

Whatever may be the technology involved in designing the handpump, but the user perception is theirown. They, more or less, are interested in the amount of water drawn and how conveniently it is done. Arlosoroff mentioned that people preferred more discharge even if some additional force is required to apply within their capability. In his own version "The field trials have demonstrated that lever –action pump users tend to use roughly the same handle movement irrespective of the total available stroke. The movement is about 300-400 mm and represent a comfortable operating action. Different users operate in different parts of the available handle arc, and handle design should therefore allow for comfortable use of a 300-400 mm movement at various positions to suit the stature of different users. The handle movement is more or less independent of handle operating force, until the pump becomes uncomfortably heavy to use. So, pump users are willing to apply quite high forces, but prefer limited movement."

(Arlosoroff et.al.-1987).

It was suggested to opt a right combination of mechanical advantage and cylinder size that can significantly reduce the forces and thereby stresses on pump rod and bearings. As far as practical, a single cylinder diameter should be adopted and that this should be the smallest size needed to cope with the range of pumping head met. Discharge and corresponding handle force required at different pumping lifts, can then be controlled by mechanical advantage- i.e. the highest discharge is achieved by longest stroke, using the minimum handle mechanical needed to keep the force within normal human capability limits. For an example, 50-mm diameter long stroke cylinder can be used for the full range of lifts up to 50 m by varying the mechanical advantage offered by the handle length. Lengthening the handle to provide a mechanical advantage of 4.5: 1; makes the pump suitable for lifts in 30 – 50 m range (Arlosoroff et. Al. –1987)

3.5: Functioning of Handpumps:-

Handpumps installed for community water supply, must fulfil the minimum of two basic considerations: it must be safe for drinking purposes and it should yield sufficient quantity of water needed for domestic purposes (Lloyd and Helmmer-1991). Safe water is meaning that it does not contribute to any health hazards to it users. It must be free from chemical contaminants and at the most without presence of dangerous micro-organisms. The quantity of water is the second aspect. People need water for their bodily thirst first, which is hardly 2-3 litres per day for a person. But other demands related to personal hygiene and culinary, are also inevitable. Some more domestic requirements like cleaning, washing, watering and cattle needs etc., increase the water demand to a tune of 20-100 litres in rural communities. The water point should also be located at a convenient place and be reliable round the year. (Lloyd and Helmer-1991)

A good functioning handpump is required to fulfil the sufficient demand of safe water to a numbers of users, located conveniently, working reliably year around, situated in healthy environmental conditions.
Example of poor performance and short life of handpumps, installed for community water supply, been observed in the decade of last sixties and early seventies (Arlosoroff-1987).

Following governing factors may effect the normal functioning of a handpump.

3.5.1: Pump Discharge:-

The discharge of the pump may the most important selection criteria of community, if it is asked to select a pump among many. People may prefer a handpump giving more discharge, even if little bit more effort is required while pumping (Arlosoroff et.al.-1987).

The theoretical discharge (Q) of a single acting reciprocating pump is function of a cylinder volume (V), swept by a plunger during its upwards stroke and the numbers of pumping strokes per unit time (N). Thus, $Q= V. N$ (Mc Junkin-1977). Again the volume of a cylinder is a product of cross-sectional area ($A= \pi/4\ D^2$) and length of plunger strokes. Thus the expression for discharge of a reciprocating pump is directly proportional to stroke length and number of strokes per unit time.

The actual discharge is generally not met with in the field measurements. Theoretical discharge is just a mathematical calculation of geometric dimensions. In the field conditions, valve closures are not so instant as and when the piston changes its direction to backward or forward strokes. There is possible leakage between plunger and cylinder wall during pumping. The difference between theoretical and actual discharges is termed as 'slip'. A good designed and well maintained handpump should not show a slip of more than 15% preferably 5%. In some cases the actual discharge exceeds to that of theoretical one(in terms of geometrical swept volume), due to negative slip. This may be possibly due to high entrance velocity at valves permitted by small diameter and long suction pipes fitted below cylinder. The valves may remain open for a long time providing passage to more water. (Mc Junkin-1977).

The discharge of India Mark-II handpumps is measured as per procedure laid down in Indian Standard Specifications IS 9301-1990. A 'type test' has been formulated to ascertain the pump performance in the field. According to that "the performance of handpump shall be checked after placing the cylinder at 50 m below the ground level in a borehole, the yield of which shall not be less than 20 litres per minutes. The pump should be primed and tested only after getting continuous flow of water through the spout. The water shall then be collected in a container for forty continuous stroke to be completed in one minute and the discharge thus measured shall not be less than 12.0 litres"(Setu-1997).

A field-testing was conducted in Ghana on over two hundred India Mark-II handpumps. The placement of cylinder below ground level varied from 25 m to 80 metres and the static water level was between 0 to 42 meters in the testing area. The findings are tabulated as below.

Table 3.3: discharge rate of I M-II handpumps in field testing in Ghana

Discharge In l p m	Cylinder Dia.(inc)	30 strokes per minutes			50 strokes per minutes			70 strokes per minutes		
		Min	Max	Ave	Min	Max	Ave	Min	Max	ave
	2.5	6.9	117	9.5	10.1	25	16.6	17 8	33	23.9
	2.0	5.3	6.8	6.1	7.3	13.5	10.2	13.7	16.7	14.8

(Source: World Bank- 1984)

If a handpump is designed for less discharge, normally required by people, the number of pumping strokes will be more for collecting same quantity of water. This will cause more wear and tear to the handpump components, which ultimately effect the functioning of handpumps.

3.5.2: Leakage Through Handpumps:

Leakage is a common defect in most of the handpumps, generally found in the riser pipes. The couplings used for jointing the various workable lengths riser pipes were found loosened in the field testing conducted in Ghana (Arlosoroff et.al.-1984). This types of leakage could arise due to improper installation of riser pipes or latter on during maintenance of handpumps. Another reason may be due to perforations in riser pipe developed due to corrosive water (Langenegger-1993).

Arlosoroff has defined the leakage in terms of number of strokes. A handpump is said to be leaky when it yields no water within first three strokes of pumping provided a rest of about five minutes allowed to the pump. The leaky handpump may render some other types of problems to the users as well as to pump itself. It will take more time in filling the same bucket of water, putting more physical strain to collect water and thus the users reluctance. Increasing the numbers of strokes in pumping water will cause more wear and tear to the handpumnp component parts. Thus increasing the number of repair interventions and reducing the functioning of handpumps (Arlosoroff et.al.-1987).

3.5.3: Reliability of Handpumps:

The conventional interpretation of reliability based on Mean Time Before Failure (MTBF) has become inappropriate by now. The critical item is the period of time for which any pump is not available for use. In terms of mechanical engineering industry, reliability is referred to the availability and is defined as below (Arlosoroff et. al. –1987).

"Reliability is the probability that the pump is in operating condition on any one day, calculated as the sum of the operating time before failure divided by the total time."

In the community water supply MTBF is rarely the most important indicator of reliability. The Mean Down Time i.e. the average period for which the pump is out of service when it does breakdown is as least as significant as the MTBF. As a better indicator of reliability in terms of availability – i.e. the probability that the equipment will be in operating condition on any one day, calculated as the operating time as a percentage of total time, or say as follows;

$$\text{Reliability} = \frac{\text{functioning time}}{\text{Total elapsed time}}$$

Thus the breakdown frequency combined with the mean down time to resume the handpump operative present a complete sense of reliability.(Arlosoroff et.al.-1987).

(a) Breakdown Frequency:

This may be defined as the number of times, a handpump goes out of order within a specified period of time. This can be expressed as once in a month or year or so. The maintenance system adopted, has a greater influence on the breakdown frequency. If preventive maintenance is ensured, it will reduce this frequency and also if curative maintenance is provided in time, it will decrease the chances of damaging other wearing parts and thereby increasing MTBF (Kalyan –1997).

The Coimbatore test project for India Mark-II and Mark-III handpumps, adopted centralised maintenance system where, the interventions required by a mobile team was tåken as a measure of reliability. Field findings reveal that average major repair need by a mobile team may perhaps be once in six years. The overall frequency of parts replacement was 9.15 times per handpump per year for I M-II and 4.45 per I M-III pumps. Frequency of rising main replacement was more which stood to 2.36 per parts replaced per year per pump (Report- Coimbatore project, 1990).

The quality of handpump materials and careful execution of field works, plays vital role in lowering down the breakdown frequency and by that the performance of handpumps is enhanced (Arlosoroff –1984). In the field observations, the reasons for bad performance of handpumps found to be related to the materials used in manufacture of component parts, fabrication processes of parts, pump installation methods and borehole drilling techniques. Some of the problems are mentioned below;

Problems related to material defects;

(i) breakage of connecting rods, couplings, riser pipes etc.
(ii) leakage due to defective couplings and perforation in riser pipes due to corrosion.
(iii) Hard pumping and rod breakage due to inaccurate tolerances.

Problems related to improper installation procedure:

(i) disconnected pump rods, riser pipes due to improper tightening of couplings, nuts and bolts.
(ii) hard pumping and/or extreme wear due to maladjustment or bad alignment of parts of pumps.
(iii) entering of dirt and polluted water into the wells if pump stand is not sealed off.

Problems related to poor well construction techniques;

(i) sand, silt and clay in the water (up to one volume percent of sandy-silty materials have been measured in ground water from boreholes equipped with handpumps).
(ii) Pump cylinders that are not submerged, partly immersed in water (probable causes of for this are clogging of screens and gravel packs, insufficient well development, depletion of aquifers water quality).

Some of the cases of inclined borewells have been reported to cause rupture due to continuous rubbing between cylinder and well lining and resulting to complete failure of boreholes (UNICEF –1995).

The accumulated impact of the above mentioned problems determine the reliability, durability and thereby the functioning of handpumps.

(b) Down Time:

It may be defined as the period for which the handpump stands idle in waiting to be repaired by the skilled mechanic or the mobile team or the users. This leaves a major impact on reliability of handpump. The higher the down time, the lesser time will be available for the functioning and also public usage.

The mean down time is constituted of following periods:

(i) time taken in reporting a breakdown information to maintaining agency.
(ii) The time lag between the receipt of breakdown message and actually reaching the pump to commence repair. And
(iii) Active repair time; i.e. the time actually taken to carry out repairs and set right the handpump in operation (Kalyan,C.K.-1997).

The reports (GoI) on functioning of India Mark-II handpumps reveal that about 85% of handpumps are operative at any point of time. It implies that a handpump sits idle approximately for about fifty days in a year. The findings of the Operation and Research Group(ORG), say that the reporting time of handpump failure varies from four to thirteen days. The actual down time, i.e. the time taken to set right the handpump and put it to service again is somewhat between seven to forty four days. The group report indicates that an India Mark-II handpump remains inoperative, on an average, for thirty-seven days in a year. (Report- GoI, 1990).

Cost effect of downtime for India Mark-II handpumps:
The Coimbatore field-testing project, worked out the maintenance cost per handpump per year for centralised maintenance system through mobile team. The team constituted of five skilled and semi-skilled persons and a van actually required carrying out the repair. Some assumptions were also made based on local situation and experience, which are;

(i) one caretaker for each handpump;
(ii) one block mechanic can repair 1500 handpumps in a year;
(iii) one mobile team with van can repair 300 handpumps in a year;
(iv) cost of spare parts is taken on the basis of frequency of replacement.

Combining all the anticipated expenditures, the cost of repair for India Mark-II was worked out to Rs. 874. 21 and Rs.381.11 to that for Mark-III (as on the rates of year1985). The cost of downtime for I M-II have been worked in following table.

Table 3.4: cost of downtime per year.

Particulars	Amount (in Rs.)
1- Capital cost	24950.00
2- Maintenance cost	874.21
3- interest @ 12% of total cost	2994.00
4- Depreciation (15 years approx.)	1663.33
5- Total of 2,3,4	5531.54

Thus the cost of operation as arrived above is Rs. 15.16 per day. If a pump is not in working order for a day, there is national loss of Rs.15.16 that day. As reported earlier, if a handpump in inoperative for 37 days in a year, the loss of benefits to the communities in indirect financial terms (since the services was provided by the government) will be to tune of Rs. 560 92 per year per handpump. Apart from this, the loss of time involved in collecting water from a more distant source and the potential adverse impact on the health of the community is also significant (Report – GoI, 1990).

Following are the possible reasons for high down time in the field conditions.
(i) delay in reporting breakdown;
(ii) communication delays;
(iii) delay in taking action on receipt of breakdown report; and
(iv) use of non-standard spare parts and faulty installations.

3.5.4: Water quality:-

(a) Corrosive Aspects :
The handpump being pumping machinery, lifts water from aquifer below ground and remains in close contact of water all the times. Therefore the quality of aquifer water leaves a potential influence on the functioning of handpump. The experiences with World Bank executed handpump projects in West African regions, indicates that the ground water quality has significant effect on the performance of handpumps (Langenegger-1993). In the areas, where ground is corrosive, non- corrosion resistant riser pipes, pump rods and cylinder etc, suffered a serious attack of corrosion and breakdown frequency increased considerably. About two third of breakdowns were recorded due corrosive effect of water. The handpump water quality survey was conducted in some of the countries like Ghana, Mali, Niger and Burkina Faso by a team of World Bank. The experience from the field trial revealed that corrosive ground water is an important factor with regard to functioning of handpumps. The aquifers with aggressive water are world wide while predominantly in West African region (around 70% region has aggressive ground water) (Langenegger – 1993).

Corrosion is a complex multi-diciplinary phenomenon. In the co-operative research report of AWWA/ DVGW, it is defined as '—the complex phenomenon of corrosion is governed by variety of chemical, physical, biological and metallurgical factors that a universal approach and solution is not possible. Equally evident is the well-recognised fact that no universal index exists for predicting corrosion in all types of water systems and for all water quality conditions.' Clearly the corrosion depends on several factors. As far as water quality is concerned, the pH value and Electrical Conductivity are the two simple indicators of corrosive water. Low pH value shows the acidic nature of water while E C is direct measure of conductivity of water acting as 'electrolyte' which is the cause of galvanic corrosion (Langenegger-1993).

Corrosive water has a two –fold effect on handpumps; first it causes mechanical failures and secondly deteriorates the water quality. The handpump component parts like riser pipes and connecting rods, being submerged in water, are get badly corroded. Considerable reduction in pump rod dimensions is observed and perforations in riser pipes are noticed.

It is found that there is rapid growth of corrosion between the pH range of 6 to 6.5. Perforated riser pipes reduce the discharge of handpumps and also create leakage that effects its functioning considerably. Secondly the corrosion products, create another type of problem by increasing the iron content of water, leaving turbidity, taste, and colour (reddish) water and sometimes odour Few side- effects like staining of cloths and food stuffs, makes the water unacceptable aesthetically. In the field trials it is found that the water points with iron content of 5 mg/l or more are rarely used by people. Iron concentration could be good indicator of water usage.

(a) Drinking Aspects:
The water supply intended for public should have the essential requirement of wholesome and potable (Bhargava,D.S.-1985). For proper control of water quality supplied to community; standards promulgated by various authorities such as WHO , EPA of United States and several other organisations of different countries, have been set. Various constituents have been limited in terms of concentrations as set in standards; mainly based on health hazard considerations and aesthetic view.

The acceptance of water quality by the users has also an impact on the functioning of handpumps. A handpump, found in good condition, operating well, yielding sufficient discharge but may hardly used by community. There may be some water quality parameter, beyond acceptable limit, which caused rejection of handpump. Such a handpump may not be regarded functioning well on water quality considerations.

Lloy and Helmer-1991, have mentioned some basic requirements of drinking water that must be considered in community water supply.

- It should be free from pathogenic (disease causing) organisms.
- Containing no compounds that have an adverse effect, acute or long term, on human health.
- Fairly clear (i.e. low turbidity, little colour)
- No salinity (salty)
- Containing compounds that cause an offensive taste or smell.
- Not causing corrosion or encrustation of water supply system, nor staining clothes when washed in it.

(Lioyd and Helmer-1991).

Following water quality parameters are most commonly taken into consideration from water use point of view (as per WHO, guidelines for drinking water- 1993)

Physical parameters:

(1) *Colour*: The colour is caused due to presence of coloured organic matter, mainly humic or fulvic acids which are associated with humus fraction of soil, It is also due to presence of iron and other metals, either as natural product or corrosion product. It may also result from industrial effluent.

Colour below 15 TCU (true colour unit) is usually acceptable to consumers and above that it may be rejected on aesthetic view.

(2) *Taste and Odour:* These originate from the biological sources or processes e.g. aquatic micro-organisms, from contamination by chemicals or as a by-product of water treatment. It may also develop during storage and distribution. Taste and odour may be cause of rejection by people. Majority of consumers complain about water quality, al over the world, mainly related to taste and odour problem caused by turbid or discoloured water and deposits (Mallevialle and suffet-1987). Difference in taste of new source in comparison to old traditional one, may reduce the acceptability.

(3) *Turbidity:* This is caused due to presence of particulate matters in suspended form. They may be particles like silt, clay or corrosion product, soluble organic compounds, microorganisms (plankton etc.) or some microscopic organisms. Turbidity is a measure of water clarity. It leaves aesthetic impact on consumers. It does not offer any direct health hazards but creates difficulties in disinfection. Ground water almost found free from turbidity. But some wells may have suspected particles of corrosion products or due to poor well sealing. The threshold turbidity limit, which can be visible to naked eyes, is above 5 NTU and water with this limit is acceptable.

Chemical Parameters:

(1) *Chlorides·* High concentration of chlorides gives an undesirable taste to water and beverages. The taste threshold for chloride ions are in the range of 200-300 mg/l. Consumers may accept to a level of 250 mg/l in exceptions. Chloride in ground water may be caused due to seawater intrusion or due to geological formations rich in chlorides. Pollution may also be a cause. It is difficult to remove the chloride from water, economically. High content may result in corrosion and may be rejected by consumers.

(2) *Hardness:* Acceptability of hardness by consumers varies considerably. It can be tolerable between 100- 300 mg/l and in exception up to 500 mg/l. It is caused due to dissolved calcium and magnesium. High hardness causes scale formation in cooking utensils and increases the soap consumption. Conversely, low hardness (below 100 mg/l), makes the water corrosive because of low buffering capacity.

(3) *Iron :* Iron is the most abundant metal in the earth crust (5%). Ground water may contain ferrous ions of several mg/l; without leaving any indication when pumped out from wells. On exposure to atmosphere, ferrous ions are oxidised to ferric giving objectionable colour and turbidity to water. It also promotes the growth of 'iron-bacteria' which derive their energy from oxidation of ferrous ions to ferric ions and in this process deposit a slimy coating on pipes and rods.

At a level above 0.3 mg/l, it stains laundry and plumbing fixtures. It also develops taste, colour and turbidity. Concentration between 1-3 mg/l can be acceptable to people drinking anaerobic well water.

Iron is essential element for human nutrition. Estimates of minimum daily requirement of iron depends on age, sex, physiological status and iron-bioavailability and it ranges from 10-50 mg/day.

Human body contains about 4.5 mg iron out of which, 70% in haemoglobin, 26% in proteins and 3.5% in myoglobin (Mathur,A.K.–1996 CGWB[1]). Iron when present more than 10 mg/kg human body weight, causes rapid increase in respiration, pulse rates, congestion of blood vessels, hypertension and drowsiness..

As a precaution against storage in body of excessive iron, in 1983, JECFA[2] established a provisional maximum tolerable daily intake (PMTDI) of 0.8 mg/kg of body weight, which applies to iron from all sources except from iron supplement for specific clinical requirements. An allocation of 10% of this PMDTI in drinking water gives a value of 2 mg/l which does not present a health hazard, except those taste and appearance.

(4) *Fluorides:*
Fluoride ions are widely distributed in the earth crust and in abundance in igneous and sedimentary rocks and minerals. Apart from weathering of rock farming minerals like topaz, fluorite, flour-appetite, Willamette etc. human activities in the form of phosphetic fertilisers or other fluoride containing industrial waste can contribute to fluoride content in ground water. Restricted aeration, climatic factors, temperature etc. are certain other factors responsible in affecting the overall fluoride concentration of ground water(Mathur- 1996, CGWB).

Soluble fluorides are readily absorbed in gastroinstetinal tracts after intake in drinking water. A concentration of 1-1.5 mg/l in drinking water is optimal and beneficial also. Below 1 mg/l it causes mottling of children teeth and excess value contributes to the risks of dental fluorisis and much higher concentration leads to skeletal fluorisis. The guideline restricts the upper limit up to 1.5 mg/l only.

1- Central Ground Water Board, India.
2- Joint FAO/WHO expert committee on food additives.
FAO- food and agricultural organisation of United Nations.

(5) *Nitrate and Nitrite:* High nitrate concentration (> 100 mg/l) in ground water, when used for drinking purposes can adversely affect the human systems and on vegetation's. Excess concentration causes mathemoglobinemia or blue babies in infants. It reduces to nitrate in gastroinstetinal tracts producing nitrosoamines and thus cause gastro-carcinomas in wide range of animal and human (Mowali and Seshaiah-1988). High nitrate may also have adverse effect on the cardiovascular systems and control nervous systems.

Excessive nitrogen compounds generally find their way in ground water body in one or more of the following ways

1- Atmospheric nitrogen fixation.
2- Atmospheric sources which include interalia;
   (a) industrial wastes (b) human and animal wastes (c) agricultural activities. (Mathur AK –1996, CGWB)

The WHO guide lines restricts the limit of nitrate to 50 mg/l.

(6) *Sulphate :* Sulphate in ground water occurs from natural resources. It is the least toxic anion, however catharsis, dehydration and gastro-instestinal irritation have been observed at high concentration. Presence of sulphate in drinking water can

cause noticeable taste and varies with the nature of associated cations. The acceptable limit on taste considerations is 250 mg/l.

(7) *pH value :* Although the pH has nothing to do with consumers, it is one of the most important operational water quality parameter. This is also a good indicator of corrosive nature of water. In case of ground water if pH is found less than 6.5, it can cause corrosion to pumping components as discussed earlier. The desirable value may vary between 6.5 –8.5 as per guidelines.

Integrated Water Quality Index :

There are a large numbers of water quality parameters, which contribute to various acceptability criterions in varying concentrations. It will be too easy if the overall effect in the water quality deviation could be expressed in an integrated manner, giving due regard to both the importance of each constituents as well as the magnitude of expected concentration (Bhargava D.S.-1985). An attempt was made to present the drinking water standards through an Integrated Water Quality Index (WQI). A model expression was developed to account for all the quality parameters of a sample based on the set objectives in terms of a sensitivity function. Once the water quality of given sample is known for its various variables, the sensitivity function for each of the tested variable can be worked out or estimated from the given graph. Thus the WQI can easily be estimated for an index and based on that decision can easily be taken for the acceptability to community supplies. Here only one standard (namely WQI, not exceeding to 90) may be enough instead of laying out permissible limits for a very large numbers of variables. Because even if the concentration of one variable rise to high level, WQI would not reach near 90. It was suggested that the community water supply should have a WQI of more than 90.

3.6: Water usage :-

The overall objective of the IDWSSD may not only be limited to make available the safe and adequate water-sanitation facilities to the communities all over the world. The intention behind the decadal approach was to provide primary health benefits and thereby to improve the socio-economic status of those people who were deprived so far. Falkenmark, 1982; finds it as are volutionary approach of the decade in liberation of rural women from the extensive burden of collecting water from long distances (Albert Buitenhuis-1993). But the real benefit can only be possible when the community USE the facility provided for, oherwise it might be a bare investment The World Bank technical paper no. 207- 1993, advocates the effective use of facilities, "effective use is the optimal, hygienic and consistent use of water and sanitation facilities to maximise benefits and minimise negative consequences, over an extended period of time."

Once the implemented and functioning , water and sanitation facilities, must be utilised by the community is to experience the positive health, economic, social and environmental impacts (Deepa Narayan-1993). The available water may not be used in sufficient quantity, by the people or being used by fewer people or may be over used and causing environmental degradations. Thus the optimal use of the facilities becomes important . the number of persons using the facility, quantity of water collected, the time taken in collection, distance travelled for collection may the good indicator of water usage.

Setu-1997, defines the water usage as volume of water used for all domestic purposes like drinking, cooking, washing, personal hygiene, vegetable gardening and cattle feeding. Also many factors effect the water usage such as cultural habits, pattern and standard of living, money paid for water and the quality of water supplied.

A survey conducted by Indian Market Research Bureau, under the UNICEF sponsorship, defines the safe water, which are usually clear, tastes sweet, free from unpleasant smell and cooks food quickly. The cooking quality of water is attractive to women in particular. Majority of people believes that visually clear and sweet water is safe for drinking while very few know that it should be free from germs also. Health aspect of unsafe water is not known to most of population. Only a very people can say about the water related diseases like diarrhoea, cholera and stomach disorders. (UNICEF-1989).

As far the cost of water is concerned, people are found very much conservative to pay for water. If the new facility of water is proposed to be taxed, they may refuse it to accept it. And also may better like to collect water from traditional sources irrespective of distance and quality. In rural areas, people always under value their own labour vested in collection of free water rather to pay for water points or yard taps. If the cost of new facility is more, people may not accept and turn to traditional sources.

(Carr and Sandhu-1988)

The quantity of water collected from a handpump, by a numbers of persons and a convenient distance etc. all factors influence the water usage. The water use is also related to the functioning of handpumps therefore this parameter may be taken as an indicator of functioning of the handpumps. The pump conditions and the pump environment play important role in attracting community for the use of facility. If the handpump is situated at unhealthy location and old traditional sources like open wells etc, are in good condition, people may prefer to use that one. The condition of pump effects the people attitude to use it. Any handpump with a large play in handle, damaged bearings, leaking tanks and difficult to operate may reflect the community from using it.

4.1 Outlines :-

Research in social sciences is direct outcome of man's urge to understand his society, its nature and working. Thus in social research, the role of social elements is very crucial. Human, being attached to his society, do not operate under controlled conditions; on contrary they are always under diverse influences such as environmental, physical and social and these influences freely impact with each other and seldom operate in isolation. This interplay of diverse influences makes social phenomena more complexes. It is again further increased by the uniqueness of each individual's behaviour in thinking, working and attitudes (Setu-1997).

The modern concept of research is, therefore broad-based and provides for meaningful investigation in the field of academics. Research, these days is treated as advancement in knowledge acquired through scientific methods. According to PV Young, social research may be defined as a scientific undertaking which, by means of logical and systematic techniques seeks to;

(i) Discover new facts or verify and test old facts;
(ii) Analyse their sequences, inter relationships and casual explanations which were derived within an appropriate theoretical frame of references.
(iii) Develop new scientific tools, concepts and theories, which would be reliable and valid study.

According to John Best, research is more systematic activity directed towards discovery and development of an organised body of knowledge (Kalyan -1997).

This chapter mainly deals with description of research methodology as adopted in the study of India Mark–II and Mark–III handpumps. First of the themes and indicators, evolved from literature review, are discussed related to the topic and afterwards the procedures adopted for field data collection and peoples' interview methods have been elaborated.

4.2 Selection of Themes & Indicators :-

For evaluation of the functioning of handpumps, a scientific and systematic approach is required. Some key issues and parameters have direct and indirect influence on the functioning, which enable to compare the two types of pumping devices of same kind. After literature review on the subject, certain themes and indicators related therewith, are evolved to measure and compare the functioning of India Mark–II and Mark–III handpumps. Also these themes and indicators have some standardised values, guidelines and national standards fixed by well known institutions like WHO, EPA or various Governments as mentioned in literatures.(see also chapter-3,para 3.5).

Present study is focused towards the functioning of handpumps. The maintenance systems and the use of water also influence considerably the functioning and for this reason some indicators are selected likewise. The system adopted for operation and maintenance of any water supply system, effects its' functioning to a great extent. The reliability of a handpump system, more or less, depends on the maintenance system followed in the area. But this theme could not be included within the purview of this study because of time limitations.

The indicators selected are as follows:

1: Discharge :-
The yield of water per unit time from handpump is a good symbol of its functioning. The Bureau of Indian Standards has fixed a standardised rate of discharge for both types of handpumps, on the basis of which a handpump can be called functioning properly or poorly. The volume of water drawn at a specified pumping rate, is the indicator of this theme. The discharge of each hand pump was measured as specified in para 7.3.2(routine tests) of Bureau of Indian Standards IS:9301; 1990 and IS:13056; 1991. The specified discharge for both types of hand pumps, should not be less than 15 lpm when pumped at 40 strokes per minutes in the laboratory and 12 lpm in the field condition.

2: Leakage :-
Some of the handpumps show a few non-yielding strokes and so are termed as leaky one. The number of strokes required, after a rest of at least five minutes, to start producing water is the indicator of a leaky handpump. Arlosoroff (1987) has defined the leaky pump which does not yield within first three strokes of pumping after a rest of five minutes.

3: Reliability: -
A handpump is said to be reliable, whenever it is pumped it must yield water. As per design conception of India Mark – II & Mark – III handpumps, it should be 100% reliable. The reliability of a hand pump is measured in combination of breakdown frequency and the average down time. The system of maintenance followed in area concerned, also effects the reliability to a great extent but detailed data could not be collected due shortage of time for this theme.

(a) Breakdown Frequency:-
This is the number of times, a handpump fails in a year. As per design considerations of handpumps under question, at least they should run for one year without any trouble. Also some reports and studies reveal that the breakdown frequency should not be more than once a year.

(b) Average Downtime:-
This is the time taken to restore functioning of handpumps reckoned from the date of failure. On an average it should not be more than one or two week. The down time is fully dependent of the maintenance system adopted in the area. In fact this is the time taken to put the hand pump into service again, as measured from the date of breakdown.

4: Water Quality :-
The water quality of aquifer has direct as well as indirect influence on the functioning of a handpump. Most of the breakage of below ground components e.g. pumps rods and riser pipes are attributed to corrosive ground water. On the other hand, the poor quality reduces the use of handpump water, which indirectly influences the functioning. The water samples of each handpump collected as per procedure laid in IS-3025, 1987 and sent to departmental labouratory for testing the quality parameters.

5: Coverage: -
The total numbers of persons using the handpump water is an indicator of this theme. It reflects the functioning of handpump indirectly. The data for this theme has been collected during the interviews and actual counting of the users around the handpump.

6: Water Usage:-

The volume of water extracted per day from the handpump is directly related to the functioning of the handpump. Necessary data to measure this theme has been collected during interviews. The people were asked for the number of buckets of water collected per day and the quantity of water used could be worked out.

7: Use of Traditional Sources:-

Inspite of the handpumps installed in the locality, some people even use their traditional sources of water for their domestic needs. This practice, indirectly effects the functioning of handpumps. During interviews it has been assured.

8: Pump Condition :-

The condition of pump, platform and drains directly reflects the quality of handpumps which has been directly observed in the field. The indicators are rated as good, moderate and bad according to present pump condition observed.

9: Pump Environment:-

The surroundings of a handpump is a reflection of upkeep of handpump, community involvement and its social aceptance. The sources of pollution and wastewater disposal systems are the indicators, which are directly observed.

10: Users' Satisfaction:-

The users' satisfaction is the overall measure of functioning of a handpump alongwith performance of maintenance team as well as maintenance system.

4.3 Sampling :-

The primary purpose of the research is to discover principles that have universal applications. Research work needs adequate and accurate data for this purpose. In order to obtain these data, a researcher conducts investigations into a given population. Information, thus, can often be derived quickly and cheaply and with sufficient accuracy from a sample of the total. Sampling refers to the investigation of part of the whole population. A statistical sample, according to Calvin, is a miniature picture of cross section of group or aggregate from which the sample is taken. In short, sample represents the whole population and by observing the samples, certain inferences may make about the population. For collecting representative data, samples are not selected haphazardly but a proper procedure is adopted, so that the influence of chance and probability can be estimated (Kalyan- 1997).

The important consideration in selecting a sample is to see that it is closely representative of the universe. The size of the sample may not be the guarantee of its being representative of the population. Sometimes a large sample poorly selected may not prove to be a true representative of universe while a small sample properly selected may be much more reliable. (Sadhu and Singh - 1985)

The state of Uttar Pradesh is a big one, constituted of eighty-three administrative districts out of which about seventy districts are benefited with handpump project and a huge number of populations are covered with water supply. To review the functioning of handpumps, a rationally good representative districts and there from few sample villages has to be selected.

In the forthcoming paragraphs, various aspects of sampling are considered in selection of samples.

Sample Size :

For a proper study, the handpumps must be used by a sufficient number of persons and also should cover a reasonable area. A handpump used by only 10–15 persons was not considered suitable to evaluate its functioning. Therefore the handpumps situated at 100-150 m distance and used by 50 or more numbers of persons were given priority.

Effort is made to get a stratified random sample of householders choosing three within 10-20m radius, three within 50-100m , and three from outer periphery or last users. The houses were chosen from the different lanes leading towards the handpump. But this ideal situation is not always metwith every handpump. At some places the number of users family were only eight to ten and also not all available for interview. At some places people feared of being taxed for using handpump and denied saying anything and some found very reluctant in conversation. Under these circumstances, the number of persons for interview was reduced to five or six only as per availability. In this way a total of 297 householder were interviewed for all forty handpumps. Effort has been made to select householders from various section of society such as, farmers, businessmen, poor persons, labourers, local mechanics etc. for getting views of whole society. Thus the samples selected are summarised as below.

Table 4.1: villagewise details of interviewed householders;

Name of village / district	Number of householders interviewed	
	I M–II	I M-III
1 - Narausa / Lucknow	17	26
2 - Hemarapur / Lucknow	9	36
3 - Chandrawal / Lucknow	25	10
4 - Bakkas / Lucknow	21	15
5 - Raini / Allahabad	--	48
6 - Sehuadih / Allahabad	--	8
7 – Atanpur / Allahabad	6	12
8 - Saraiharkishan / Allahabad	14	--
9 - Baksera / Allahabad	18	--
10- Baijahi / Allahabad	32	--
Total	142	155

4.4 Selection of Study Area:-

The users of the handpump in the state are the target population in this study. According to Paul Nichols (1991), the accuracy of sample in representing the target population; depends on the sample size and the method of its selection. Again it is stated that for bigger the sample, more accurate the results but higher the cost. It was decided to select only two districts out of eighty three districts in the state; keeping in view the limited time for study and minimum cost expenditure available for logistics.

4.4.1 Selection of districts :-

The rural population of the state is fully covered with hand pump projects and mostly IndiaMark–II handpumps are installed in all of the plain districts. Whereas India Mark–III handpumps are installed only in some villages of a few districts that too with material assistance provided by UNICEF. These districts are Lucknow, Jhansi, Banda, Allahabad and Sonbhadra. The basic information regarding the number of hand pumps installed, number of villages benefited, the topography and hydrography of the districts, water scarcity status, presence of traditional sources etc. were collected in the beginning. District Allahabad has got an extra weight over other semi-hilly districts because of its' conversion program. It was reported that in Allahanbad district, conversion of India Mark–II into India Mark–III handpump is being done in some of the blocks. Under these situations this district was found more logical to be selected out of the above five districts. Out of these five only one, the Lucknow is situated in central part of Indo Gangatic plain whereas others are along the foot of semi-hilly region of the Vindhyan range. To select a judicious area of study, among these, two districts, one from plain region and other from semi-hilly region has to be considered. The underlying concept is being to compare both the handpumps, nearly in the same field conditions, using the same borewell and also used by the same community members. Thus finally the two districts, Lucknow and Allahabad are kept within the purview of present study.

4.4.2 Selection of Villages :-

Each of the selected districts is constituted of several tehsils and a numbers of development blocks and many hundred of villages therein. A preferential sample of villages was selected keeping the following consideration in view.

1: - Preference has been given to those villages where both types of handpumps, Mark – II and Mark – III are installed.
2: -The village population is such that it represents a stratified sample of small habitation as well as the huge population i.e. village of less population and large population.
3: - The villages are located in such a way to cover the general topography of the district.
4: - Some of the villages may have traditional sources of water also.
5: - Those villages are preferred where conversion is being done.
6: - Some villages are selected from remote countryside, which is rarely accessible, and some are near to the towns.

So many villages were shorted out satisfying above criteria. Only following were chosen using the lottery system.

Table 4.2; details of selected villages:

S.N.	Name of villages	Population (1991)	Number of Hamlets	No. of H Ps	
				IM-II	IM-III
1.	Narausa	1914	9	7	5
2.	Hemrapur	3721	5	16	9
3.	Chandrawal	1311	5	10	5
4.	Bakkas	5433	10	24	12
5.	Raini	1449	3	1	7
6.	Sehuadih	1713	4	7	2
7.	Atanpur	1588	4	5	2
8.	Sariaharkisan	223	2	1	-
9.	Baksera	397	2	3	-
10.	Baijahi	1312	3	6	-

Sample Size;

After visiting all the handpumps installed in the village including hamlets, only few working handpumps were selected for detailed observations. This biased sampling was done in the light of the main objective of study, which is to evaluate the functioning of India Mark–II and Mar–III handpumps. Some of the both types of handpumps are found out of order since installation. To compare the functioning of two types of handpumps, it is more judicious to select them in working order. Also they should be of nearly the same age to equalise the effect of passage of time.

The following points were considered while selecting the handpumps for the detailed investigation s in the field.

1- Handpump must be in working order.
2- Both types of handpumps may be installed in the same year around.
3- May be located in same village or near vicinity.
4- Handpumps may have a running period of 5-6 years or more numbers of year.
5- Handpump may be in use by 50 or more numbers of people.
6- Too new or too old handpumps may be avoided as for as possible.

A number of handpumps fall under this criteria but only forty handpumps were selected for study according to lacal convenience and accessibility. Based on the above factors and considerations, the villagewise break-up of handpumps is presented as below.

Table 4.2: details of samples selected for observations:

Names of villages/ districts	Number of samples selected	
	India Mark-II	India Mark-III
1- Narausa / Lucknow	2	3
2- Hemarapur / Lucknow	1	4
3- Chandrawal / Lucknow	4	1
4- Bakkas / Lucknow	3	2
5- Raini / Allahabad	-	7
6- Sehuadih / Allahabad	-	1
7- Atanpur / Allahabad	1	2
8- Saraiharkishan / Allahabad	2	-
9- Baksera / Allahabad	3	-
10- Baijahi / Allahabad	4	-
Total	20	20

4.5 : Collection of Field Data and Informations :-

As mentioned in the previous sections that this study is aimed for evaluation of functioning of two types of handpumps and certain themes and indicator are evolved for comparison. Some of the indicators are obtained from direct observations and rest is to be extracted from people using the handpump through interviews.

4.5.1 Interviews :-

Discussion at Top Managerial Level:
Drinking water supply in the rural area is being provided through India Mark –II handpumps in most of the districts of the state where ground water of acceptable quality is available. The departmental information regarding selection of handpump, installation procedure and maintenance system of handpump, organisational set-up, activities of department, details of handpump installation programme etc. all information were scheduled to collect from different levels of offices. The office of the Managing Director is the topmost administrative headquarter and hereafter referred as Head Office whereas the office of Executive Engineer is lowest field unit responsible for execution of field works and hereafter refered to as the Divisional Office. The office personnel in Head Office were approached and discussed with the present policies adopted in the water supply sector, the government directives regarding maintenance of handpumps as well as piped water supply systems. Presently only India Mark –II handpumps are being installed in thousands of numbers throughout the state but Mark –III being cornered. The best effort was made to know the reason behind this policy. In this regard Chief Engineer concerned was also approached and his opinion was sought for. The material manager, who is responsible for material procurement to the whole state was also interviewed. The main reason for not purchasing India Mark –III handpumps was asked to material manager. The secretary (management), who is looking for the works management of the whole state, was interviewed. The manager (monitoring) was approached to know the physical progress of handpump installation and repairs for the current year. Also the annual expenditure incurred on repair and maintenance of handpumps was collected from the finance section. The Chief Engineer (E/M), who is also incharge of UNICEF assisted programme, was approached to know the installation progress of India Mark-III handpumps in the state. The required data and other necessary information were collected from there. The hydrogeological cell was visited to gather informations on groundwater and other hydrogeological informations of the state. The research and development wing deals with water quality management of whole state and so the research officer was approached to know the water quality problems in the state.

Discussion at Division Level:
After collecting data from Head Office, the smallest unit, Divisional Office, was visited. The major handpump programme is being implemented and also maintained by these units scattered throughout the state. The head of divisional unit, the Executive Engineer was interviewed regarding the handpump installation project. His opinion regarding adoption of India Mark –II handpumps only was also obtained. The maintenance procedure being followed and various difficulties encountered in the field were discussed with him. The data regarding the handpumps installed till date, number of handpumps out of order presently, the expenditure incurred on maintenance and repair, the number and names of villages installed with India Mark –II and Mark –III handpumps, dates of their installations, maintenance and repair history of handpumps, geological information of area and some strata charts of few boreholes etc. all data available in the office was collected from there. The staff engaged on installation and maintenance of handpumps, like work supervisers, mechanics and members of crew were interviewed for the field problems being faced in the villages. Their limits of working and availability of spare parts, conveyance provided to attend the complains, method of collecting complains, breakdown frequency, down time, type of frequent failures and reason behind that, number of complains for Mark –II and Mark –III and their repair difficulties etc. and so many other information were recorded in the interview. The details and kinds of training given to field staff, practical demonstration of handpump installation

and repair works, the comparative easiness in repair of both types of handpumps, number of complains per month for the both types, availability of spare parts and their overall view about the two types of pumps were gathered during the discussions. The middle level technical staff, like assistant engineer and junior engineers were also interviewed and their experiences regarding functioning of both types of pumps was shared with. Their own constraints being faced in maintenance, Availability of spare parts, easiness in attending complains, help or co-operation gained from users, people's opinion about both types of pumps and their training, caretakers nomination and formulation of village level committee for maintenance, handing over of pumps to users, their main work of priority, promptness shown in repair and their own interest is in repair or installation of handpumps etc. all issues were discussed with.

In the original proposal it was decided to select nine householders for interview all around the handpump within a periphery of 250 m. This distance was taken as norms of handpump installation distance between two handpumps is kept as 500 m and its coverage be about 250 persons each. But in the selected villages it was found that handpumps were installed irrespective of standard distance and coverage norms. Some of the two handpumps were installed too close and also for very less numbers of users. This also created problem in selection of handpumps for study.

4.5.2: Village Visits :-

As and when the basic information and data were obtained, the selected villages were visited. The villages are quite scattered and a variety of people live there divided in different communal, political, social and religious segments and are also guided by some influential person in the village. In general people seldom come to a consensus on the issues like handpump installation sites or any other governmental activity. The gram pradhan, is the head of village, elected by the people and assisted by the members of gram sabha who are also elected and represent their hamlets or segments of population. Most of the important decisions are taken in the meetings of gram sabha by the way of democratic pattern. For collection of detailed informations and correct data, the co-operation of this village body was inevitable.

After a reconnaissance survey of the village, gram pradhan concerned of each village was approached. He was briefed with the purpose of author's visit and requested to call a meeting of the gram sabha. The members of gram sabha were addressed by the gram pradhan and explained about the visit of author. All the members were asked for their co-operation in the study of handpumps and to provide correct data or information about the questions asked. The author also addressed the members and the main purpose of study was made clear to them. The members seemed to be convinced but requested for recommending some more handpumps and to repair those which are out of order for years.

The visit of village was done with respective gram sabha member. All the drinking water sources were located and water point map alongwith house settling pattern was prepared showing lanes, streets, open wells, ponds and natural streams etc. The idea behind this source mapping is that to identify the sources of water collection. All the handpumps installed in the village were visited first before selection for study.

4.5.3 Collecting Field Data :-

Each sample was observed minutely during the field visit, on the technical aspects relating to the indicators. The findings were recorded on an observation sheet prepared earlier. The numbers of households using handpumps was ascertained on the spot and the numbers of persons taking handpump water was counted. The range of coverage by each handpump was decided by measuring the distance upto last household using handpump. First of all the handpump was observed for an overall appearance and then inspected minutely for the discharge, leakage, condition of handpump and condition of platform with drainage. The abstract of each handpump observation is summarised as attached in annexure VII, sheet no. I, II and III.

The discharge of each handpump was measured with the help of a graduated plastic bucket of 20-litre capacity. The pump was run for one minute at a rate of 40 strokes per minute and water collected in the bucket was directly measured according to graduation marks filled. Two to three trials were done to compensate the slight deviation in pumping rate and the average discharge was recorded.

The leakage, first was ascertained by asking people that if the pump yield immediately early in the morning as and when it is pumped. If their answer was found that it yields after sometimes, pump was considered leaky one. Thus the suspected handpump was kept idle at least for five minutes and then pumped at the rated speed to yield the water. The number of strokes taken to start yielding was counted. If this number is found less than three strokes, pump is supposed to be non-leaky and if more, recorded as leaky one.

The condition of handpump was observed for eleven factors in all which are; play in handle, corrosion of parts, loose nutbolts, lack of greasing, damaged handpump, leakage from water tank, missing nutbolts, worn-out slit, handle reversed and loose foundation. The observation were taken in negative aspects, that means, if observation found 'yes' reflects poor condition and '+' sign is given and when found 'No' reflects good functioning and '-' sign is given. In this way the handpump with single positive sign is rated as good, with double positive sign as moderate and those with three or more are rated as bad condition of hand pumps. This approach is followed in accordance with Lloyd and Halmer water quality survey (1991).

While observing the platform conditions and drainage facilities, technical as well as sanitary aspects were considered and thus four factors were observed to measure this indicator. Damaged platform, stagnant water around platform, lack of wastewater drainage and source of pollution within 10 m of handpump were observed and recorded. The rating to platform condition is also given in the same way as that explained before.

Observations on converted handpumps:
A number of such converted hand pumps were seen, for selecting them to study in details, but most of them were found not in running condition and so overlooked. Only three numbers of such converted hand pumps could be found for study and their detailed observations are discussed along with other hand pumps. These are coded as hand pump no. HP22, HP24 and HP28. During interview of users' some additional questions were asked about these converted hand pumps. The additional findings on the converted hand pumps were noted down.

4.5.3 Interview Procedures :-

The purpose of interview was to extract data from the people to quantify the indicators for evaluation. A questionnaire was designed (as annexure-III) in such a way to know the real situations without hammering or displeasing the person interviewed. The aim was to know the volume of water collected per day by each family, usage of the collected water, average failure rate of handpump, average time taken in its repair, reasons for not using handpump water, the maintenance procedure, water quality perception such as colour, taste, odour etc. and after all the general satisfaction with handpump water supply. The existence of water committee and the role of caretakers were also asked for.

During the interview the people were asked in order of sequence of the questionnaire prepared. Regarding amount of water collected per day, they were asked that how many containers of water normally they collect. The containers were checked and their capacity was measured. In general people use metal bucket of 6 to 10 litres capacity. Children generally use smaller buckets. Taking approximate average volume of water collected was recorded in the questionnaire, from which per capita rate of consumption can be calculated. The utilisation of the collected water in different domestic needs like drinking, cooking, utensil washing, bathing etc. was also asked during discussions.

Second stress was given to ascertain the breakdown frequency of the handpumps. People were asked for how frequently the handpump fails and the information was recorded as frequently (for those handpumps which fail in few months) occasionally (fail in one year) and rarely (those fail seldom in 2 or 3 years). Simultaneously the question was asked for the time taken on repair of handpump and the agency involved for repair. The total number of breakdowns since installation was also asked and the procedure of repair was ascertained.

Every householder was asked for using the water source such as handpump or open well in the dry season as well as wet season The water use for cooking, drinking, bathing, washing, gardening cattle feeding etc. were asked and observations marked in the source use matrix. The reason behind the using and not using the handpumps was clarified and recorded accordingly. At last the people were asked for overall satisfaction from the handpump water supply programme and their view were recorded.

With installation of India Mark-III handpumps, one caretaker was nominated for each handpump. Effort was made to interview them. But very few were effective and available for interview. Some available caretakers were interviewed as per prepared questionaire. Their training period, demonstration of handpump repair, duties assigned to them were asked. The effort was made to know from them the breakdown frequency, average downtime, mode of sending failure information, self-repairing capacity, availability of spare parts etc. They were also asked for their interest involved in this work, how much time they devote to look after the handpump.

4.5.4: Water Quality Testing: -

As pointed out earlier that the groundwater quality has two fold effect on the functioning of handpumps. Therefore the quality of water obtained from handpumps under this study has to be tested. Qualitative analysis of the samples, was decided to be conducted in the laboratories established at district head quarters. The department has established a well-equipped laboratory for analysis of important parameters on physical, chemical and biological qualities. At the head office level, there is a research and development unit under the control of Chief engineer (PPRD) and with a well-equipped laboratory run by a research officer and a number of qualified testing staff. But unfortunately this laboratory is also not functioning very well at this time. Some of the very important instruments and apparatus are out of order. The reason behind this was told the shortage of maintenance fund. Anyhow only few parameters were tested in this laboratory and those are: TDS, pH value, chlorides, fluorides, total hardness, sulphates, nitrates, nitrites and alkalinity. The turbiditymeter and electrical conductivitymeter were out of order and biological testing unit was completely closed.

Under these situations, only aforesaid quality parameters were tested for the samples collected from each handpump. During the field visits the samples were obtained personally from the each handpump and reached to the laboratory within 24 hours of collection. In the case of Allahabad district, the laboratory assistant was on leave and also most of the instruments were not working. Hence it was decided to get the samples tested at head office laboratory. The samples collected from Allahabad villages were sent to Lucknow within 24 hours of collection so as to get correct results. Some of the local sources like open wells are also being used by the people for drinking purposes. Samples of such wells were taken for testing. In general handpump water is found almost free from microorganisms. Even though two samples were tested for bacterial contamination in other laboratory run by the State Health Institute, Lucknow.

Following are the villagewise details of water samples collected for water quality analysis.

Table 4.5: details of water samples for quality analysis;

Name of villages / districts	Types of sources of samples		
	I M -II HP	I M -III HP	Wells
1 - Narausa / Lucknow	2	3	2
2 - Hemarapur / Lucknow	1	4	--
3 - Chandrawal / Lucknow	4	1	--
4 - Bakkas / Lucknow	3	2	2
5 - Raini / Allahabad	--	7	1
6 - Sehuadih / Allahabad	--	1	--
7 - Atanpur / Allahabad	1	2	--
8 - Saraiharkishan / Allahabad	2	--	--
9 - Baksera / Allahabad	3	--	1
10- Baijahi / Allahabad	4	--	--
Total	20	20	6

The collection of samples was done in accordance with the procedure suggested as in Indian Standards I S: 3025 and also the testing procedure being followed in the departmental laboratory.

5.1 Outlines :-

A systematic and scientific analysis of the collected data is the first step in approaches, which lead towards the outcome of study. The analysis can be done in different ways. Some authors (Sadhu and singh 1985) mention about two methods; the tabulation and classification of collected data to present it in an organised format. Part of the data gathered, may be in shape of words or texts and their interpretation is always diverse. As Mathew and Huberman (1984) say: " -- and given the facts that words are slippery, ambiguous symbols, the possibility of researcher *bias* looms quite large; we must be concerned with the *replicability* of qualitative analysis."

Thus, the findings from a bundle of field observations and data and to organise them skilfully in meaningful, vivid and acceptable manner that may often prove far more convincing to a reader; are the central idea in the presentation of results.(Mathew et.al.-1984)

In this chapter the analysis have been produced in a sequential order of the objectives of the study. First of all the functioning of hand pumps have been evaluated and the themes and indicators are quantified. The maintenance procedure has been explained. Secondly, the water usage and water quality has been reviewed and lastly the comparative statement on performance of both types of hand pumps is presented.

5.2 Brief Dricption of Study Area :-

A brief description of study area is given as below.

Lucknow District:-

This being the capital of state, is a prominent town covering an area of 2528 sq. km. and a total population of 2,762,801(1991 census) out of which 63% people live in rural areas. It is located between latitudes of 26^0 $30'$ & 27^0 $10'$ N and longitudes of 80^0 $30'$ & 81^0 $13'$ E. The general topography of the district is quite plain, being amidst of alluvial belt between the rivers the Ganga and Yamuna. The main river passing through the district is Gomti, a tributary of Ganga River system. Lucknow town being the main administrative headquarters with four sub-divisions and nine developments blocks. There are 897 revenue villages , all covered with water supply through handpumps. There are about 8000 nos. of India Mark – II and Mark – III handpumps installed upto last December 1997. The literacy rate in urban towns is 64% whereas only 33.2% in rural areas. There are three climatic seasons; winter summer and rains, each approximately of four months duration in a year. Average annual rainfall is between 900 to 1100 mm. The temperature varies between 4.3^0 C in winter to 44.5^0 C in summer. The relative humidity varies from 19% to 86%. (Source census records)

The uppermost layer of alluvium is composed of loam, silt and clay in varying proportion down to a depth of about 62-m b.g.l. The ground water occurs in pore spaces of unconsolidated alluvial material in the zone of saturation. Water table in open wells varies from 3. 96 m to 29 .3 m bgl with a fluctuation of - 2.5 to 3.8 m in the Gomti catchment. Ground water flows from north east to westwards and southwards and from north to south, to north of Gomti river, with a hydraulic gradient ranging from 1.0 m / km to 0.33 m / km. The entire district is full of ground water, with a net annual resource of 818.779 m cum. Whereas the annual ground water drawoff is only 429. 871 m cum .
This makes a stable background behind the success of handpump programme in the district (source : CGWB, India)
The villages selected from this district are summarised as below;

Table 5.1 details of selected villages;

Particulars	Names of selected villages			
	Narausa	Hemrapur	Chandrawal	Bakkas
▪ Location w r.t. HQ	N	W	S	E
▪ Distance from HQ	45 km	40 km	30 km	20 km
▪ Numbers of hamlets	9	5	5	10
▪ Population (total)	1914	3721	1311	5433
▪ Area sq. kms	402	381	495	731
▪ Numbers of households	343	612	231	907
▪ Numbers of houses	342	609	231	895
▪ Population density/sq.km.	4.76	9.77	5 67	7.43
▪ Schools	P S	P S+JHS	P S	P S (2 nos)
▪ Hospitals	MWS	--	MWC	PHC
▪ Water Supply Handpumps (UPJN) Handpumps (others)	 12 2	 21 4	 11 4	 30 6
▪ Traditional sources	O W	None	O W	O W
▪ Numbers of cattles	875	655	921	1870
▪ Groundwater table	2.00m	18.00m	14.00m	5.00m
▪ General topography	Plain	Plain	Plain	Plain
▪ Drinking water problem	No	Yes	yes	Yes

HQ- head quarter (of district), MWC- mid wifery centre
PHC- primary health centre, PS- primary schools
OW- open well, UPJN-Uttar Pradesh Jal Nig

Allahabad District :

Allahabad, the religious town of north India is situated at the confluence of rivers Ganga and Yamuna, covering an area of 7261 sq. km. has a total population of 4,921,313 out of that79% people live in rural area. It is located between the parallel of latitudes of 24^0 47′ & 25^0 47′ N and longitudes of 81^0 09′ & 82^0 21′ E. The district has a mixed physiography mainly divided in three units; the trans-Ganga, Doaba and trans-Yamuna. Trans-Ganga, occupies the area north to river Ganga, essentially a plain countryside. The general slope is towards east and south-east. Doaba region falls between Ganga and Yamuna and makes a high ridge of alluvium soil. The trans Yamuna is the largest physiographic unit popularly known as Yamunapar. Hilocks are conspicuos in area. Rocky outcorps of various dimensions produced rugged topography. The ground level varies between 171. 24 msl to 104. 8 mal. The district represents a complex geology. The formations belonging to quarternary period, cover a large part which directly overlies on the Vindhyan formation that cover a bulk of district area. The southern plateau area constitutes the Vindhyan sedimentary whereas the quaternary covers the northern part of district. In general the quaternary constitutes of alluvium ; sand, silt, clay, canker and laterites and Vindhyan range that of sandstone and shales.

Ground water occurs within the primary porosity of alluvium sediments in the north, the aquifer material being medium too coarse sand and are unconfined at shallow depths and semi-confined at deeper depths. Depth of water table varies between 2.0 m to 20.0 m. In Doaba area it is between 4.5 m to 18 m and in Yamunapar region the water availability and its movement demonstrates a markable variation from place to place due to heterogeneity of formations.

The district is divided in nine administrative subdivisions or tehsils and twenty seven development blocks with a total of 1827 revenue villages. Most of the villages are covered with drinking water supply through piped water or handpumps. There are about 150 nos. of piped water supplies as well as about 18,000 nos. of India Mark–II and Mark–III installed allover the district. Three climatic seasons, winter, summer and rainy are found there. The mean annual nos. of rainy days is 53 and the average annual rainfall is 959.10mm. Maximum temperature is in summer, 45.6^0 C and 5^0 C minimum in winter. The district has a sufficient ground water potential of 1849.34 million cum. Whereas the annual ground water drawoff is only 496.65 m cum. Leaving a sufficient reserve for future exploitation in drinking water supply and irrigation. All of the rural piped water supply schemes constructed on groudwater as a source of water.

The villages selected for study in the district are summarised as below.

Table 5.2 details of selected villages;

Particulars	Names of villages					
	Raini	Sehuadih	Atanpur	Saraiharkisan	Baksera	Baijahi
-Location w.r.t HQ	N	N	NE	NE	N	WE
-Distance w r.t HQ	55 km	50 km	45 Km	45 km	40 km	40 km
-Number of hamlets	3	4	4	2	2	3
-Population (1991)	1449	1713	1588	223	397	1312
-Area in sq. km	277.62	644.30	323.10	53 02	158 02	219.75
-Number of H H	168	257	291	29	79	216
-Number of houses	163	252	267	29	78	212
-Popu.density/sq km	5 21	2 66	4.51	4 2	2 5	5.97
-Schools	P S	P S	P S	--	--	P S
-Hospitals	MWC	MWC	MWC	--	--	MWC
-Water Supply UPJN handpumps Others handpumps	 8 -	 7 2	 6 1	 1 1	 1 2	 5 1
-Traditional source	OW	OW	OW	OW	OW	OW
-Groundwater table	5 m	5.5 m	6 m	7 m	7 m	6 m
-Topography	Plain	Plain	Plain	Plain	Plain	Plain
-Scarcity of water	Yes	Yes	No	Yes	Yes	yes

H H- Households

5.3 Review on Functioning of Handpumps :-

The following themes and indicators are observed to evaluate the functioning of handpumps.

1:- Pump Discharge:-

This study is oriented on the functioning of India Mark-II and Mark-III hand pumps and in all forty numbers of pumps; each type 20 nos. was selected for observations. The measured discharge of all the hand pumps is presented in the appendix III

(Observation sheet-I) The abstracts of the discharge found in different villages are tabulated as below.

Table 5.3: discharge of hand pumps in selected villages;

Name of villages And districts	Discharge in Litres per minutes	
	India Mark-II	India Mark-III
	Discharge	Discharge
Narausa / Lko	20 , 16#	11#, 4#, 16
Hemrapur / Lko	12	11#, 14, 11#, 11#
Chandraswal / Lko	11.5#,14, 10, 15	13
Bakkas / Lko	14, 10, 12, 14#	11.5
Raini / Alld.	-- -- --	10,10,9#,8#,10#,11#,12
Sehuadih / Alld.	-- -- --	11
Atanpur / Alld.	11	8 ,12
Saraiharkishan / Alld.	9,14	-- -- --
Baksera / Alld.	12,12,12	-- -- --
Baijahi / Alld.	10, 10, 9, 11	-- -- --

 # - leaky hand pumps

All the forty handpumps were run for measuring the discharge and the measurement was taken as per procedure discussed in methodology. Some of the pumps were giving sufficient discharge while few gave very less therefore user were unsatisfied with those.

2:- Leakage : -

All the handpumpswere checked for leakage by asking the users as well as by self observations. Out of twenty visited India Mark-II handpumps only three were found leaky whereas nine number that of India Mark-III were leacky. It is worth notable that most of leaky handpumps are giving less discharge. In the table 5.3 the discharge figures marked with # were found leaky one.

3:- Reliability: -

At present, in the selected districts, the centralised maintenance system being followed by the executing agency itself for both types of hand pumps. The data regarding breakdown frequency and down time for each hand pump has been obtained during the interviews.

(a) Breakdown frequency : -

The breakdown frequency is the number of times a hand pump goes out of service normally during the service period. This data has been collected from the householders' interview. The frequency as classified in the methodology, has been worked out and tabulated as below;

Table 5.4 numbers of hand pumps based on breakdown frequency:

Names of Villages/Distt.	Breakdown Frequency					
	Frequently(<6M)		Occasionally(<1Y)		Rarely (> 1 Y)	
	I M-II	I M-III	I M-II	IM-III	IM-II	I M-III
Distt.- Lucknow						
Narausa	1	1	--	--	1	2
Hemrapur	--	--	1	3	--	1
Chandrawal	1	--	--	1	3	--
Bakkas	1	1	1	--	1	1
District total	3	2	2	4	5	4
Distt. Allahabad						
Raini	--	1	--	2	--	4
Sehuadih	--	--	--	1	--	--
AtanPur	--	--	1	--	--	2
Saraiharkisan	1	--	--	--	1	--
Baksera	1	--	--	--	2	--
Baijahi.	4	--	--	--	--	--
District total	6	1	1	3	3	6

In the above interview, a little variation was found from person to person but the overall situation was almost clear to ascertain the breakdown frequency. The responses of all the householders are given in the appendix (annexure-IX) attached. Most of the people responded well while some were found unknown about hand pump breakdowns and repairs. Such houses were situated at outer periphery of hand pump coverage range and having vicinity of other hand pump or own source. It can be seen from the above table that only 9 nos. India Mark-II handpumps are found failing frequently as against only three India Mark-III. It is worth to note that about half of the both hand pumps, fail rarely i.e. two to three years. Also some of the hand pumps were found working non-break since very beginning of their installation and that for a period of five years or so. It is found that the sturdiness of both types of hand pumps is unchallenged

(b) Down time : -

During the interview with householders, effort was made to obtain the down time in reality. About 300 of householders were approached and there opinion, regarding down time of the hand pump they use, are abstracted in the appendix (annexure-IX) attached with. Some of the handpumps were repaired by the villagers themselves.

In the following table, average down time is summarised as per responses obtained. As for as type of hand pump is concerned, no difference was observed between I M-II and I M-III with regard to down time except some ease in repair work. Those hand pumps, which did not fail since their installation, have been reckoned with down time of more than a month, because they are supposed to be repaired by the central agency.

Table 5.5; Numbers of hand pumps with respect to down time;

Name of Villages/district	Average down time of hand pumps					
	< 1 week		< 1 month		> 1 month	
	IM-II	I M-III	I M-II	I M-III	I M-II	I M-III
Narausa/Lko	--	-	--	--	2	3
Hemrapur/Lko	1*	4*	--	--	--	--
Chandrawal/Lko	1*	--	1	1	2	--
Bakkas/Lko	1*	--	--	--	2	2
Raini/ Alld.	--	--	--	1*	--	6
Sehuadih/Alld.	--	--	--	--	--	1
Atanpur/Alld.	--	--	--	--	1	2
Sariaharkisan/Alld.	1*	--	1	--	--	--
Baksera/Alld.	--	--	1	--	2	--
Bajahi/Alld.	1	--	3	--	--	--
Total	4*, 1	4*	6	1*, 1	9	14

* hand pumps repaired by people themselves.

It can be seen from the table that most of the hand pumps has a down time of one month or more. In those villages where there is scarcity of drinking water and hand pumps are only dependable source of water supply, people get the hand pumps repaired themselves within a week, irrespective of its type i.e. whether I M-II or I M-III.

4: Coverage:-

A hand pump is supplying water to how many people may be called as it coverage. The number of person using the hand pump water was counted, going door to door in during the observations of pumps and the detailed in the annexure (observation sheet no. –I). The following table shows the users in an interval of 50 persons.

Table 5.6 Hand pump used by number of persons;

Numbers of Users in group	Number of hand pumps			
	Lucknow district		Allahabad district	
	I M – II	I M – III	I M – II	I M – III
50 –100	5	2	4	5
100 – 150	2	2	2	2
151 – 200	-	1	3	3
201 – 250	1	1	1	-
251 – 300	2	-	-	-
301 – 350	-	3	-	-
350 –400	-	1	-	-
Total	10	10	10	10

From the table it can be seen that most of the visited handpumps are not being used optimally. Also worth to note that in Allahabad district, most of the handpumps are being used by too less persons.

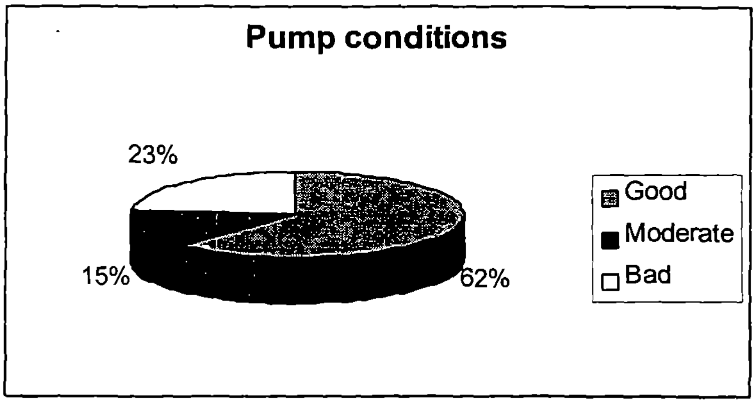
5: Pump condition:-

All the hand pumps were closely inspected for the following eleven factors which reflects the functioning of hand pumps as shown in the table. The hand pump wise detail has been attached as annexure-VII (sheet-III) in the end. A suitable rating have been given to each hand pump according to their condition found in the field. As described in methodology.

Table 5.7 Hand pump conditions;

Characteristics observed	Observations							
	Lucknow district				Allahabad district			
	I M – II		I M – III		I M – II		I M - III	
	Yes	No	Yes	No	Yes	No	Yes	No
Lateral play in handle	3	7	5	5	5	5	2	8
Clear sign of corrosion(CP)	1	9	1	9	1	9	-	10
Loose nutbolts (LN)	1	9	2	8	1	9	-	10
Lack of greasing (LG)	6	4	8	2	7	3	5	5
Damage to handpump (DH)	1	9	-	10	-	10	1	9
Damaged bearing (DB)	3	7	2	8	2	8	-	10
Leaking tank (LT)	1	9	1	9	1	9	1	9
Missing nutbolts (MB)	2	8	2	8	2	8	2	8
Worn out slits (WS)	2	8	1	9	2	8	2	8
Handle reversed (HR)	-	10	1	9	-	10	-	10
Loose foundation (LF)	-	10	1	9	2	8	-	10

On the basis of observed factors as shown in the table, the overall rating as described in methodology(good, mderate and bad) for condition of hand pumps have been given as shown in following pie chart It is seen that the majority of visited hand pumps are found in good conditions while a little are in bad conditions and merely few in moderate condition.



6: *Platform Condition:-*

All the platforms have been observed for the following four parameters considering the technical and sanitary aspects of the environment.

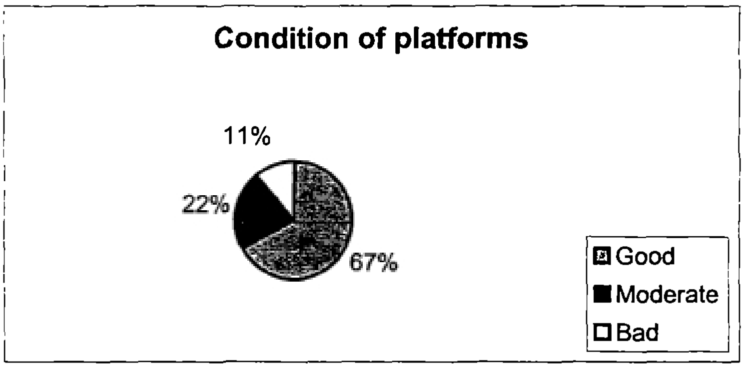
1- Whether the platform is constructed as per prescribed dimensions around hand pump and it is damaged or not.
2- Is there stagnant pool of water around the hand pump.
3- Is the hand pump lacking in drainage for disposal of waste water?
4- Is there any latrine, septic tank or animal shed in the near vicinity of the hand pump i.e. the source of pollution within ten metres of hand pump.

The observation of each hand pump are attached in the annexe-VII (sheet-III) and also summarised in the following table.

Table 5.8; platform conditions.

Parameters Observed	Lucknow district				Allahabad district			
	I M –II		I M –III		I M –II		I M -III	
	Yes	No	Yes	No	Yes	No	Yes	No
Damaged platforms	-	10	3	7	3	7	2	8
Stagnant water	1	9	1	9	3	7	-	10
Lacks in drainage	-	10	3	7	1	9	-	10
Source of pollution	1	9	-	10	1	9	-	10

On the basis of above findings the rating is provided to each hand pump as shown in the following pie chart. It is seen that majority of hand pumps platforms is found in good condition and a very few are in bad condition.



7: ***Water quality***:-

The water sample from each hand pump collected has been tested in the laboratory for the parameters, which have potential effect on functioning of hand pumps are tabulated as below. The results in details, are summarised in the forthcoming table under review on water quality.

Table 5.9 :number of handpumps, water quality (WHO guidelines followed);

Quality Parameters tested	Lucknow district				Allahabad district				Wells	
	IMII-(nos)		IMIII(nos)		IM-II(nos)		IM-III(nos)			
	A	R	A	R	A	R	A	R	A	R
TDS	10	-	10	-	10	-	10	-	3	3
PH	10	-	10	-	10	-	10	-	6	-
Chlorides	10	-	10	-	10	-	10	-	3	3
Fluorides	10	-	10	-	10	-	10	-	5	1
Hardness	10	-	10	-	9	1	10	-	4	2
Sulphate	10	-	10	-	10	-	10	-	5	1
Iron	7	3	5	5	10	-	10	-	6	-
Ntrate	10	-	10	-	10	-	10	-	6	-

A- acceptable on WHO guidelines
R- rejectable on WHO guidelines

It can be seen that most of the quality parameters are well within the acceptable limits except iron in some of the handpump water.

8: ***Quantity :-***

The quantity of water extracted from each hand pump is worked out as shown in observation annexure-VII (sheet –I)..The results are tabulated as lightly used, moderately used and heavily used according to the quantity of water extracted Arlosoroff mentions the quantity of water use up to 8 kl/day and the minimum discharge of a handpump as 0.2 lit/sec. Thus the quantity of water extracted below 4 Kl/day is considered less utilised, 4-8 as moderately utilised and above 8 KL/day as heavily utilised. Following table represents the results.

Table 5.10 quantity of water extracted from hand pump

Category of Utilisation	No. of handpumps		Total
	I M – II	I M–III	
Lighly used(< 4k l)	12	13	25
Moderately used(4-8kl)	8	4	12
Heavily used(> 8 k l)	-	3	3
Total	20	20	40

It is clear from the table that about more than half hand pumps are under utilised and too less are put to optimum utilisation.

Findings from conversion Programme:-

As stated earlierthat in Allahabad district there was conversion of India Mark-II handpumps to that of India Mark-III. Following are the additional findings on the converted handpumps.
It can be assessed that the conversion programme is not very attractive among the users and also it is not feasible in most of the cases to utilise the same borewell for I M –III pumping machinery.

Table 5.11; Findings on converted handpumps

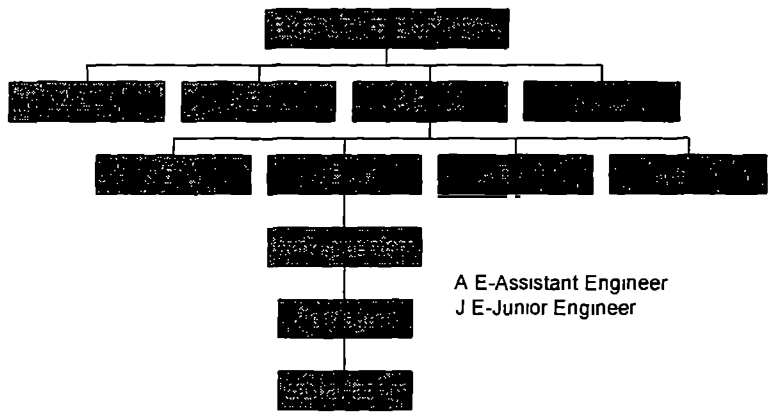
Particulars	HP Code	Originally I M –II	Converted to I M –III
Discharge	HP22	More before convert	After convert-10 lpm
	HP24	More before convert	After convert- 8 lpm
	HP28	No change	No change
Users' view on Functioning	HP22	It was better	Not too good
	HP24	It was better	Not good, giving sand
	HP28	No difference	No difference
Repair easiness	HP22	Mechanic required	Easy to repair
	HP24	Mechanic required	Easy to repair
	HP28	Mechanic required	Easy to repair

5.2: Maintenance Organisation :-

5.2.1 General Set-up :-

The operation and maintenance of hand pump is entrusted to the divisional units, which are also responsible for installation of hand pumps. The structure of hand pump maintenance units is as follows.

Structure of Divisional Unit



Each district of the state has been provided with at least one divisional unit, sometimes more according to work load in the district. Executive engineer empowered with drawing & disbursement, decision making and assisted by four assistant engineer's heads the division. Again assistant engineers are responsible for the all works at sub- division level. There are four to six junior engineers under each assistant engineer who look for work directly in the field at block level. Each junior is provided with root level field staff like work supervisor and work agents. The number of field staff varies according to workload of junior engineer. All the works entrusted to the divisional units is carried out through this team of field staff.

Training of staff:

The most of the field staff like work supervisor and work agents are trained for the installation and maintenance of hand pumps. The technical staff like assistant engineer and juniors is also trained for different types of works from time to time.

Policy on Operation and maintenance:

Since beginning of hand pump programme in early eighties, it was supposed that the maintenance would be done by the respective gram panchayats (the ellected village body). But with the major failure of hand pumps, due to lack of technical know- how, the maintenance is now entrusted to the executing body itself which is UP Jal Nigam . The funds for maintenance are made available in the annual budget by the government.

5.2.2 Maintenance procedure:-

At present centralised maintenance system is being followed in the both districts selected for this study. Each divisional unit has trained maintenance staff, posted at every block level. The failure report of hand pump is obtained from the villagers in the division office, via posted letters or personally handed over by gram pradhan or any village member. Some pre- printed and pre- stamped self-addressed post cards are also distributed among the villagers. Recently the kisan sewa kendras (the farmers' service centre) have been started by the state government, where all the complains of the villagers are recorded by an officer and then it is sent to the divisions of concerned department for immediate compliance. Some complains are received at the block development offices and also a complain register is kept there for lodging complains by the villagers.

Thus the complains collected from all the sources, is sent to the assistant engineer and thereby to junior engineer concerned of the area and the field staff; work supervisor or work agents are directed to visit the hand pump and get it repaired. The field staff is equipped with maintenance tools and few spare parts of general replacement. The work supervisor goes for a search of mechanic in the area and engages some casual labour required to taking out riser pipes and cylinder assembly etc. The hand pump is set right with available spare parts. Sometimes if any spare part is not available with, the supervisor comes back to divisional store to collect it and then go back to repair the hand pump. In this way different field staff posted in the blocks repairs the hand pumps of each block. In each block there are about 800 – 1000 numbers of hand pumps installed on an average throughout the state. Nearly the same procedure of maintenance is being followed in most of the districts of the states.

5.2.3: Community Involvement & Role of caretakers:-

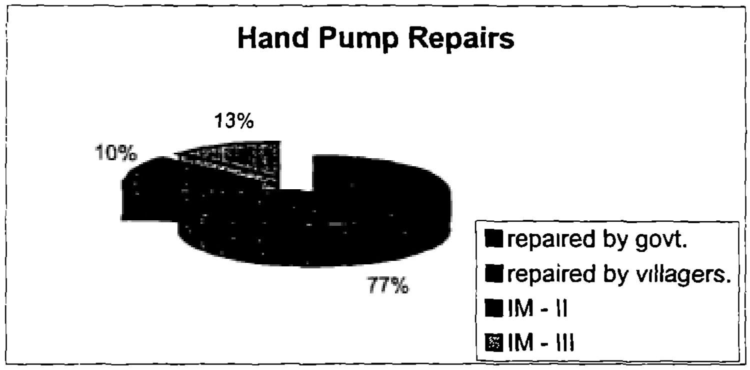
There is very little involvement of beneficiaries in the hand pump installation as well as in maintenance system. In some of the external supported programmes, such as Dutch Assisted Programme and UNICEF programmes, community participation component have been introduced and village level committee were constituted for maintenance. The districts under study area are covered with UNICEF programmes and all India mark–III hand pumps were installed with material support from UNICEF and community participation was ensured through some NGO (non-governmental organisation). Before installation of these hand pumps, the NGOs approached villagers, sites were selected in consultation of community and one caretaker was nominated for each hand pump.

During the field visits the caretakers were tried to contact. Some were available and most of them doing even nothing to look after the hand pumps. Very little felt some responsibility and were cautious about cleanliness and abuse of hand pumps. Out of twenty, I M–III hand pumps visited, only five caretakers were available and that too only three were active to some extent. The caretakers were least bothered about the maintenance of hand pumps. Even some of the hand pumps were noticed which needed immediate replacement of some components like bearings, handle axle, cupseals etc. But they even did not feel necessary to report the maintaining agency. In reality the caretakers were found almost non-functional. As for as maintenance is concerned, both types of hand pumps, I M–II & I M–III, are being maintained in the way by the agency.

Following table shows the status of maintenance of all the hand pumps under the purview of this study.

Table 5.12 maintenance status of hand pumps.

Description of repairs	Age group Of H P	Frequency Of repair	No. of hand pumps	
			I M –II	I M –III
Replacement of Cupseals	4 - 5 yrs.	Once	-	2
	5 – 6 yrs.	Once	1	5
		Twice	2	-
	8 – 9 yrs.	Thrice	6	-
	2 – 3 yrs.	Once	-	1
Bearing replacement	8 – 9 yrs.	Once	4	2
Handle / axle repair And replacement	8- 9 yrs.	Once	3	1
	5 – 6 yrs.	Once	-	1
Chain repair or Replacement	8 – 9 yrs.	Once	4	-
	5 – 6 yrs.	Once	-	1
Riser pipe repair Or replacement	5 –6 yrs.	Once	2	-
	8 – 9 yrs.	Once	3	-
Connecting rod Replacement	8 – 9 yrs.	Once	3	-
	5 – 6 yrs.	Once	2	1
	2- 3 yrs.	Once	-	1
Platform repair	5 – 6 yrs.	Once	2	-
	4 – 5 yrs.	Once	-	1
	3 –4 yrs.	Once	1	-
Not any repair	2 – 3 yrs.	-	5	4
	5 – 6 yrs.	-	-	1
	6 – 7 yrs.	-	1	-



From the above table it can be seen that the maximum number of hand pumps required replacement of cupseals for two to three time and also frequency is more for older hand pumps. The incidents of bearing, chain and riser pipe replacement is also more for older pumps. It is noticeable that I M–III hand pumps have less numbers of repair interventions in comparison to I M–II.

The villagers themselves with the help of local artisans repaired some of the both types of hand pumps. It is also worth noticeable that there is no problem in rectifying either I M–II or I M–III hand pumps. Following pie chart reveals the position of repairs by governmental agency and villagers.

5.2.4: Supply of Spare Parts:-

The superintending engineer at the circle level does the management of spare parts required in the maintenance of hand pumps. The annual demand of each component part is obtained from all divisional units and tenders are invited from licensed manufacturers of parts or the approved suppliers. Only ISI marked (Indian standard Identification) parts are received in the governmental supplies. All materials are kept in the central store at division level and issued to juniors as and when demanded. The spare parts are also available in open market but mostly non- ISI marked and locally produced. In repair work, carried out by villagers themselves, locally available non-ISI marked spare parts are used.

5.2.5: Expenditure on Operation & Maintenance:-

The expenditure incurred on maintenance of hand pumps is met with the budget provision of the division in each financial year. The ten percent of the funds allocated for works under hand pump programmes like, Minimum Need Programme (MNP) and Accelerated Rural Water Supply Programme (ARWSP) is expent on the maintenance of hand pumps installed the district. The main expenditure comes out on the supply of spare parts and the breakdown repair of temporarily out-of order hand pumps. Also the salaries of field staff and their travelling allowances are included in maintenance expenditure. Besides, there are many hand pumps that are permanently out-of order, due to number of reasons. These are rejuvenated under some special programme run by the state government. Regarding maintenance cost following information are collected as shown in the table below.

Table5.13; Repair of hand pumps:

Particulars	Total nos. Of HP	H P out- of order		% age of failure	
		Temp.	Permanent	Temp.	Permanent
Lucknow	8223	1088	265	13.25	3.25
Allahabad	12930	3332	590	26.75	4.50
All UP	611118	80957	24365	13.25	4.00

(the figures shown are 1- 4- 97 to 31–1– 98)

It can be seen from the above table that about 15% of hand pumps installed in the state are always under repair because it being a continuous process of failure and repair. At the same time 3-5 % of hand pumps are found permanently dissabled due to certain reasons. There is no separate break-up of I M –II and I M –III hand pumps available neither at divisional units nor at head office.

The total expenditure incurred on repairs at state level is reported as Rs. 115,314,000 and a total of 76,390 numbers of hand pumps were repaired during the aforesaid period. With this figure, the average repair cost per hand pump work out to Rs. 1510 per hand pump. Out of this more than half may for the salary of field staff. If it is deducted, the actual repair cost may come down to a tune of Rs. 600- 700 per hand pump only.

5.3: Review on Water use and Water Quality : -

5.3.1: Water use : -

The purpose of providing water facilities is to increase the water use for all domestic purposes. The volume of water collected from any source of water, gives the idea about water use pattern within the households. Following points are considered while evaluating water use in the study area;

-- quantity of water used for all purposes.
-- convenience of water point (distance of water point)
-- availability of traditional sources.

The findings on the water use and availability of traditional sources are given in detail alongwith abstract of house holders' interview as annexed at the end annexure-IX. Following table explains the overall situation of water use in the study area.

Table. 5.14: Average rate of water use :

Water use in lpcd	Nos. of households(frequency)		Total
	Lucknow	Allahabad	
0 – 5	4	-	4
5 – 10	11	1	12
10 – 15	31	20	51
15 – 20	30	48	78
20 – 25	28	23	51
25 - 30	23	26	49
30 – 35	16	17	33
35 – 40	11	6	17
40 – 45	1	1	2
Total	155	142	297
Average	21.4	22.7o	-

Table 5.14 shows the frequency distribution of householders for water use on a class interval of 5 lpcd. It is seen that maximum number of householders use 15 – 20 lpcd of water in both of the districts. About 80% of householders were found using water between a range of 15 – 35 lpcd and about 10% using around 40 lpcd of water. Some families collect even too less water, that is below 10 lpcd. The average water use in both of the districts, Lucknow and Allahabad, work out to 21.4 lpcd and 22.70 lpcd respectly.

Table 5.15; Water usage and reasons for use or non-use;

Distance in m	Source Of Use	Nos. of householders using water for										Reason for use /no use
		Drinking		Cooking		Bathing		Cloth washing		Others		
		D	W	D	W	D	W	D	W	D	W	
0 – 50	H P	266	205	226	205	220	199	221	200	221	200	SC
	OHP	1	1	1	1	1	1	1	1	1	1	OS
	OW	4	4	4	4	13	13	13	13	13	13	OS
	PS	2	2	2	2	2	2	2	2	2	2	PC
50 – 100	HP	61	48	61	48	57	57	57	57	57	57	SC
	OHP	1	1	1	1	1	1	1	1	1	1	OS
	OW	5	5	5	5	12	12	12	12	12	12	OS
	PS	-	-	-	-	-	-	-	-	-	-	-
100 - 150	HP	7	7	7	7	7	7	7	7	7	7	NAS
	OHP	1	1	1	1	1	1	1	1	1	1	OS
	OW	2	2	2	2	2	2	2	2	2	2	OS
	PS	-	-	-	-	-	-	-	-	-	-	-

HP-handpump,
OHP- own handpump,
OW- own well,
PS- piped supply
SC- source convenient,
OS- own source,
PC- private connection, NAS-no alternative source

Table 5.15 shows the water usages in various domestic needs. It is very clear that majority of householders collect water from hand pumps for their drinking and cooking needs. Very few families use their own open wells or own hand pumps for all of domestic purposes

5.3.2; Water Quality: -

As stated earlier that water quality leaves influence on the functioning of hand pumps. And so the water samples of all visited hand pumps have been tested. As some people are using some well water for drinking, a total six numbers of well water was also collected for testing. The test results of following quality parameters are summarised as in table 5.16.

Table 5.16

Water Quality Parameters

Name/ distt Of Village	HP code	HP type	source of water	TDS	pH	Chlorides	Fluorides	Total Hardness	Sulphate	Iron	Nitrate
				Chemical Parameters (in ppm)							
Narausa/Lko	HP 1	III	BW	500	7 5	10	0 75	288	-	0 5	-
	HP 2	II	BW	520	7 5	10	0 9	312	24 4	trace	-
	HP 3	III	BW	490	7 5	18	0 6	272	19 2	1	-
	HP 4	II	Bw	520	7 5	11	0 5	296	19.2	0 6	-
	HP 5	III	BW	486	7 5	8	0 5	288	9 6	0.2	-
		W 1	OW	**1320**	7 9	230	0 3	500	211 2	0 15	8 86
		W 2	OW	**788**	7 5	34	0 3	450	28.8	0 1	0 22
Hemrapur/Lko	HP 6	III	BW	400	7 5	10	0 3	240	-	0 4	-
	HP 7	III	BW	410	7 5	10	0 4	244	-	0 4	-
	HP 8	III	BW	420	7 5	11	0 3	264	-	0 3	0.44
	HP 9	III	BW	460	7 5	12	0 6	300	trace	0 5	0 22
	HP10	II	BW	380	7 5	14	0 25	200	-	0 3	-
Chandraval/Lko	HP11	III	BW	480	7 5	20	0 5	240	-	trace	-
	HP12	II	BW	500	7 5	28	0 5	260	9 6	0 2	-
	HP13	II	BW	490	7 5	30	0 25	250	9 6	trace	-
	HP14	II	BW	480	7 5	24	0 5	246	9 6	0 5	-
	HP15	II	BW	470	7 5	28	0 25	230	-	0 4	-
	HP16	III	BW	400	7 5	10	0 25	248	14.4	0 2	-
Bakkas/Lko	HP17	II	BW	420	7 5	17	0 25	296	14 4	0 3	-
	HP18	II	BW	416	7 5	8	0 25	246	19 2	0 2	-
	HP 19	III	BW	420	7 5	10	0 3	240	-	0 1	-
	HP20	II	BW	410	7 5	11	0 3	226	trace	0 2	-
		W 3	OW	**2312**	7 8	412	0 4	**1296**	384	0 1	**48.7**
		W 4	OW	**2008**	7 8	498	0 4	**720**	**576**	0 15	**44.3**
Raini/Alld	HP21	III	BW	480	7 5	50	0 75	224	48	0 2	-
	HP22	III	BW	490	7 5	20	0 4	248	38 4	0.02	-
	HP23	III	BW	480	7 5	22	0 4	280	38 4	0.05	-
	HP24	III	BW	520	7 6	16	0 3	316	28 8	0 05	0 44
	HP25	III	BW	500	7 5	20	0 75	276	28 8	0.05	-
	HP26	III	BW	500	7 8	22	0 6	324	19 2	0 1	4 46
		W 5	OW	470	7 5	38	1 6	264	19 2	0 02	-
	HP27	III	BW	550	7 8	44	0 6	344	48	0 1	-
Sehuadih/Alld	HP28	III	BW	460	7 5	13	1	224	19 2	0 1	-
Atanpur/Alld	HP29	III	BW	460	7 5	13	0 5	236	-	0 2	-
	HP30	III	BW	500	7 8	16	0 5	336	-	0 2	-
	HP31	II	BW	640	7 6	80	0 4	380	48	0 1	0 44
Sarai H /Alld	HP32	II	BW	**1880**	7 9	**890**	0 4	**580**	38 4	0 1	0 88
	HP33	II	BW	480	7 5	29	0 4	252	-	0 15	-
Baksera/Alld	HP34	II	BW	496	7 7	43	0 5	294	9 6	0,15	-
	HP35	II	BW	568	7 6	55	0 4	382	4 8	0 1	-
	HP36	II	BW	440	7 5	13	0 4	254	4 8	0 1	-
Bajahi/Alld	HP37	II	BW	556	7 5	13	0 3	338	-	0 01	-
	HP38	II	BW	608	7 5	49	0 3	318	-	0.1	-
	HP39	II	BW	826	7 6	93	0 3	250	28 8	0 8	2 22
	HP40	II	BW	492	7 5	17	0 3	318	-	0 15	-
		W 6	OW	**698**	7 8	47	2	400	4 8	-	0 44

5.3.3 Users' Satisfaction :-

Overall view about the handpump was sought during the interview. Most of the people were found almost satisfied with the water supply system through the handpumps. Out of 297 persons interviewed using all 40 numbers of handpumps, only 23 porsons (7%) were found unsatisfied insufficient water quantity that too in case of only three handpumps. Water quality of most of the handpumps was acceptable to villagers. Only 38 (13%) persons complained for bad quality of water around five handpumps and four out of these are in Lucknow district and only one in Allahabad district. Handpump users were almost found satisfied with handpumps.

5.3.4 Some additional findings:

During the interviews with users', some interesting facts about the use and operation of hand pumps came out. Few hand pumps were found with their handles just reversed towards the spout side. People were asked for this reversion, one reply was the convenience in using hand pump water for bathing or drinking by a single person alone without use of any bucket or can. Another reason was stated, the inconvenience caused by a long handle. It created obstruction in movement of public as well as vehicles or animals, in some of the narrow localities and people got it reversed them very easily. Some of the village women were asked to start pumping water, just to observe their operating mode. It was seen that most of the women put their hands around the mid point of handle and started pumping easily. The handles of these pumps were closely watched. It was noticed that has turned too smooth in the middle and upward side. This smoothness reveals that the hand pump has been operated most of the times from the middle of the handle by a numbers of people. Especially for India Mark –III hand pumps, separate bathing platform were constructed, even then the people were seen bathing just below the spout on the platforms constructed around hand pumps. It was convenient, according to them, to draw more water easily for complete bathing and cloth washing. This created splashing of wastewater around the hand pump and polluting the surrounding environment.

This chapter provides the detailed discussions on different parameters observed as presented in the result chapter. The interlinkage between the indicators and the functioning of handpumps has been described and comparisons have been made on the basis of results obtained. The chapter starts with discussion on functioning of handpumps and the relationship of various parameters involved in the study. Further it provides a table for assessment of overall functioning of both types of handpumps.

6.1 Functioning of Handpumps :-

The study of various literatures related to the topic provided the basic information on the parameters, which had influence on the functioning of handpumps. The relevant parameters were made indicators as mentioned in methodology, and observed in the field as presented in the results. On the basis of literature review, a handpump can be called well functioning only when it provides the specified discharge, be reliable, non-leaky, covering desired population, supplying adequate quantity of good quality water for all domestic purposes, providing good pump environment and condition, attracting more users compared to traditional sources and overall satisfying it's beneficiaries.

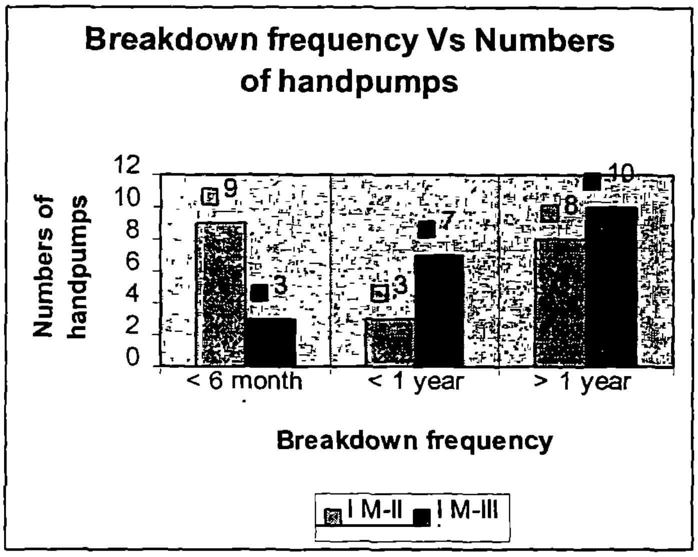
Following sub-sections explain the possible relationship of indicators with the functioning of system. The observed value of indicators are compared to that of the standards as laid down in the National Specifications and also as desired in the design conceptions described in the literatures.

6.1.1 Reliability of Handpumps :-

As per design considerations of India Mark-II and Mark-III handpumps, Mark-III be more reliable (up to 100%) compared to Mark-II. The reliability is also more or less dependent on the maintenance system followed for O&M of the handpumps and the institutional support from the users. In the present study only centralised maintenance system have been adopted for both types of handpumps. In the absence of institutional frame work for maintenance of Mark-III handpumps, its VLOM concept is omitted and it may be regarded as good as Mark-II. Therefore the clear judgement on reliability, as described in literatures can not be made in this study. Where as the breakdown frequency and average downtime for both the pumps are comparable as under the same system of maintenance.

(a) breakdown frequency :-

It is mentioned in the literatures that both the handpumps must run without any trouble at least for one year and that too with no maintenance. From the following graph it is clear that India Mark-III offered fewer breakdowns compared to Mark-II. Some of Mark-III handpumps are attended by the caretakers and their role in preventive maintenance may have resulted in decreasing the breakdown frequency.

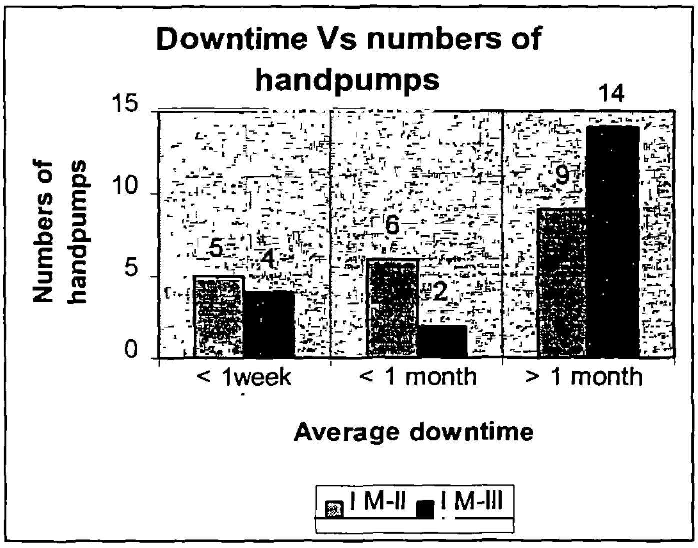


(b) **downtime :-**

In the centralised maintenance system the downtime for both the handpumps will be taken as the same because the repair work is to be carried out by the same mobile team. As per maintenance norms for centralised system, the average downtime should not be more than one or two week. But in the field observations, very different situation was seen. Most of the people responded the average down time of one month or even more in the centralised maintenance system. Sometimes when the complaint is not attended timely by the government employees, people call for the local mistri(mechanic) and get the hand pump repaired by own contribution. In some villages where there is no alternative source of water and people survive on hand pumps only, they get the hand pump repaired on the same day with the help of local mistri. Thus more variation is found in the down time responses of all the forty hand pumps visited.

Out of the forty hand pumps, nine number (23%) are found to be repaired and maintained by the people. Only one hand pump in village Baijahi of Allahabad district found to be set right within a week, as it is being located in the front of house of an employee of the agency. Also it was found that some other handpumps in the same village are repaired in months. A majority of hand pumps (57%) has a down time of more than one month. On an average, the downtime found between one to two months in both districts.

As the down time for both types of hand pumps are the same, the availability of hand pump for use will be the same. Robustness of both types of pumps is proved equally. Some of the both types are working non-break for numbers of years. Under these situation it is difficult to judge that which one is more reliable or more time available for use. Whereas I M-III may prove more reliable if the villagers are trained for repairs, caretakers are inspired to perform their duties and maintenance is handed over to communities. Average downtime Vs numbers of handpumps as observed in field is shown in following bar chart.



6.1.2 Discharge of Handpumps :-

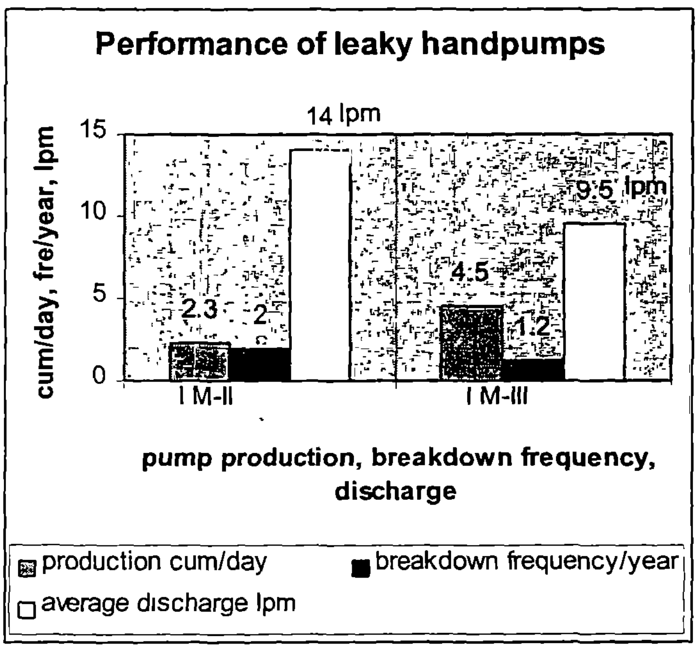
As per Indian Standard Specifications, the discharge of both handpumps is the same, 12 lpm at a pumping rate of 40 strokes per minutes in the field conditions. In the present study, 60% India Mark-II handpumps were found at the specified level of 12 lpm where as only 25% of Mark-III handpumps were yielding the specified discharge (details shown in table 5.3 of chapter-5). On the scale of this indicator, India Mark-II was found functioning better than Mark-III. The reason behind this may be heavy wear and tear to the cupseals of mark-III handpumps. The discharge of pumps may be related to the daily production of water and thereby the intensity of use. It can be seen from the table 5.10 (chapter-5) that the handpumps under heavy use are giving less discharge. It is seen that most of handpumps having discharge between 10-14 lpm, are producing medium to heavy quantity of water while the pumps with more discharge rate are producing less quantity due to less number of users. Also some of the handpumps are being used by a large numbers of people but water production is less due to use of some traditional sources of water for some of their domestic needs. One India Mark-III handpump was found giving exceptionally less discharge of only 4 lpm at the specified rate of pumping even after changing the cupseal. This was due to heavy slip between cup seals and cylinder liner. Because of excessive wear of cylinder liner by sand intrusion from the borewell was noticed.

6.1.3 Leakage from Handpump :-

Leakage from handpumps directly effects the discharge. It may also be related to breakdown frequency of handpumps. It was seen in the study that most of leaky handpumps were frequently repaired. The leakage may have developed due to improper fittings of riser pipe joints. Some of pumps were giving sufficient discharge out of being leaky one. In such pumps leakage was mainly caused by improper pipe joints or due to perforations in pipes caused by corrosive water.

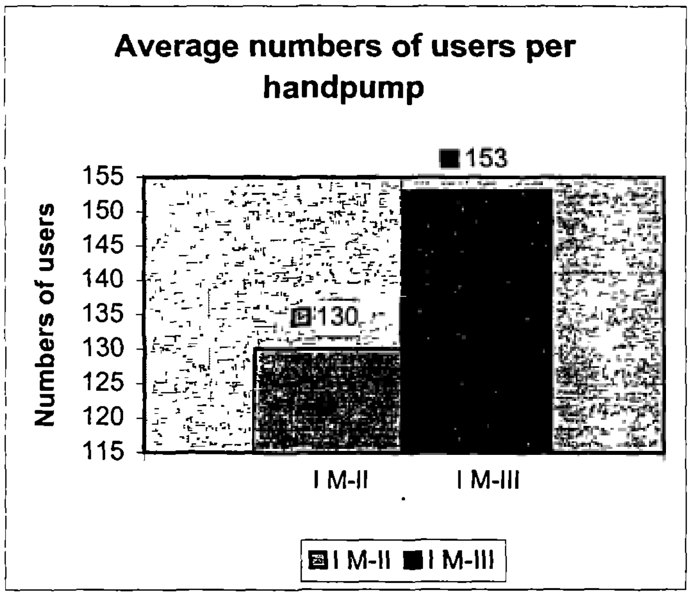
In the present study only three India mark-II handpumps were found leaky out of twenty visited. The main reason of leakage was from loose pipe joints or perforations. Where as nine numbers of India mark-III , out of twenty were found leaky, four of them were caused by excessive wear to cupseals or cylinder liners. These were giving less discharge also. As a comparison, India Mark-II found functioning well against India mark-III. Leakage from loose pipe joints in case of India mark-III handpumps is also too difficult to repair as it needs heavy lifting device to dismantle 65mm diameter G I pipes for the rectification.

The average water production per day, breakdown frequency and discharge of leaky handpumps of both types is compared in following bar chart.



6.1.4 Population Coverage by handpumps:-

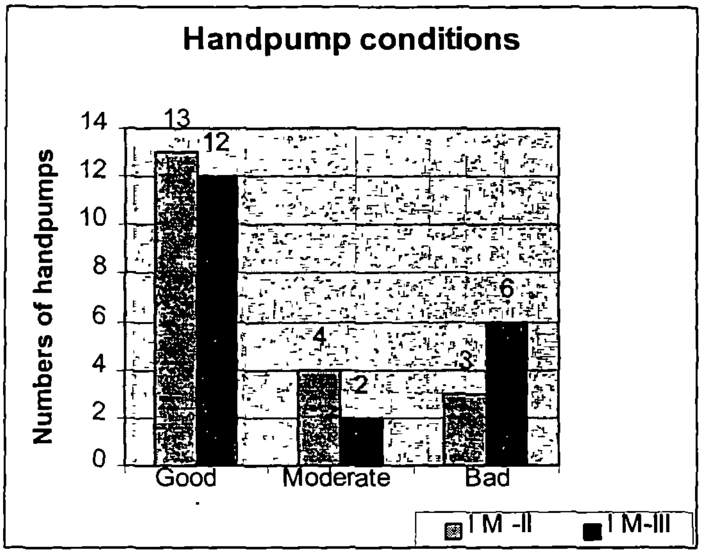
Both pumps are designed to cater the water demand of 250 persons at a supply rate of 40 lpcd. In the present a large variation was observed. 250 persons put only two India Mark-II and one India mark-III handpumps to optimal use. Four numbers of India Mark-III handpumps are being over used by more than 250 persons where as rest of handpumps are under used by fewer people even below 100 persons. The average numbers of users per handpumps is as follows compared in the graph.



6.1.5 Pump conditions :-

The pump condition may have direct relationship with the numbers of users. More the users, the more damages and wear-tear to handpumps may be expected to the handpumps.
In the present study, most of the handpumps were found in good condition irrespective of large numbers of users. It was seen that in those villages where there was no other alternative source of water, people were found more careful in using the handpumps and that resulted to their good conditions.

As per installation norms, the spout of water tank be fixed away from the pumping side or handle. The idea behind this is to safeguard the spout away from the easy reach of users' hands. Users' hands suspected to be carrying some contaminants due to improper washing after defecation, particularly children. If anyhow, spout is touched by a polluted hand carrying some pathogenic microorganisms, the bacteria may be transferred to the boreholes and thus contaminating the entire source of water. In the study area two such handpumps were seen that their handles were just reversed towards spout side for the convenience of operating handle by a single person. This was possible due to the symmetry of holes made in flanges of water tank for fixing nutbolts. Such situations be always prevented.



6.1.6 Pump Environment :-

Platforms, drains and bathing platforms are constructed to keep the pump surroundings neat clean and hygienic. In the present study most of the handpumps were found with well-constructed platforms and drains except very few. At some places people were taking bath just below the spout instead of bathing platform provided. Some handpumps were left for public use without constructing platforms due certain reasons and thus creating unhygienic surroundings. The bathing platforms were provided for only India Mark–III handpumps. Where as India Mark-II handpumps were without such bathing facilities though it seems necessary from hygienic point of view. Among the agency personnel, platform construction is taken as non-priority work like handpump repair. Handpumps are left for public use for months without constructing platforms due to some constraints that creates dirty surroundings. The platform design and drawings also contribute to some extent for delays in platform construction. Changes in platform designs may be considerable to avoid such situations.

In the present study only 11% of handpumps were found in a bad condition and 22% in moderate condition. The platform condition may have relation to the numbers of users that may cause more damages. But in the study area, such type of situation was not found. In most of the villages people were found careful about handpump surrounding except few places. It is worth to notice that only three numbers India Mark-III handpumps have bad surrounding as against only one India Mark-II with broken platform.

6.2 Water Use :-

The distance of water point from the household was observed as a major factor in deciding the type of source for collection of water irrespective of water quality consideration. Walking distance from the hand pump and up to the last user household at the periphery of coverage range was measured by counting steps and time taken in reaching was also observed. A water source mapping was already done and the coverage range of each hand pump was decided. The people were asked for why they prefer any particular source to collect water and for what purpose water is used in their houses. It was found that people were more attracted towards the nearness of water points instead of quality. The accessibility to the source of water was also an important factor observed on the water use and source use. Some of the hand pumps were located in such a way that were inaccessible even to those households which were within a periphery of 20 m of hand pump and people were compelled to opt for alternate sources.

The presence of traditional sources effects the water use pattern widely in the villages. Some households were found using hand pump water only for bathing, cloth washing and personal hygiene and that too only male members of the family. Whereas the female members were using traditional sources for drinking, cooking, utensil washing and other needs because of it being easily accessible at a very short distance. In some of the villages, where ground water table is at a shallow depth, people have there own local hand pumps and always prefer to use that for all domestic purposes. At the same time, few households collected their drinking water needs from the nearby I M –II or I M –III hand pumps and other requirements were fetch by own local hand pump or open wells.

Also less number of traditional water sources, the open wells, are available in some villages which are used by the families residing nearby. The hand pumps provided by agency are situated far away from such localities.

6.3 Water Quality :-

If we have a general look on the values of various quality parameters obtained from the sample testing, most of the values are well within the acceptable limits of WHO guide lines. Also the pH values does not indicate towards any aggressivity of water as it is always found above 7.5 or even more. Only very few parameters, like total dissolved solids, chlorides and total hardness are crossing the upper acceptable limit and that too in the case of well water only. Iron is found in almost of the samples, in some hand pumps it is found in excess.

6.4.1 Additional Findings :-

Both types of visited hand pumps are found functioning equally well in the area of study. Though there are number of hand pumps that were not in functioning order at the time of field visits, mainly due to lack of maintenance. This included both types. In some of the chosen villages few I M –III hand pumps were found totally defunct since after few months of their installation. The reason was the failure of borewells.

Findings from Discussions of Agency Officials:

Different levels of officers and field workers were discussed about the overall performance of I M –II and I M –III hand pumps. Since I M –II hand pumps are being installed from last fifteen years, the staff at various levels has gained a lot of field experience and expertise of installation as well as maintenance of I M –II hand pumps. In the opinion of agency personnel, I M–II hand pump is still performing better in comparison to I M –III. It was stated that large number of I M –III hand pumps are reported to gone out of order at a early stage of their installation. A high level committee of few chief engineers, was constituted in the year 1994, to find out the relative utility of both hand pumps. Their recommendation was in favour of I M –II, based on realities found in the field and total cost of installation and afterward maintenance by the agency. As far as ease of maintenance is concerned, it was not found practical till community is fully involved and trained for repairing. The root level staff also favoured the better functioning of IM-II handpumps. Some registered suppliers of handpumps and BIS licensed manufacturers, were also approached and a factory visit was done. It was found that more number I M –II hand pumps are being produced and supplied annually, as compared to I M –III hand pumps. Since there is no demand for India Mark-III handpumps any state.

6.5 Comparison of India Mark-II and Mark-III handpumps:-

Following table presents the comparative picture of both types of handpumps. The results obtained from the field observations for various indicators are summarised and tabulated below.

Table 6.1; Comparison of handpumps:

S.N.	Indicators	Desired level	IndiaMark-II	India Mark-III
1-	Discharge	12 lpm	45% below Desired level	70% below desired level
2-	Leakage	non-leaky	15% leaky	45% leaky
3-	Breakdown	< 6 month	45% out of 20HP	15%out of 20HP
	Frequency	< 1 year	15% out of 20HP	35%out of 20 HP
		> 1 year	40% out of 20HP	50%out of 20 HP
4-	Downtime	< 1 week	5% (by agency)	----
			20% (by people)	20% (by people)
		< 1 month	30%(by agency)	5% (by agency)
				5% (by people)
		> 1 month	45% (by agency)	70%(by agency)
5-	Coverage	< 250 persons/HP	80% out of 20 HP	75% out of 20 HP
		= 250 persons/HP	10% out of 20 HP	5% out of 20 HP
		> 250 persons/HP	10% out of 20 HP	20% out of 20 HP
6-	Pump Condition	Good	65% out of 20 HP	60% out of 20 HP
		Moderate	20% out of 20 HP	10% out of 20 HP
		Bad	15% out of 20 HP	30% out of 20 HP
7-	Pump Environment	Good	65% out of 20 HP	70% out of 20 HP
		Moderate	30% out of 20 HP	15% out of 20 HP
		Bad	5% out of 20 HP	15% out of 20 HP
8-	Water Produce	< 4 kl/day	60% out of 20 HP	65% out of 20HP
		4-8 kl/day	40% out of 20 HP	20% out of 20 HP
		> 8 kl/day	---	15% out of 20 HP

This chapter provides the overall picture of the study. It starts with brief description of the objectives of study. Then it presents the conclusions drawn out of the field findings and discussions on results. At last it gives some recommendations for the improvements and betterment of the handpump water supply system.

7.1 Objectives of Study :-

The topic of study is the evaluation of functioning of India Mark-II and India Mark-III handpumps in the state of Uttar Pradesh, India. India Mark-II handpump was developed in last seventies to cater water demand in the rural areas but its maintenance was not easy for villagers. To be maintained and repaired at village level, India Mark-III handpump was developed by doing some modifications in the existing design of India Mark-II handpump. But in the state of Uttar Pradesh, India Mark-II handpumps are only being installed at large scale. India mark-III is installed only with financial support of some external agency like UNICEF or others.

The question arises whether the India Mark-III handpumps are not functioning well in the field in comparison to India Mark-II. And due to this reason, it is not being installed out of being an improved VLOM version of its own. This study is intended to evaluate the functioning of both the handpumps with the following objectives.

1- To evaluate the functioning of India Mark-II and Mark-III handpumps.
2- To evaluate the water use and water quality of handpumps.
3- To compare the performance of India Mark-II and Mark-III handpumps and to suggest some improvements for better functioning of the system.

7.2 Conclusions :-

Following conclusions are drawn from the study of in all forty handpumps, twenty of each type installed in two different districts of the state.

➢ All the handpumps found functioning well but only 60% of India Mark-II and 25% of Mark-III met the standard discharge set by Bureau of Indian Standards (BIS). The reason behind low discharge is high wear-tear to cupseals and cylinder liners. Sand intrusion in the wells is prime cause for rapid wear- tear of cylinder components. Leakage also contributes to low discharge upto some extent. The discharge of such handpumps is not much below the standard value which is roughly 25% below the desired level. But the production of water is found sufficient enough to meet the water demand of community covered. Only one exception of too less discharge (4lpm) was noticed in case of India Mark-III handpump which was due to heavy wear of cylinder liner caused by excessive sand intrusion since beginning.

➢ Fifteen percent of India Mark-II and forty percent Mark-III handpumps were found leaky. But they do not effect the discharge too adversely. Leakage is caused due to heavy wear-tear to cylinder components and also due to faulty pipe joints. Leakage developed due to improper jointing of India Mark-III handpumps are difficult to repair, as it requires heavy lifting devices.

- Breakdown frequency found more in case of India Mark-II handpumps. About 45% of Mark-II pumps broke six monthly, 15% one yearly and 40% broke over one year. Where as only 15% Mark-III pumps failed six monthly, 35% one yearly and 50% over one year. Some of both handpumps noticed working non-break for a period of over five years since their installation. Thus the sturdiness of both the handpumps is proved equally good. The average breakdown frequency of both the handpumps is concluded to once in two years on the basis of field observations. The early breakdown of handpumps is mostly contributed to quality of construction of boreholes and improper installation of pumping assembly.

- The downtime is almost dependent to maintenance system adopted for the handpumps. The centralised maintenance system is followed in both the districts of study and the average downtime is found to be one month as against one week mentioned in literatures.

- Majority of handpumps is found in good condition. Platforms and the surroundings are also good in most of the cases. Some of the platforms and drains were found damaged due to poor quality of construction. Delay in platform construction creates unhygienic surroundings. In those villages where there are no alternative sources of water, people are willingly self involved in maintenance, upkeep and also construction of platforms.

- Majority of handpumps is found lightly used by comparatively less numbers of users than specified 250 persons. The minimum numbers of users found to be 50 and maximum 375 for certain handpumps. The average numbers of users per India Mark-II handpump is found 130 and 153 per Mark-III as against the norm of 250 persons per pump.

- Average volume of water used by each person is found 21.4 lpcd in Lucknow district and 22.7lpcd in Allahabad district, which is about the half of the prescribed norm of 40 lpcd. Majority of people use 15-20 lpcd of water almost for drinking and cooking needs. Some people use the traditional sources of water for purposes other than drinking due to convenience of water point.

- Water quality of all the handpumps was found to well within the acceptable limits as lay down under WHO guidelines. Corrosive nature of water was absent as the pH value always found above 7.5 in all the samples. Only eight samples found exceeding the allowable limit of iron as per WHO guidelines but well within the acceptable limit specified by Bureau of Indian standards (BIS). Few samples of traditional sources contained high concentration of TDS, hardness and chlorides which exceed the acceptable limits but people found using water for all domestic needs.

- Conversion of India Mark-II by replacing the pumping assembly to that of Mark-III, in the same borehole, is not found encouraging. The discharge of these pumps found less than standards and also pumps started to pour sands. Besides there are numbers of practical conversion problems which cause damage to the boreholes.

- About 80% of users found satisfied with the handpump water supply system. Some complains were observed regarding bad taste of water. Such handpumps contained excess of iron which produced taste but the concentration was not beyond the acceptable limit. Very few complained about insufficient quantity of water available from handpumps. Only one such handpump was shorted out which was defective since the installation.

- Both India Mark-II and Mark-III handpumps found functioning well in the field conditions. The difference lies only in the maintainability of the handpumps. Installation of India Mark-III handpumps without involving and training the community for village level maintenance, is meaningless. Rather it is equivalent to installation of India Mark-II handpumps. Also now the maintenance of India Mark-II handpumps is not beyond the capacity of villagers. If basic training of maintenance is necessary for India Mark-III handpumps, the same can be extended to Mark-II also to make it possible for maintenance at village level.

  Thus the main difference between India Mark-II and Mark-III comes to the cost of installation. The India Mark-III is nearly 30% more costly than that of India mark-II. This is the major reason for non- adopting Mark-III handpumps at a large scale in the rural water supply programme of the state.

7.3 Recommendations :-

Following recommendations are suggested to improve the handpump system of water supply.

1- Preventive maintenance should be made compulsory likewise the breakdown maintenance, through the block/area mechanic in the centralised maintenance also. Regular watch over the wearing and moving components parts be ensured. Their timely replacement may improve the functioning and thereby the service life of handpumps. Discharge of handpumps be measured quarterly or so, and cupseals be replaced when the discharge falls below 10 lpm.

2- Further modification in the design of India Mark-III handpumps be made to bring down the overall cost of installation to the level of India Mark-II handpumps. Reduction in riser pipe diameter, to make it fit for 100 mm dia. borewel, may provide substantial cost reduction and also facilitate easy repairs of leakages from riser pipes.

3- To disturb the symmetry in the holes of top flange of water tank, made for nut bolt fittings; so that handle could not be reversed towards the spout side. This can be done very simply, by a little displacement of any two holes in the top flange of water tank but matching to the bottom flange of handle box. This will make the reversion of handle impossible to the villagers and thus avoid the risk of borehole contamination.

4- Length of handle be reduced to a suitable mechanical advantage acceptable to adults persons operation (preferably 4.5 : 1, as suggested by Arlosoroff et.al.-1987). A T-bar handle may be used to counterbalance the weight of connecting rods. Efforts for cost reduction be made to make it affordable to upper class rural society so that it can be adopted as a yard handpump.

5- Platform design be modified for easy construction using locally available materials like bricks. Only pedastal grouting may of concrete and bathing platforms and drains be built in brick masonry. Community be involved in simple construction of platforms with local materials which may develop the sense of ownership among them. Bathing platforms for India Mark-II handpumps should also be provided.

6- Community involvement and their training for village level maintenance be started for India Mark-II handpumps also. Nominated caretakers be provided with some incentives and trained complete repairs.

7- Further changes in fostering policy of providing free handpump water supply to the rural sector be started. For a sustainable handpump water supply system, ownership must be realised by the community and it is only possible when community is involved in sharing the cost of handpumps to some extent. It is suggested to integrate the handpump programme with rural sanitation and individual yard handpumps be promoted along with sanitation programme.

8- Water quality monitoring should be ensured at a regular interval on yearly basis. So that a safe and potable water supply to the community can be an assurance.

Note:- The views and ideas discussed in this thesis pertain to the author's own. It does not relate in any way to the IHE or the UP Jal Nigam or any other agency.

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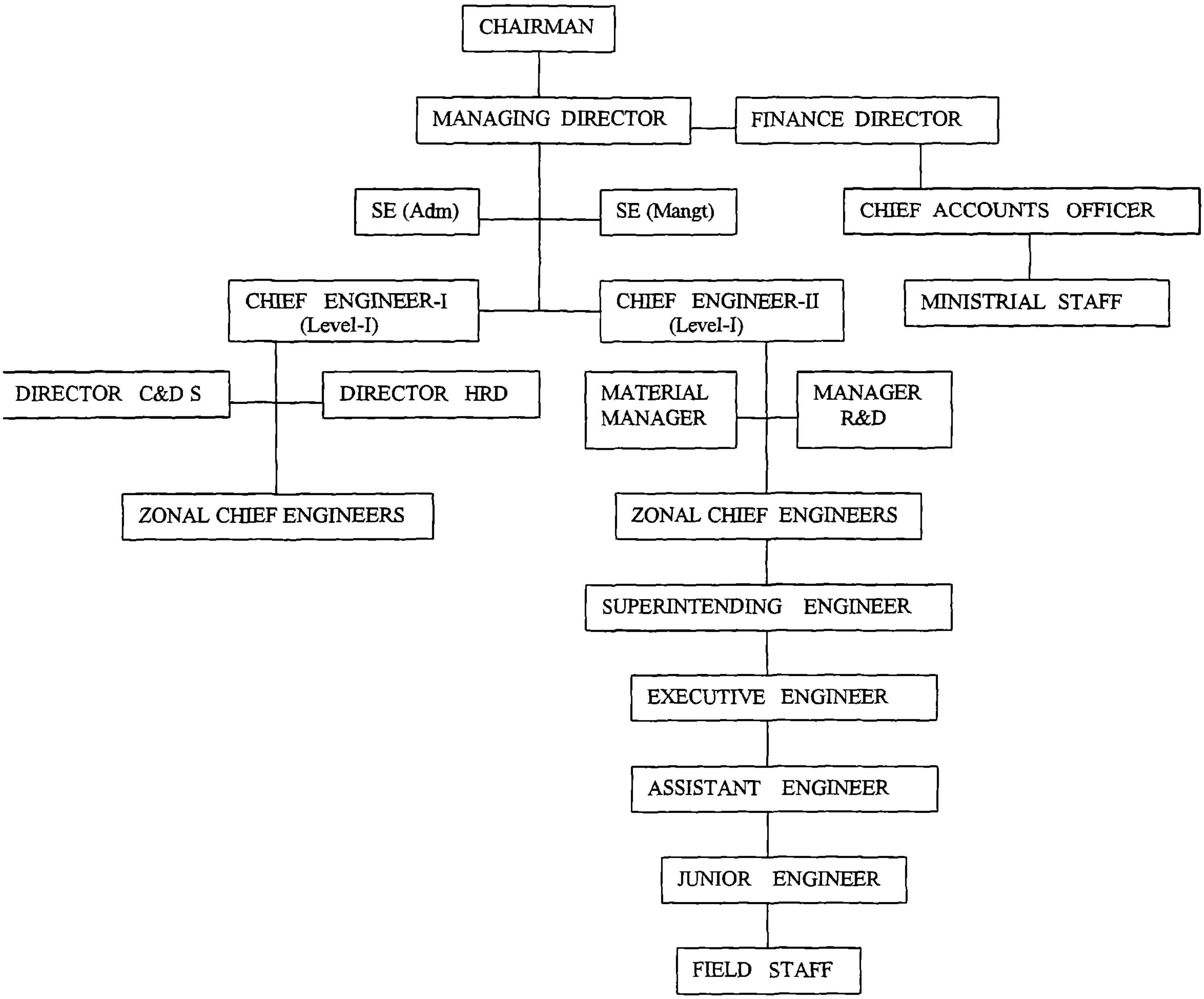
ORGANISATION OGRAM **ANNEXURE-I**

UP JAL NIGAM



Annexure - II

Village Information

- Name of Village :
- District :
- Tehsil\block :
- Distance from distt.HQ. :
- Population(1991/present) :
- No.of households :
- Area of village :
- Schools :
- Hospitals :
- Services : Water supply :
  sanitation :
- Irrigation facilities :
- No. of handpumps :
- Traditional sources of water :
- No. of Cattles :
- Accessible by :

(motor, by cycle or on foot)

- Water supply maintained by :
- Village map(prepared on site) :

Annexure - III

Questionnaire for village

Name of village : Village Code :

Block : Tehsil : District :

Name of the house hold chief :
Occupation :
No. of members in the family :

Total :
Adults :
Children :

1. Who normally collects water in your family ? :
2. Do you like/ use H. P. Water ? :
3. How many buckets of water is collected daily ?
   from hand pump :
   from other source :
4. Do you get sufficient water as you need ? :
5. Normally at what time water you collect ? :
6. How do find the taste of water ? :
7. Have you to wait in queue for collecting water ? :
8. How frequently hand pump breaks down ? :
9. From where you collect water when it fails ?:
10. Who repairs the hand pump when it fails ? :
11. How many days is taken in repair it ? :
12. When was the last break of H.P. ? :
13. Do you see any difference between I.M. - II & III ? :
14. Can you repair this H.P. ? :
15. When was the break before last ? :

Annexure - IV

Observation Sheet - I

Name of village : Village Code :
Block : Tehsil : District :

Hand pump No./location :

- general appearence : good/ moderate/ poor
- condition of plateform/ bathing plateform : --------do-------
- disposal of used water : pond/drain/kitchen garden/soak
- no. of houses within 60 mts. :
- no. of users within 60 mts. :
- functioning of hand pumps -
  - in order : yes/no
  - discharge after 40 strokes/mts : lits.
- leakage : yields water after 3 strokes
- water level :
- general quality of water
  - giving sand, turbid : yes/no
  - colour :
  - taste : good/brakish/smelling
- measured horizontal play : mm.
- installation depth :
- month/year of installation :

Annexure-IV

Sheet no.II

Condition of hand pump :-

- horizontal play of handle more than 3 mm : yes/no
- how much is the play :
- clear signs of correction : yes/no
- loosing of nut bolts : yes/no
- chain is dry or (without greasing) : yes/no
- damages to hand pump body : yes/no
- damaged bearings : yes/no
- leakage from water tank : yes/no
- missing nut bolts : yes/no
- wear and tear of handle slit : yes/no
- handle and spout in right position : yes/no
- movement of pedestal while pumping : yes/no
- noise while pumping : yes/no
- no. of strokes for yielding water :

Annexure-IV

Sheet no. - III

Conditions of plateform and drain :-

Technical Aspects :

- dimension of plateform/drain :
- pedstal well grouted :
- damage to drain :
- adequate length of drain :
- suitability of hand pump site :

Sanitary aspects :

- colour of plateform(signof staining) :
- damages to plateform :
- impounding of water around plateform :
- latrines within 10 m of hand pump :
- Cleanlyness :

Annexure - V

Caretaker questionnaire :

Name :
Qualification : Occupation :

1. What kind of training undergone? When it was conducted ? and what was the period ?
2. How often you visit hand pumps ?
3. How do you receive complaints ?
4. How many complaints are received in month ?
5. How do you attend the complaints ?
6. What types of repairs you can do ?
7. If the failure is beyond your limit, what you do ?
8. How long does it takes to rectify a complain ?
9. What is the normal breakdown time for major/ minor problems ?
10. Do you get spare parts easily ?
11. Are you satisfied with hand pumps ?
12. What difference do you see between I.M. II & III ?
13. How it is repaired ?

Annexure -VI

Breakdown Matrix

Type of failure	Repair time	Reasons/ remarks

Source - Use Matrix

Purpose	Source of water						Reasons for use non-use
	hand pump		open well		river/ stream		
seasons	wet	dry	wet	dry	wet	dry	
drinking							
cooking							
washing							
personal hygiene							
gardening							
cattle feeding							

Abstract of direct observations Sheet-I

Name of villages	HP code	HP type	discharge lpm	leakage Y/N	HH using all needs	handpumps D/C	B/C	HH not using HP	Total nos. of users	Conspt. rate lpcd	Quantity extracted kld
1	2	3	4	5	6	7	8	9	10	11	12
Narausa distt. Lucknow											
	HP 1	III	11	Y	20	-	-	-	59 + sc	17	1.4
	HP 2	II	20	N	26	-	-	-	134	25	3.35
	HP 3	III	4	Y	5	9	4	3	102	18	1.85
	HP 4	II	16	Y	13	-	-	5	62	26	1.6
	HP 5	III	16	N	20	-	-	-	68	28	1.9
Hemrapur distt Lucknow											
	HP 6	III	11	Y	46	-	-	-	325	28	9.1
	HP 7	III	14	N	41	-	-	-	375	32	12
	HP 8	III	11	Y	50	-	-	-	350	22	7.7
	HP 9	III	11	Y	42	-	-	-	350	33	11.55
	HP 10	II	12	N	32	-	-	-	299	17	5
Chandrawal distt. Lucknow											
	HP 11	III	13	N	43	-	-	-	230	17	3.9
	HP 12	II	11.5	Y	11	-	-	-	54	19	1
	HP 13	II	14	N	28	-	-	-	220	18	4
	HP 14	II	10	N	16	-	-	-	122	22	2.7
	HP 15	II	15	N	10	-	-	-	70	16	1.15
Bakkas distt. Lucknow											
	HP 16	III	11.5	N	32	5	-	2	130	22	2.85
	HP 17	II	14	Y	17	3	-	-	80	16	1.3
	HP 18	II	10	N	29	3	-	2	255	18	4.05
	HP 19	III	12	N	20	2	-	1	165	29	4.8
	HP 20	II	14	N	14	-	-	-	60	22	132

1	2	3	4	5	6	7	8	9	10	11	12
Raini distt Allahabad											
	HP 21	III	10	N	26	-	-	-	200	22	4.4
	HP 22	III convert	10	N	7	-	-	-	55	22	1.2
	HP 23	III	9	Y	12	-	-	-	88	18	1.6
	HP 24	III	8	Y	22	-	-	-	122	18	2.2
	HP 25	III convert	10	Y	28	-	-	-	200	20	4
	HP 26	III	11	Y	11	-	-	-	65	17	1.1
	HP 27	III	12	N	12	3	-	3	118	19	2.25
Sehua dih distt. Allahabad											
	HP 28	III convert	11	N	20	3	-	3	154	18	2.75
Atanpur distt. Allahabad											
	HP 29	III	12	N	12	-	-	-	70	23	1 6
	HP 30	III	8	N	10	-	-	-	58	23	1.35
	HP 31	II	11	N	8	-	-	-	50	23	1.35
Sarai Harkishan distt Allahabad											
	HP 32	II	9	N	18	-	-	-	148	30	4.4
	HP 33	II	14	N	11	1	-	2	103	28	2.9
Baksera distt. Allahabad											
	HP 34	II	12	N	12	-	-	-	86	25	2.15
	HP 35	II	12	N	6	-	-	2	89	28	2.5
	HP 36	II	12	N	6	-	-	-	51	21	1.1
Baijahi distt. Allahabad											
	HP 37	II	10	N	8	-	-	-	230	25	5.75
	HP 38	II	10	N	18	-	-	-	153	29	4.45
	HP 39	II	9	N	17	2	-	3	166	30	5
	HP 40	II	11	N	23	-	-	-	164	28	4.6

HH - householders
D/C - drinking & cooking
B/C - bathing & cloth washing
sc - school children

Abstract of observations; sheet -II

		Condition of handpumps											Ratings		
1	2	3	4	5	6	7	8	9	10	11	12	113	14	15	16
HP CODE	HP TYPE	PH	CP	LN	LG	DH	DB	LT	MB	WS	HR	LF	G	M	B
HP 1	III	+	-	-	+	-	+	-	+	-	-	-			*
HP 2	II	-	-	-	-	-	-	-	-	-	-	-	*		
HP 3	III	-	-	-	-	-	-	-	-	-	-	-	*		
HP 4	II	+	-	+	+	-	+	+	+	+	-	-			*
HP 5	III	-	-	-	-	-	-	-	-	-	-	-	*		
HP 6	III	+	-	-	+	-	+	-	-	+	-	-			*
HP 7	III	-	+	+	-	-	-	+	-	-	+	+			*
HP 8	III	+	-	+	-	-	+	-	+	-	-	-			*
HP 9	III	+	-	-	-	-	-	-	-	-	-	-	*		
HP 10	II	+	-	-	-	-	+	-	-	-	-	-		*	
HP 11	III	-	-	-	-	-	-	-	-	-	-	-	*		
HP 12	II	-	-	-	-	-	-	-	-	-	-	-	*		
HP 13	II	+	+	-	-	+	-	-	+	+	-	-			*
HP 14	II	-	-	-	-	-	-	-	-	-	-	-	*		
HP 15	II	-	-	-	-	-	-	-	-	-	-	-	*		
HP 16	III	+	-	-	-	-	+	-	-	-	-	-		*	
HP 17	II	-	-	-	-	-	-	-	-	-	-	-	*		
HP 18	II	-	-	-	-	-	-	-	-	-	-	-	*		
HP 19	III	-	-	-	-	-	-	-	-	-	-	-	*		
HP 20	II	-	-	-	-	-	-	-	-	-	-	-	*		
HP 21	III	-	-	-	-	-	-	-	-	-	-	-	*		
HP 22	III	-	-	-	-	-	-	-	-	-	-	-	*		
HP 23	III	-	-	-	-	-	-	-	-	-	-	-	*		
HP 24	III	+	-	-	-	+	-	+	+	+	-	-			*
HP 25	III	-	-	-	-	-	-	-	-	-	-	-	*		
HP 26	III	+	-	-	-	-	-	-	+	+	+	-			*
HP 27	III	-	-	-	-	-	-	-	-	-	-	-	*		
HP 28	III	-	-	-	-	-	-	-	+	-	-	-	*		
HP 29	III	-	-	-	-	-	-	-	-	-	-	-	*		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
HP 30	III	-	-	-	-	-	-	-	-	-	-	-	*		
HP 31	II	+	-	-	-	-	-	-	-	-	-	-	*		
HP 32	II	+	+	+	-	-	+	+	+	-	-	+			*
HP 33	II	-	-	-	-	-	-	-	-	-	-	-	*		
HP 34	II	+	-	-	-	-	-	-	-	-	-	-	*		
HP 35	II	+	-	-	-	-	-	-	-	-	-	+		*	
HP 36	II	-	-	-	-	-	-	-	-	-	-	-	*		
HP 37	II	-	-	-	-	-	-	-	-	-	-	-	*		
HP 38	II	-	-	-	-	-	-	-	+	-	-	-	*		
HP 39	II	+	-	-	-	-	+	-	-	-	-	-		*	
HP 40	II	-	-	-	-	-	-	-	-	-	-	-	*		

Handpump Conditions -- Observations taken in negative aspects
PH - play in handle -- + sign is given to negative observation
CP - corroded parts -- ,- sign is given to positive observation
LN - loose nutbolts + is taken as good in rating
LG - lack of greasing +' + is taken as moderate in rating
DH - damage to HP +', + + or more is taken as bad in rating
DB - damage to bearing
LT - leaking tank
WS - wornout slit
HR - handle reversed
LF - loose foundation

Abstract of Observations ; sheet-III

Condition of Platforms						Ratings		
1	2	3	4	5	6	7	8	9
HP code	HP type	DP	SW	LD	SP	G	M	B
HP 1	III	-	-	-	-	*		
HP 2	II	-	+	-	-		*	
HP 3	III	-	-	-	-	*		
HP 4	II	-	-	-	-	*		
HP 5	III	-	-	-	-	*		
HP 6	III	-	+	+	-			*
HP 7	III	+	-	+	-			*
HP 8	III	+	-	+	-			*
HP 9	III	-	-	-	-	*		
HP 10	II	-	-	-	+		*	
HP 11	III	+	-	-	-		*	
HP 12	II	-	-	-	-	*		
HP 13	II	-	-	-	-	*		
HP 14	II	-	-	-	-	*		
HP 15	II	-	-	-	-	*		
HP 16	III	-	-	-	-	*		
HP 17	II	-	-	-	-	*		
HP 18	II	-	-	-	-	*		
HP 19	III	-	-	-	-	*		
HP 20	II	-	-	-	-	*		
HP 21	III	-	-	-	-	*		
HP 22	III	-	-	-	-	*		
HP 23	III	+	-	-	-		*	
HP 24	III	+	-	-	-		*	
HP 25	III	-	-	-	-	*		

1	2	3	4	5	6	7	8	9
HP 26`	III	-	-	-	-	*		
HP 27	III	-	-	-	-	*		
HP 28	III	-	-	-	-	*		
HP 29	III	-	-	-	-	*		
HP 30	III	-	-	-	-	*		
HP31	II	-	+	-	-		*	
1	2	3	4		5	6	7	8
HP 32	II	+	+	+	+			*
HP 33	II	+	-	-	-		*	
HP 34	II	+	-	-	-		*	
HP 35	II	-	+	-	-		*	
HP 36	II	-	-	-	-	*		
Hp 37	II	-	-	-	-	*		
HP 38	II	-	-	-	-	*		
HP 39	II	-	-	-	-	*		
HP 40	II	-	-	-	-	*		

Platform conditions:
DP - damaged platforms
SW - stagnant water
LD - lacking in drainage
SP - source of pollution within 10 m

,-- Observations taken in negative as
-'- , '+' sign is given to negative obs
-'- , - sign is given to positive obs
No 'plus' sign is rated as good
Single 'plus' is rated as moderate
more 'plus' is rated as bad

Water Quality Parameters

Name/ distt. Of village	HP cod	HP type	source of water	Chemical Parameters (in ppm) TDS	pH	Chlorides	Flyorides	Total Hardness	Sulphate	Iron	Nitrate	Nitrite	Alkalinity
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Narausa/Lko	HP	III	BW	500	7.5	10	0.75	288	-	0.5	-	-	304
	HP	II	BW	520	7.5	10	0.9	312	24.4	trace	-	-	288
	HP	III	BW	490	7.5	18	0.6	272	19.2	1	-	-	276
	HP	II	Bw	520	7.5	11	0.5	296	19 2	0.6	-	-	280
	HP	III	BW	486	7.5	8	0.5	288	9.6	0.2	-	-	292
		W 1	OW	**1320**	7.9	230	0.3	500	211.2	0.15	8.86	trace	700
		W 2	OW	**788**	7.5	34	0.3	450	28.8	0 1	0.22	-	320
Hemrapur/Lk	HP	III	BW	400	7.5	10	0.3	240	-	0.4	-	-	236
	HP	III	BW	410	7.5	10	0.4	244	-	0.4	-	-	224
	HP	III	BW	420	7.5	11	0.3	264	-	0.3	0 44	-	264
	HP	III	BW	460	7.5	12	0.6	300	trace	0.5	0.22	-	296
	HP1	II	BW	380	7.5	14	0.25	200	-	0.3	-	-	216
Chandraval/L	P1	III	BW	480	7.5	20	0.5	240	-	trace	-	-	220
	HP1	II	BW	500	7.5	28	0.5	260	9.6	0.2	-	-	230
	HP1	II	BW	490	7.5	30	0.25	250	9.6	trace	-	-	220
	HP1	II	BW	480	7.5	24	0.5	246	9.6	0.5	-	-	230
	HP1	II	BW	470	7.5	28	0.25	230	-	0.4	-	-	220
	HP1	III	BW	400	7.5	10	0.25	248	14.4	0.2	-	-	220
Bakkas/Lko	P1	II	BW	420	7.5	17	0.25	296	14.4	0.3	-	-	252
	HP1	II	BW	416	7.5	8	0.25	246	19.2	0.2	-	-	256
	HP 1	III	BW	420	7.5	10	0.3	240	-	0.1	-	-	248
	HP2	II	BW	410	7.5	11	0.3	226	trace	0.2	-	-	216
		W 3	OW	**2312**	7.8	412	0.4	**1296**	384	0 1	**48.7**	-	607
		W 4	OW	**2008**	7.8	498	0.4	**720**	576	0.15	**44.3**	-	736
Raini/Alld.	P2	III	BW	480	7.5	50	0.75	224	48	0.2	-	-	220
	HP2	III	BW	490	7.5	20	0.4	248	38.4	0.02	-	-	144
	HP2	III	BW	480	7.5	22	0.4	280	38.4	0.05	-	-	264

1	2	3	4	5	6	7	8	9	10	11	12	13	14
	HP2	III	BW	520	7.6	16	0.3	316	28.8	0.05	0.44	-	280
	HP2	III	BW	500	7.5	20	0.75	276	28 8	0 05	-	-	240
	HP2	III	BW	500	7 8	22	0.6	324	19.2	0.1	4 46	trace	288
		W 5	OW	470	7 5	38	1 6	264	19.2	0.02	-	-	244
	HP2	III	BW	550	7.8	44	0.6	344	48	0.1	-	-	272
Sehuadih/All	P2	III	BW	460	7.5	13	1	224	19.2	0.1	-	-	248
Atanpur/Alld.	P2	III	BW	460	7.5	13	0.5	236	-	0.2	-	-	244
	HP3	III	BW	500	7.8	16	0.5	336	-	0 2	-	-	300
	HP3	II	BW	640	7.6	80	0.4	380	48	0.1	0.44	-	360
Sarai H /Alld.	P3	II	BW	**1880**	7.9	**890**	0 4	580	38.4	0 1	0.88	-	558
	HP3	II	BW	480	7.5	29	0.4	252	-	0.15	-	-	258
Baksera/Alld.	P3	II	BW	496	7 7	43	0 5	294	9.6	0,15	-	-	470
	HP3	II	BW	568	7.6	55	0.4	382	4.8	0.1	-	-	392
	HP3	II	BW	440	7.5	13	0.4	254	4.8	0.1	-	-	300
Bajahi/Alld.	P3	II	BW	556	7.5	13	0.3	338	-	0 01	-	-	280
	HP3	II	BW	608	7.5	49	0.3	318	-	0.1	-	-	262
	HP3	II	BW	826	7.6	93	0 3	250	28.8	0.8	2.22	-	366
	HP4	II	BW	492	7.5	17	0.3	318	-	0.15	-	-	240
		W 6	OW	**698**	7.8	47	2	400	4 8	-	0.44	trace	488

Abstract of Householders Interviews

Name of village	HP code & type	HH no	Functioning of Hand: Breakdow frequency	Down time	Quality users'view	Adequacy of water	convenien of WP (distance)	Volume of water collected	Water Usages: Drinking	cooking	Bathing	Cloth washing	Others
Narausa	HP 1	1	R	2 M	G	S	< 20 m	43	HP	HP	HP	HP	HP
	M - III	2	R	2-3 M	G	S	<20m	33	HP	HP	HP	HP	HP
		3	R	1-2 M	G	S	<20m	31	HP	HP	HP	HP	HP
		4	R	N K	G	S	<50m	11	HP	HP	HP OW	HP OW	HP OW
		5	R	2-3 M	G	S	<50 m	-	OW OHP	OW OHP	OW OHP	OW OHP	OW OHP
		6	R	3-4 M	G	S	<50 m	8	HP	HP	HP OW	HP OW	HP OW
		7	R	1-2 M	G	S	<75 m	8	HP OHP	HP OHP	HP OHP	HP OHP	HP OHP
		8	R	3-4 M	G	S	<75 m	7	HP	HP	HP OW	HP OW	HP OW
		9	R	N K	G	S	<75 m	9	HP	HP	HP OW	HP OW	HP OW
	HP 2	10	R	1 M	G	S	<20m	25	HP	HP	HP	HP	HP
	M - II	11	R	1-2 M	G	S	<20m	33	HP	HP	HP	HP	HP
		12	R	2-3 M	G	S	<20m	22	HP	HP	HP	HP	HP
		13	R	1-2 M	G	S	<30 m	30	HP	HP	HP	HP	HP
		14	R	1-2 M	G	S	<30m	17	HP	HP	HP	HP	HP
		15	R	2-3M	G	S	<30m	30	HP	HP	HP	HP	HP
		16	R	3-4M	G	S	<50 m	30	HP	HP	HP	HP	HP
		17	R	2-3 M	G	S	<50 m	40	HP	HP	HP	HP	HP
		18	R	2-3 M	G	S	<50 m	30	HP	HP	HP	HP	HP
	HP 3	19	F	3-4 M	B	I	<50 m	9	HP OW	HP OW	OW	HP OW	HP OW
	M - III	20	F	2-3 M	B	I	<50 m	24	HP OW	HP OW	HP OW	HP OW	HP OW
		21	F	1-2M	B	I	<50 m	7	HP OW	HP OW	HP OW	HP OW	HP OW
		22	F	2-3 M	B	I	<100 m	8	HP OW	HP OW	HP OW	HP OW	HP OW
		23	F	3-4 M	B	I	<100 m	24	HP OW	HP OW	HP OW	HP OW	HP OW

1	2	3	4	5	6	7	8	9	10	11	12	13	14
		24	F	2- 3 M	B	I	<100 m	29	OW	OW	OW	OW	OW
		25	F	N K	B	I	<150 m	40	OW	OW	OW	OW	OW
		26	F	3-4 M	B	I	<150 m	7	HP OW	HP OW	HP OW	HP OW	HP OW
		27	F	NK	B	I	<150 m		OHP	OHP	HOHP	OHP	OHP
	HP 4	28	F	5-6 W	G	S	< 20 m	38	HP	HP	HP	HP	HP
	M - II	29	F	3-4 W	G	S	< 20m	27	HP	HP	HP	HP	HP
		30	F	4-5 W	G	S	< 20 m	40	HP	HP	HP	HP	HP
		31	F	4-6W	G	S	<50 m	30	HP	HP	HP	HP	HP
		32	F	3-4W	G	S	<50 m	30	HP	HP	HP	HP	HP
		33	F	3-4W	G	S	<50 m	30	HP	HP	HP	HP	HP
		34	F	5-6W	G	S	<100 m	8	HP OW	HP OW	HP OW	HP OW	HP OW
		35	F	N K	G	S	< 100 m	7	HP OW	HP OW	HP OW	HP OW	HP OW
	HP 5	36	R	1-2 M	G	S	<20 m	33	HP	HP	HP	HP	HP
	M - III	37	R	2-3 M	G	S	<20 m	25	HP	HP	HP	HP	HP
		38	R	2-3 M	G	S	<20 m	30	HP	HP	HP	HP	HP
		39	R	1-2 M	G	S	<50 m	20	HP	HP	HP	HP	HP
		40	R	3-4M	G	S	<50 m	30	HP	HP	HP	HP	HP
		41	R	1-2 M	G	S	< 50 m	30	HP	HP	HP	HP	HP
		42	R	2-3 M	G	S	<100 m	30	HP	HP	HP	HP	HP
		43	R	1-2 M	G	S	<100 m	25	HP	HP	HP	HP	HP
Hemrapur	HP 6	44	R	2-3 M	G	S	<20 m	24	HP	HP	HP	HP	HP
	M - III	45	R	2-3 M	G	S	< 20 m	22	HP	HP	HP	HP	HP
		46	R	1-2 M	G	S	<20 m	28	HP	HP	HP	HP	HP
		47	R	1-2 M	G	S	<50 m	36	HP	HP	HP	HP	HP
		48	R	2-3 M	G	S	<50 m	38	HP	HP	HP	HP	HP
		49	R	2- 3 M	G	S	< 50 m	30	HP	HP	HP	HP	HP
		50	R	2-3 M	G	S	< 100 m	40	HP	HP	HP	HP	HP
		51	R	NK	G	S	<100 m	20	HP	HP	HP	HP	HP
		52	R	3-4 M	G	S	<100 m	17	HP	HP	HP	HP	HP

1	2	3	4	5	6	7	8	9	10	11	12	13	14
	HP 7	53	O	1W	G	S	<20 m	22	HP	HP	HP	HP	HP
	M - III	54	O	1-2 W	G	S	< 20 m	25	HP	HP	HP	HP	HP
		55	O	1-2 W	G	S	< 20 m	36	HP	HP	HP	HP	HP
		56	O	2 W	G	S	< 50 m	33	HP	HP	HP	HP	HP
		57	O	1-2 W	G	S	< 50 m	32	HP	HP	HP	HP	HP
		58	O	2 W	G	S	< 50 m	38	HP	HP	HP	HP	HP
		59	O	1 W	G	S	< 100 m	34	HP	HP	HP	HP	HP
		60	O	2 W	G	S	< 100 m	30	HP	HP	HP	HP	HP
		61	O	1 W	G	S	< 100 m	29	HP	HP	HP	HP	HP
	HP 8												
	M - III	62	O	2 D	G	S	< 20 m	34	HP	HP	HP	HP	HP
		63	O	3 D	G	S	< 20 m	25	HP	HP	HP	HP	HP
		64	O	1 D	G	S	< 20 m	30	HP	HP	HP	HP	HP
		65	O	2 D	G	S	< 50 m	25	HP	HP	HP	HP	HP
		66	O	2 D	G	S	< 50 m	20	HP	HP	HP	HP	HP
		67	O	1 D	G	S	< 50 m	25	HP	HP	HP	HP	HP
		68	O	3 - 4 D	G	S	< 100 m	16	HP	HP	HP	HP	HP
		69	O	2 D	G	S	< 100 m	15	HP	HP	HP	HP	HP
		70	O	3 D	G	S	< 100 m	13	HP	HP	HP	HP	HP
	HP 9												
	M - III	71	O	1 D	G	S	< 50 m	40	HP	HP	HP	HP	HP
		72	O	2 D	G	S	< 50 m	30	HP	HP	HP	HP	HP
		73	O	2 D	G	S	< 50 m	37	HP	HP	HP	HP	HP
		74	O	1 D	G	S	< 100 m	34	HP	HP	HP	HP	HP
		75	O	1-2 D	G	S	< 100 m	35	HP	HP	HP	HP	HP
		76	O	1 -2 D	G	S	< 100 m	32	HP	HP	HP	HP	HP
		77	O	2 D	G	S	< 150 m	30	HP	HP	HP	HP	HP
		78	O	2- 3 D	G	S	< 150 m	30	HP	HP	HP	HP	HP
		79	O	2-3 D	G	S	< 150 m	32	HP	HP	HP	HP	HP

1	2	3	4	5	6	7	8	9	10	11	12	13	14
	HP 10												
	M -II	80	O	1 D	B	S	< 20 m	20	HP	HP	HP	HP	HP
		81	O	1 -2 D	B	S	< 20 m	23	HP	HP	HP	HP	HP
		82	O	2 D	B	S	< 20 m	20	HP	HP	HP	HP	HP
		83	O	1 -2 D	B	S	< 50 m	14	HP	HP	HP	HP	HP
		84	O	1 D	B	S	< 50 m	15	HP	HP	HP	HP	HP
		85	O	2 D	B	S	< 50 m	24	HP	HP	HP	HP	HP
		86	O	1 D	B	S	< 100 m	10	HP	HP	HP	HP	HP
		87	O	2 D	B	S	< 100 m	13	HP	HP	HP	HP	HP
		88	O	1 D	B	S	< 100 m	13	HP	HP	HP	HP	HP
Chandrav	HP 11	89	O	1 M	G	S	< 20 m	24	HP	HP	HP	HP	HP
	M - III	90	O	1- 2 M	G	S	< 20 m	16	HP	HP	HP	HP	HP
		91	O	2 M	G	S	< 20 m	16	HP	HP	HP	HP	HP
		92	O	1 M	G	S	< 50 m	15	HP	HP	HP	HP	HP
		93	O	1-2 M	G	S	< 50 m	12	HP	HP	HP	HP	HP
		94	O	4- 6 W	G	S	< 50 m	17	HP	HP	HP	HP	HP
		95	O	3- 4 W	G	S	< 50 m	16	HP	HP	HP	HP	HP
		96	O	4- 5 W	G	S	< 75m	12	HP	HP	HP	HP	HP
		97	O	4- 5 W	G	S	< 75 m	14	HP	HP	HP	HP	HP
		98	O	N K	G	S	< 75 m	13	HP	HP	HP	HP	HP
	HP 12	99	R	4- 6 W	G	S	< 20 m	19	HP	HP	HP	HP	HP
	M - II	100	R	4-5 W	G	S	< 20 M	33	HP	HP	HP	HP	HP
		101	R	3 -4 W	G	S	< 20 m	24	HP	HP	HP	HP	HP
		102	R	3-4 W	G	S	< 50 m	12	HP	HP	HP	HP	HP
		103	R	3 - 4 W	G	S	< 50 m	14	HP	HP	HP	HP	HP
		104	R	4-6 W	G	S	< 50 m	14	HP	HP	HP	HP	HP
	HP 13												
	M - II	105	F	1 D	B	S	< 20 m	24	HP	HP	HP	HP	HP
		106	F	2 D	B	S	< 20 m	18	HP	HP	HP	HP	HP
		107	F	1-2 D	B	S	< 20 m	14	HP	HP	HP	HP	HP

1	2	3	4	5	6	7	8	9	10	11	12	12	14
		108	F	2 - 3 D	B	S	< 50 m	20	HP	HP	HP	HP	HP
		109	F	2 D	B	S	< 50 m	16	HP	HP	HP	HP	HP
		110	F	2-3 D	B	S	< 50 M	18	HP	HP	HP	HP	HP
	HP 14	111	R	1-2 M	G	S	< 20 M	20	HP	HP	HP	HP	HP
	M - II	112	R	2- 3 M	G	S	< 20 m	24	HP	HP	HP	HP	HP
		113	R	1- 2 M	G	S	< 20 m	28	HP	HP	HP	HP	HP
		114	R	2 -3 M	G	S	< 50 m	22	HP	HP	HP	HP	HP
		115	R	2- 3 M	G	S	< 50 m	20	HP	HP	HP	HP	HP
		116	R	1-2 M	G	S	< 50 m	13	HP	HP	HP	HP	HP
	HP 15	117	R	2- 3 M	G	S	< 20 m	13	HP	HP	HP	HP	HP
	M - II	118	R	2-3 M	G	S	< 20 m	20	HP	HP	HP	HP	HP
		119	R	1-2 M	G	S	< 20 m	15	HP	HP	HP	HP	HP
		120	R	1- 2M	G	S	< 50 m	15	HP	HP	HP	HP	HP
		121	R	2 -3 M	G	S	< 50 M	14	HP	HP	HP	HP	HP
		122	R	1-2 M	G	S	< 50 m	16	HP	HP	HP	HP	HP
Bakkas	HP 16	123	F	1-2 M	G	S	< 20 m	17	HP	HP	HP	HP	HP
	M - III	124	F	2-3 M	G	S	< 20 m	33	HP	HP	HP	HP	HP
		125	F	2-3 M	G	S	< 20 m	27	HP	HP	HP	HP	HP
		126	F	1-2 M	G	S	< 50 m	30	HP	HP	HP	HP	HP
		127	F	1-2 M	G	S	< 50 m	14	HP	HP	HP, OW	HP, OW	HP, OW
		128	F	2 -3 M	G	S	< 50 m	16	HP	HP	HP, OW	HP, OW	HP, OW
		129	F	2- 3 M	G	S	< 100 m	14	HP	HP	OW	OW	OW
		130	F	1- 2 M	G	S	< 100 m	18	HP	HP	HP	HP	HP
		131	F	2-3 M	G	S	<100 m	25	HP	HP	HP	HP	HP
	HP 17												
	M - II	132	F	2-3 D	B	S	< 20 m	14	HP	HP	HP	HP	HP
		133	F	2- 3 D	B	S	< 20m	17	HP	HP	HP	HP	HP
		134	F	2- 3 D	B	S	< 20 M	15	HP	HP	HP	HP	HP
		135	F	1-2 D	B	S	< 50 M	20	HP	HP	HP	HP	HP
		136	F	1-2 D	B	S	< 50 m	12	HP	HP	HP	HP	HP

1	2	3	4	5	6	7	8	9	10	11	12	13	14
		137	F	2-3 D	B	S	< 50 m	17	HP	HP	HP	HP	HP
	HP 18	138	O	1- 2 M	G	S	< 20 m	38	HP	HP	HP, OW	HP, OW	HP, OW
	M II	139	O	1- 2 M	G	S	< 20 m	19	HP	HP	HP ,OW	HP, OW	HP, OW
		140	O	2- 3 M	G	S	< 20 m	14	HP	HP	HP	HP	HP
		141	O	1- 2 M	G	S	< 50 m	12	HP	HP	HP, OW	HP, OW	HP, OW
		142	O	2- 3 M	G	S	< 50 m	13	HP	HP	HP	HP	HP
		143	O	2- 3 M	G	S	<50 m	14	HP	HP	HP, OW	HP, OW	HP, OW
		144	O	1- 2 M	G	S	< 100 m	12	HP	HP	OW	OW	OW
		145	O	2- 3 M	G	S	<100 m	14	HP	HP	OW	OW	OW
		146	O	NK	G	S	< 100 m	24	HP	HP	HP	HP	HP
	HP 19	147	R	1-2 M	G	S	< 20 m	23	HP	HP	HP	HP	HP
	M - III	148	R	1-2 M	G	S	< 20 m	35	HP	HP	HP	HP	HP
		149	R	2- 3M	G	S	< 20 m	25	HP	HP	HP	HP	HP
		150	R	2-3 M	G	S	< 50 m	32	HP	HP	HP	HP	HP
		151	R	1-2 M	G	S	< 50 m	24	HP	HP	HP	HP	HP
		152	R	1-2 M	G	S	< 50 m	24	HP	HP	HP	HP	HP
	HP 20												
	M - II	153	R	2- 3 M	G	S	< 20 m	14	HP	HP	HP	HP	HP
		154	R	2-3 M	G	S	< 20 m	25	HP	HP	HP	HP	HP
		155	R	1-2 M	G	S	< 20 m	28	HP	HP	HP	HP	HP
		156	R	1-2 M	G	S	< 50 m	20	HP	HP	HP	HP	HP
		157	R	2- 3 M	G	S	<50 m	20	HP	HP	HP	HP	HP
		158	R	2- 3 M	G	S	< 50 m	22	HP	HP	HP	HP	HP

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Raini	HP 21	159	R	1 -2 M	G	S	< 50 m	35	HP	HP	HP	HP	HP
Allahabad	M - III	160	R	2-3 M	G	S	< 50 m	19	HP	HP	HP	HP	HP
		161	R	1- 2 M	G	S	< 50 m	29	HP	HP	HP	HP	HP
		162	R	1- 2 M	G	S	< 100 m	29	HP	HP	HP	HP	HP
		163	R	2- 3 M	G	S	< 100 m	25	HP	HP	HP	HP	HP
		164	R	2 - 3 M	G	S	< 100 m	20	HP	HP	HP	HP	HP
		165	R	1 - 2 M	G	S	< 150 m	12	HP	HP	HP	HP	HP
		166	R	1 - 2 M	G	S	< 150 m	14	HP	HP	HP	HP	HP
		167	R	NK	G	S	< 150 m	15	HP	HP	HP	HP	HP
	HP 22												
	M - III	168	R	1 - 2 M	G	S	< 50 m	30	HP	HP	HP	HP	HP
		169	R	2- 3 M	G	S	< 50 m	20	HP	HP	HP	HP	HP
		170	R	1-2 M	G	S	< 50 m	27	HP	HP	HP	HP	HP
		171	R	2- 3 M	G	S	< 100 m	22	HP	HP	HP	HP	HP
		172	R	2- 3 M	G	S	< 100 m	20	HP	HP	HP	HP	HP
		173	R	1- 2 M	G	S	< 100 m	14	HP	HP	HP	HP	HP
	HP 23												
	M - III	174	R	1- 2 M	G	S	< 20 m	22	HP	HP	HP	HP	HP
		175	R	1-2 M	G	S	< 20 m	22	HP	HP	HP	HP	HP
		176	R	2- 3 M	G	S	< 20 m	14	HP	HP	HP	HP	HP
		177	R	2-3 M	G	S	< 50 m	14	HP	HP	HP	HP	HP
		178	R	1-2 M	G	S	< 50 m	24	HP	HP	HP	HP	HP
		179	R	2- 3 M	G	S	< 50 m	12	HP	HP	HP	HP	HP
		180	R	N K	G	S	< 100 M	12	HP	HP	HP	HP	HP
	HP 24	181	O	2-3 M	G	I	< 20 m	18	HP	HP	HP	HP	HP
	M - III	182	O	2- 3 M	G	I	< 20 m	20	HP	HP	HP	HP	HP
		183	O	1- 2 M	G	I	<20 m	16	HP	HP	HP	HP	HP

1	2	3	4	5	6	7	8	9	10	11	12	13	13
		184	O	2 M	G	I	< 50 m	24	HP	HP	HP	HP	HP
		185	O	2 M	G	I	< 50 m	16	HP	HP	HP	HP	HP
		186	O	2 M	G	I	< 100 m	14	HP	HP	HP	HP	HP
		187	O	NK	G	I	< 100 m	16	HP	HP	HP	HP	HP
	HP 25	188	F	2- 3 M	B	I	< 20 m	25	HP	HP	HP	HP	HP
	M - III	189	F	2-3 M	B	I	< 20 m	30	HP	HP	HP	HP	HP
		190	F	2- 3 M	B	I	< 20 m	17	HP	HP	HP	HP	HP
		191	F	1-2 M	B	I	< 50 M	15	HP	HP	HP	HP	HP
		192	F	1-2 M	B	I	< 50 m	20	HP	HP	HP	HP	HP
		193	F	2-3 M	B	I	< 100 m	24	HP	HP	HP	HP	HP
		194	F	1-2 M	B	I	< 100M	15	HP	HP	HP	HP	HP
		195	F	N K	B	I	< 100 m	15	HP	HP	HP	HP	HP
	HP 26	196	R	1 M	G	S	< 20 m	12	HP	HP	HP	HP	HP
	M - III	197	R	2 M	G	S	< 20 m	16	HP	HP	HP	HP	HP
		198	R	2- 3 M	G	S	< 20 m	14	HP	HP	HP	HP	HP
		199	R	NK	G	S	< 50 m	20	HP	HP	HP	HP	HP
		200	R	2 M	G	S	< 50 m	20	HP	HP	HP	HP	HP
		201	R	2 M	G	S	< 100 M	18	HP	HP	HP	HP	HP
	HP 27	202	O	2 W	G	S	< 20 m	20	HP	HP	HP	HP	HP
	M - III	203	O	3 W	G	S	< 20 m	12	HP	HP	HP	HP	HP
		204	O	2 W	G	S	< 20 m	30	HP	HP	HP	HP	HP
		205	O	3 W	G	S	< 50 m	12	HP	HP	HP	HP	HP
		206	O	2 W	G	S	< 50 m	18	HP	HP	HP	HP	HP
		207	O	4 W	G	S	< 50 m	20	HP	HP	HP	HP	HP
Sehuadih	HP 28	208	O	2 M	G	S	< 20 m	20	HP	HP`	HP	HP	HP
	M - III	209	O	3 M	G	S	< 20 m	14	HP	HP`	HP	HP	HP
		210	O	2 M	G	S	< 20 m	17	HP	HP`	HP	HP	HP

1	2	3	4	5	6	7	8	9	10	11	12	13	14
		211	O	2 M	G	S	< 50 m	16	HP	HP`	HP	HP	HP
		212	O	2 M	G	S	< 50 m	25	HP	HP`	HP	HP	HP
		213	O	3 M	G	S	< 50 m	20	HP	HP`	HP	HP	HP
		214	O	2 M	G	S	< 100 m	20	HP	HP`	HP	HP	HP
		215	O	N K	G	S	< 100 m	9	HP	HP`	HP	HP	HP
Atanpur	HP 29	216	R	1 M	G	S	< 20 m	20	HP	HP`	HP	HP	HP
	M - III	217	R	2 M	G	S	< 20 m	14	HP	HP`	HP	HP	HP
		218	R	2 M	G	S	< 20 m	24	HP	HP`	HP	HP	HP
		219	R	1-2 M	G	S	< 50 m	32	HP	HP`	HP	HP	HP
		221	R	1 M	G	S	< 50 m	30	HP	HP`	HP	HP	HP
	HP 30	222	R	2-3 M	G	S	< 20 m	30	HP	HP	HP	HP	HP
	M -III	223	R	1-2 M	G	S	< 20 m	32	HP	HP	HP	HP	HP
		224	R	1 M	G	S	< 2O m	20	HP	HP	HP	HP	HP
		225	R	1-2 M	G	S	< 50 m	24	HP	HP	HP	HP	HP
		226	R	2 M	G	S	< 100 m	15	HP	HP	HP	HP	HP
		227	R	N K	G	S	< 100m	14	HP	HP	HP	HP	HP
	HP 31	228	O	2 M	G	S	< 20 m	35	HP	HP	HP	HP	HP
	M - II	229	O	2-3 M	G	S	< 20 m	25	HP	HP	HP	HP	HP
		230	O	1- 2 M	G	S	< 20 m	16	HP	HP	HP	HP	HP
		231	O	1 M	G	S	< 50 m	17	HP	HP	HP	HP	HP
		232	O	2 M	G	S	< 50 m	18	HP	HP	HP	HP	HP
		233	O	1 M	G	S	< 50 M	20	HP	HP	HP	HP	HP
Sarai harkisan	HP 32	234	F	1 W	G	S	< 20 m	27	HP	HP	HP	HP	HP
	M - II	235	F	1-2 W	G	S	< 20 m	28	HP	HP	HP	HP	HP
		236	F	1 W	G	S	< 20 m	32	HP	HP	HP	HP	HP
		237	F	1-2 W	G	S	< 50 m	40	HP	HP	HP	HP	HP
		238	F	2- 3 W	G	S	< 50m	34	HP	HP	HP	HP	HP

1	2	3	4	5	6	7	8	9	10	11	12	13	14
		239	F	1 W	G	S	< 50 m	32	HP	HP	HP	HP	HP
		240	F	1-2 W	G	S	< 100 m	24	HP	HP	HP	HP	HP
		241	F	2 -3 W	G	S	< 100 m	20	HP	HP	HP	HP	HP
	HP 33	242	R	1- 2 M	G	S	< 20 m	20	HP	HP	HP	HP	HP
	M - II	243	R	2-3 M	G	S	< 20 m	25	HP	HP	HP	HP	HP
		244	R	1 M	G	S	< 20 m	35	HP	HP	HP	HP	HP
		245	R	1 M	G	S	< 50 m	25	HP	HP	HP	HP	HP
		246	R	1-2 M	G	S	< 50 m	30	HP	HP	HP	HP	HP
		247	R	2 M	G	S	< 50 m	28	HP	HP	HP	HP	HP
Baksera	HP 34	248	R	2 M	G	S	< 20 m	27	HP	HP	HP	HP	HP
	M - II	249	R	2 M	G	S	< 20 m	34	HP	HP	HP	HP	HP
		250	R	1 M	G	S	< 20 m	29	HP	HP	HP	HP	HP
		251	R	1 -2 M	G	S	< 50 m	19	HP	HP	HP	HP	HP
		252	R	1 M	G	S	< 50 m	19	HP	HP	HP	HP	HP
		253	R	2 M	G	S	< 50 m	18	HP	HP	HP	HP	HP
	HP 35	254	F	3 M	G	S	< 20 m	27	HP	HP	HP	HP	HP
	M - II	255	F	2 M	G	S	< 20 m	28	HP, PS	HP, PS	HP, PS	HP, PS	HP, PS
		256	F	1-2 M	G	S	< 20 M	35	HP	HP	HP	HP	HP
		257	F	2 M	G	S	< 50 m	18	HP, PS	HP, PS	HP, PS	HP, PS	HP, PS
		258	F	1-2 M	G	S	< 50 m	40	HP	HP	HP	HP	HP
		259	F	2 M	G	S	< 100 m	28	HP	HP	HP	HP	HP
	HP 36	260	R	1 M	G	S	< 20 m	18	HP	HP	HP	HP	HP
	M -II	261	R	1 M	G	S	< 20 m	22	HP	HP	HP	HP	HP
		262	R	2 M	G	S	< 20 m	25	HP	HP	HP	HP	HP
		263	R	1-2 M	G	S	< 50 M	24	HP	HP	HP	HP	HP
		264	R	1-2 M	G	S	< 50 m	18	HP	HP	HP	HP	HP
		265	R	2 M	G	S	< 50 m	17	HP	HP	HP	HP	HP

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Baijahi	HP 37	266	F	1 W	G	S	< 20 m	32	HP	HP	HP	HP	HP
	M - II	267	F	2 W	G	S	< 20 m	32	HP	HP	HP	HP	HP
		268	F	2 W	G	S	< 20 m	25	HP	HP	HP	HP	HP
		269	F	1- 2 W	G	S	< 50 m	27	HP	HP	HP	HP	HP
		270	F	1 -2 W	G	S	< 50 m	30	HP	HP	HP	HP	HP
		271	F	2 W	G	S	< 50 m	24	HP	HP	HP	HP	HP
		272	F	1 W	G	S	< 100 m	16	HP	HP	HP	HP	HP
		273	F	2 W	G	S	< 100 m	20	HP	HP	HP	HP	HP
	HP 38	274	F	2 W	G	S	< 20 m	32	HP	HP	HP	HP	HP
	M - II	275	F	2 W	G	S	< 20 m	41	HP	HP	HP	HP	HP
		276	F	1- 2 W	G	S	< 20 m	16	HP	HP	HP	HP	HP
		277	F	1 W	G	S	< 50 m	36	HP	HP	HP	HP	HP
		278	F	1 W	G	S	< 50 m	30	HP	HP	HP	HP	HP
		279	F	2 W	G	S	< 50 m	18	HP	HP	HP	HP	HP
		280	F	2 W	G	S	< 100 m	26	HP	HP	HP	HP	HP
		281	F	2 W	G	S	< 100 m	19	HP	HP	HP	HP	HP
	HP 39	282	F	2- 3 W	G	S	< 20 m	27	HP	HP	HP	HP	HP
	M - II	283	F	2 - 3 W	G	S	< 20 m	40	HP	HP	HP	HP	HP
		284	F	1-2 W	G	S	< 20 m	34	HP	HP	HP	HP	HP
		285	F	1 W	G	S	< 50 m	30	HP	HP	HP	HP	HP
		286	F	2 W	G	S	< 50 m	32	HP	HP	HP	HP	HP
		287	F	2 W	G	S	< 50 m	27	HP	HP	HP	HP	HP
		288	F	1- 2 W	G	S	< 100 m	19	HP	HP	HP	HP	HP
		289	F	1 W	G	S	< 100 m	20	HP	HP	HP	HP	HP
	HP 40	290	F	3 D	G	S	< 20 m	40	HP	HP	HP	HP	HP
	M - II	291	F	2-3 D	G	S	< 20 m	37	HP	HP	HP	HP	HP
		292	F	3 -4 D	G	S	< 20 m	34	HP	HP	HP	HP	HP
		293	F	3 D	G	S	< 50 m	30	HP	HP	HP	HP	HP
		294	F	3 D	G	S	< 50 m	32	HP	HP	HP	HP	HP

1	2	3	4	5	6	7	8	9	10	11	12	13	14
		295	F	2- 3 D	G	S	< 50 m	17	HP	HP	HP, OW	HP, OW	HP, OW
		296	F	3- 4 D	G	S	< 100 m	25	HP	HP	HP, OW	HP, OW	HP, OW
		297	F	3- 4 D	G	S	< 100 m	20	HP	HP	HP, OW	HP, OW	HP, OW

Functioning of handpumps
R - Rarely breaks
O - Occasionally breaks
F - Frequently breaks
N K - Not known
G - Good quality water
B - Bad quality water
S - Sufficient quantity of water
I - Inadequate quantity of water

Water Usages
HP - Householders using handpump water
OW - Householders using Open Well water
PS - Householders using Piped Water Supply
OHP - Householders using own handpumps