INDIVIDUAL STUDY REPORT COMPLETED IN FULLFILMENT OF MASTER OF ENGINEERING DEGREE.(1997-1998)

SUBJECT:- RAINWATER HARVESTING SYSTEM OF ROOF CATCHMENT IN MIZORAM:INDIA.

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CONTENT

SUMMARY

Rainwater harvesting system from roof catchment in Aizawl City, Mizoram India is presented. It is one of the cheapest ways to supply water for domestic purposes. A literature review indicates the keys areas and experiences on urban rainwater harvesting. The city of Aizawl introduced a programme to promote and implement rainwater in 1980's and the technology are acceptable by the household. There is a high replication on the programme by the community since operation and maintenance is low though the initial cost is high. The affordability is mainly based on whether priority is given by the household or not. There are some alternative options given for solving problems of water supply in rural and urban areas in Mizoram apart from rainwater harvesting system.

Literature Review: Rainwater harvesting of roof catchment systems has been used since early Roman times. Despite of the decline in the first part of this century, the system started to spread during the last 20 years, especially in E Africa and S E Asia. In developing countries, it is an appropriate technology and acceptable. Affordability is ultimately community decision. The nation-wide replication is rainwater jar programme in Thailand. In order to have successful programme, good management on O&M is necessary.

Results: Rainwater is water in the purest form. A study conducted by Industrial Toxicology Research Centre, Lucknow City on water quality on different sources of water revealed that rainwater stored for long period of time without treatment developed bacterial growth but is free from undesirable chemicals. Such bacteria can be removed by simple chlorination. The per capita investment cost for 10,000-litre capacity of galvanised plain sheet tank is Rs 1700 per person. Mostly the amount of water collected does not bridge the driest period because they can not afford more storage capacity. In Mizoram the full potential of rainwater is not exploited yet.

Conclusions: The Rainwater harvesting system has advantages and disadvantages as well. However, it continues to play a very important role in Mizoram even after piped water supply is constructed in 1988, as public water supply through pumping system is extremely costly. In Aizawl City, the rainwater harvesting system coverage is about 30% of the population. Without rainwater collection system, it is not thinkable how will the people manage. If the government has taken initiative by introducing the programme on awareness campaign regarding rainwater harvesting system, it would have been drastically more supplemented the shortfall of present water supply system.

Recommendations: Rainwater catchment system is a simple technology appropriate to developing countries also for urban areas. Therefore the system must be encouraged. The central and the state government should take actions. User education must be given priority in order to be successful in the management of the system .For Aizawl City; it is also recommended that identify some additional sources to supplement rainwater-harvesting system. An options are the Hand Pump Tube well and traditional spring source. These two systems can also be promoted apart from rainwater harvesting.

1.INTRODUCTION:

Nature has created land, forest, greenery, rivers, lakes, etc and there is a balanced of planetary Eco-system. Over-enthusiasm of man sometimes compelled him to utilise those natural resources to such an extent that Eco-system is being disturbed. Human existence is based on man's natural environment. Man is dependent on it to provide him air to breathe, water to drink, food to eat and other resources to make his life enjoyable and these are basic needs of every human being. Human activity is brought about the occurrence of rain. Rainwater originates from evaporation and transpiration of water vapour at the surface. It is clear that rainwater is an important water source. The principles of rainwater harvesting is that **to collect rain water, in places with shortage of water, and where excess of water occurs seasonally, and storing it for beneficial uses by the people in a dry period.**

The process to be discussed is rainwater harvesting through roof collection per household for domestic purposes. One of the most important criteria for rainwater harvesting is the prevailing of rainfall. Depending upon the areas, at some places sufficient or abundant rainfall occurs. While at some places there is very intensive rainfall. In spite of different methods, rainwater harvesting system has two common characteristics; namely: -

- Rainfall has an intermittent character.
- Compared with other water supply systems, it is relatively small-scale operation.

The constructions and operations required for rainwater harvesting is relatively simple and hence the O&M cost is low. The rainwater storage tanks can be constructed by using different kinds of materials like concrete; concrete lined with bamboo, ferro-cement, and stone masonry and galvanised iron/plain sheets, etc. The size of the tank depends on rainfall frequency, duration and magnitude, demand on the system and characteristics of the catchment area.

Rainwater harvesting is very useful and offers many benefits in places with difficulty in water supply, fuel and other supplies, maintenance, high cost, etc. When, there is a breakdown in the urban water supply, people often fetch water from traditional sources like ponds / lakes, springs, rivers, etc which are usually polluted. During this period, rainwater collection probably is the most suitable water supply system to satisfy basic human needs.

Rainwater harvesting programme is also one of the government's programmed, taken up by Public Health Engineering Department Mizoram. The scheme covered only rural areas not urban. All the expenditure is borne by the household in urban areas.

The case study of **Aizawl City,** the capital city of **Mizoram State,** will be presented. The design and cost analysis of the system will be highlighted in the report.

2.LITERATURE REVIEW: -

Rainwater harvesting systems have been used since ancient times and evidence of roof catchment systems date back to early Roman times and also in Israel, Turkey, Bermuda, Africa, Asia, Latin America and Australia, not only for drinking and domestic purposes but also for agriculture and livestock. Despite a decline in the interest of the system in the first part of this century, during the last 20 years the technology has started to spread rapidly from many areas world-wide, particularly in E.Africa and S.E.Asia. The interest of the technology is mainly due to lack of other available sources and becomes an alternative forms of supply. (Environmental Sanitation Reviews, No-32, 1991)

Rainwater catchment system is an appropriate technology in developing countries. Appropriate with respect to level of service, ability to pay willingness to pay, cultural and behavioural constraints and local conditions. (Waller, 1989). There is various method of rainwater catchment system. Namely roof, ground and rock catchment. (Lee & Visscher, 1992). The quality is relatively good from roof catchment and cleans enough for any one to drink specially from roofs with galvanised corrugated iron sheets. The quality from jar does not meet WHO drinking standard, but it would be far more beneficial to concentrate resources on improving sanitary and water handling practices rather than try to meet WHO standard. (Gould, 1991)

Different kinds of materials are used for construction of storage tanks in different countries are: -reinforced cement concrete tanks, cement jars, concrete ring tanks, ferro cement tanks, brick and block tanks, galvanised plain sheet tanks, galvanised iron tanks, burnt clay pots, plastic tanks, metal tanks, wooden tanks, (Mayo, 1991; Gould, 1991).

In many other parts of the world, galvanised corrugated iron roofs are commonly used. (Waller, 1989). Roof catchment technology is mostly used in Thailand, Philippines, India, South Australia, Botswana and Kenya. In Botswana, even ground catchment technology is developed. In Kenya, ground and rock catchment technologies have been developed and a wide variety of designs and implementation strategies are in operation. (Mbugua, 1993). Rainwater is used for domestic and drinking purposes. (Ndege, 1992). In South Africa, there is optimisation of ground catchment to maximise rainwater collection. (Chibi, 1991). In China, the technology adopted is ground and roof catchment. The rainwater is stored in under-ground storage tank with tap and hand pump facilities. (Ling Bo & Liu Jiayi, 1991). In Tanzania little attention has been paid to rainwater harvesting from roof catchment. The implementation of the rainwater-harvesting programme has always proved to be difficult mostly due to availability of funds and costly technology. However the government has generally tried to promote in drought prone regions. (Mayo, 1991)

Bamboo reinforcement water tanks were widely used in many countries, but have been found deteriorated rapidly over time due to the deterioration of reinforcing. Ferro cement tanks are widely used. They are being introduced in Botswana to replace commonly used galvanised corrugated metal tanks. (Waller, 1991) Different kinds of rainwater tanks are used in Tanzania. However, concrete tanks are commonly used and ferro cement tanks are also available. (Mayo, 1991). Ferro cement tanks and concrete ring tanks are used in Kenya. The programme has become completely self-financing

and around 3000 tanks. have been constructed. The success is due to setting up of revolving fund among groups. In Capiz province (The Philippines), 500 tanks of wire framed ferro cement rainwater catchment tanks have been constructed. Thailand is famous for rainwater jar programme and the results for this programme are quite staggering with around 10 million rainwater jars constructed in just over 5 years. (Environmental Sanitation Reviews, No-32, 1991). The objective is to provide a minimum of 2cum-cement jar per family. (Waller, 1989).

Financial and economic issues are crucial to the introduction of water harvesting system. Cost estimates show a wide range, depending on the method used to arrive at the figures. Factors, which contribute to these differences, include:

- Inflation since time of calculation
- Exchange rate conversions
- Exclusion or inclusion overhead project costs
- Exclusion or inclusion of commercial materials, skilled labour, local materials, self help labour, transport, equipment, technical advisor
- Different pricing in different countries

For example, the equivalent wage for self-helping daily labour (1989) varies significantly per country: (Lee & Visscher, 1990)

- In Tanzania US$ 0.25-0.50
- In Kenya US$ 0.70-1.00
- In Botswana US$ 1.50
- In Togo&Mali US$ 1.50-2.00

In China, a storage tank with 20 cum capacity cost US$ 35. If tap is provided US$ 58. (Ling Bo & Jiayi, 1991). In Thailand, it was estimated by researchers at Khon Kaen University that the cost of constructing the 6 million jars initially planned could be cut from around US$ 132 million to just US$ 25 million by mobilising the village level resources. (Wirojanagud & vanvarothorn, 1990). In Philippines, the implementation strategy used for this project was that loans provided to fund the cost of the tanks included the component for covering the cost of an associated income-generating venture. (Environmental Sanitation Reviews, No-32, 1991)

The analysis of rainwater harvesting system in the world-wide with respect to their acceptability, affordability, replicability, operation & maintenance and management are mentioned below.

2.1: ACCEPTABILITY:

The acceptability of rainwater catchment system depends on appropriate technology. If it is socially inappropriate or unacceptable, it is unlikely to be successful. Local customs, perceptions and preferences must be given a high priority. It is always vital to be sensitive to local perceptions regarding the quality and suitable of rainwater. Although some people regard it as tasty but some considered being flat and tasteless. (Lotham & Gould, 1986). All the people do not know that rainwater is pure until it reaches roof level. The poor quality of rainwater is usually a result of storing and handling.

It is also important to know willingness of contribution by community either in cash or in kind to obtain a better water supply. Encouraging such contributions will help the government to achieve better coverage at lower cost and more important, stimulate users to accept greater responsibility for the system. (Gould, 1991)

2.2.AFFORDABILIY:

Whether a rainwater harvesting can be afforded by the community depends on many factors, but is ultimately the community decision. They should clearly understand that the cost and inputs required in construction and maintenance of the system. In most parts of developing countries, the cost of rainwater catchment system will be far beyond the means of most households. (Gould, 1991). Most programmes rely on the contribution of free labour and local materials by the community and despite these, significant subsidies from funding agencies or government is still generally needed. However, the storage capacity has not significantly increased partly due to affordability and partly due to lack of unawareness of existence of cheaper technology. For those who can afford large storage capacities, the quality of rainwater remains a problem. Many families can not afford the required capacity tanks. (Mayo, 1991).

2.3:REPLICABILITY:

Self-sustaining replication is the goal of many rainwater catchment implementation programmes; such a level of success is rare. One example of a single programme and design that has achieved the nation-wide replication is the rainwater jar programmes in Thailand. This has been widely documented. (Wirojanagud & Chindraprasirt, 1987; Tunyavanich & Hewison, 1989; Wirojanagud & Vanvarothorn, 1990). The success of rainwater catchment system in Thailand was based on a large number of pre-conditions unlikely to be found elsewhere and similar rates of replication should not be expected. The emphasis is no longer on implementation and financing of the programmes, but on improving water quality through better operation and maintenance of the system and improved hygiene education. In other parts of the world, pilot scheme and location-specific research are needed to an arrive at best system for wider replication. There are a number of examples of the replication of the designs and implementation strategies between countries, which are noteworthy. (Gould, 1991)

2.4:OPERATION AND MAINTENANCE:

Rainwater harvesting is a very appropriate technology for developing countries due to its simple construction and operation and maintenance. To maintain good quality of rainwater, cleaning or sweeping of the roof surfaces may be advisable before the first rains. A more convenient method is to detach the downward pipe from the tank and allow the initial rainfall to wash the roof and the first flush to run to waste until the run off is clean. The poor operation and maintenance is sometimes due to the fact that the programme is totally financed by external sources or the government lead to the progressive lack of interest, compared with self help involving which community participation. (Waller, 1989)

Serious problems such as cracked or leaking tanks need to be repaired quickly. Ferro cement designs have a distinct advantage over commercially available metal tanks in

this respect, since they can be relatively easily repaired. (Environmental Sanitation Reviews, No-32, 1991)

2.5:MANAGEMENT:

The rainwater harvesting system can be simply broken down not because of technical failure, but due to lack of management. Good management results success in the system. Due to limited supply rate, the rainwater is used only for cooking and drinking purposes, for washing and other domestic uses; the household should try to manage with other sources. In order to save water, water must not allowed leak from tap fittings or in tanks. Proper management is required while opening and closing the tap.

3.DESCRIPTION OF THE LAND, MIZORAM:

Mizoram is one of the states in India. It is located in the extreme north east corner of India bordering Myanmar (Burma) in the east and Bangladesh in the Southwest. Mizoram State having an area of only 21,081 sq.km is entirely mountainous region covered with green vegetation. The State being in the southeast monsoon area enjoys abundant monsoon rainfall. The average annual rainfall is about 250 cm. In spite of heavy monsoon rains the dry season always has acute water scarcity.

Mizoram State is thinly populated. The density of population is 33 persons per sq. km. All the towns and villages are located on the upper reaches of the hill slopes. The people are mostly engaged in agriculture and horticulture for their livelihood. Major industries are yet to come. The atmosphere is free from pollution; rainwater is clean and ideal for domestic uses

The geological formations of the hills are of sedimentary rocks comprising mostly of hard shale. Due to this geological formation the rainwater run off is very rapid. The traditional means of water supply is rainwater collection during the rainy season and storing them for use during dry days. The dry period is about 4 months from November to February.

4.CASE STUDY OF AIZAWL CITY:

4.1: PRESENT SITUATION:

Rainwater harvesting plays a very important role and it is one of the additional source to supplement the shortfall of water supply system in Aizawl.The history of Aizawl dated back to 1894, only 100 years back when the British established the first administrative unit at Aizawl. During that time, there was not any piped water supply facilities water supply to the British post was from 1.2 million gallons capacity underground rainwater reservoir constructed with stone masonry and the roof catchment was constructed with galvanised corrugated iron sheet (G.C.I. sheet). To suit the climate, buildings are mostly constructed with sloping roof using galvanised iron sheet, which is ideal for rainwater catchment. Roof top rainwater catchment system has been practised as the most convenient and economical water supply system.

Aizawl has a population of over 150,000 people (1991 census) The public water supply system by pumping from a perennial river involves pumping through a static head of 1040 metres using 8 km long of 305 mm diameter pipeline. The water supply system was designed for 80,000 people with 135 litre per capita per day rate of supply. The population of Aizawl increased rapidly due to migration from rural areas and the population doubled every decade. The present population is about 300,000 and the public water supply is grossly insufficient. The shortfall of water requirement is supplemented by rainwater.

4.2: RAINFALL DATA:

The rainfall data of Aizawl City in different years and the rainfall distribution during the twelve months of the year is given in the following tables:

(a) Monthly distribution of rainfall:

Year	1988	1990	1991	1992	1993	1994	1995	1996
Jan	0.06	0.16	0.11	0.50	1.80	0.30	0.40	0.80
Feb	2.80	2.40	3.00	6.80	12.9	1.60	1.00	3.7
Mar	6.40	17.7	2.80	0.70	9.90	23.3	3.70	16.9
Apr	13.7	26.0	13.7	5.00	10.8	16.0	4.00	10.7
May	33.3	39.8	20.2	16.1	48.2	15.9	36.7	29.8
Jun	49.7	31.7	40.2	27.7	64.1	30.2	44.9	34.7
Jul	55.2	41.6	71.1	37.4	70.9	41.7	40.5	36.7
Aug	44.4	55.2	45.3	38.2	46.2	43.4	47.4	35.1
Sep	32.7	42.2	34.6	31.6	33.9	21.0	34.9	43.6
Oct	23.1	9.80	30.2	25.6	21.7	11.1	17.1	20.5
Nov	4.10	12.4	0.13	3.90	2.40	2.60	19.5	3.40
Dec	0.10	3.70	0.10	1.00	0.10	0.02	0.05	0.40
Total	265.6	282.7	261.4	194.5	322.8	207.0	250.0	236.3

- The average rainfall per annum is 250 cm

(b). Annual Rainfall:

Year	1988	1990	1991	1992	1993	1994	1995	1996
Rainfall(cm)	265.6	282.7	261.4	194.5	322.8	207.0	250.0	236.3

4.3: DESIGN SYSTEM:

The following parameters are important for the design of rainwater harvesting tank: -

- Average monthly rainfall (cm/month)
- Number of people to be served,
- Daily per capita requirement (consumption = lcd),
- N° of consecutive days without rainfall ,
- Size of available catchment area ,
- Loses of water due to evaporation and leakage.

The run off coefficients differs in literature. For different materials, the run off coefficient is (As per National drinking Water Seminar, Vol.-II, 1988)

- -Roof tiles 0.8 – 0.9
- -G.I.sheet 0.7 – 0.9
- -Brick pavement 0.7 – 0.8

Due to splashing, gusting winds, evaporation and direction of rainfall, not all the water falling from the roof is collected and generally 70% is used for calculation of actual quantity of water. (As per United Nations, RAS / 87/ 009). However, in Mizoram a run off of 100% is considered. (Dunglena,1998)

4.3.1: STRUCTURE AND SIZE:

About 95% of individual household rainwater storage tanks are constructed in cylindrical shape. The following simple formula can be adopted for computation of the yield.

Quantity of water = Catchment area * Rainfall * Run off coefficient

Water demand: The bare minimum domestic water consumption by an average mizo family having water storage tank next to the house without internal pipe connections is assumed as 10 litre per capita per day only. The driest period is assumed as 120 days. Thus, the quantity of rainwater required by an average family of 8-persons to last the dry season is calculated as: -

8 * 10 * 120 = 9600 litres
Say = 10,000 litres

One or more tanks of 10,000 litres capacity rainwater tank are considered for one family at present.

4.3.2: CONSTRUCTION AND MATERIALS:

The essential components for rooftop harvesting system are: -

- Roof catchment materials,
- Gutters for collection of roof water ,
- Down pipe to convey rainwater from gutters to storage tank ,
- 'Foul flush' system to divert the contaminated run off from roof ,
- Storage tank above or below the ground
- Water withdrawal arrangement ,

In the past few years' materials used for rainwater tanks are galvanised corrugated iron sheets, RCC, Ferro cement, and plastic. Nowadays galvanised plain sheets are commonly used since they are available in the market and they are cheaper.

The tanks are constructed by joining the galvanised plain sheets together in a cylindrical shape. Therefore leakage commonly occurs at the joints. To avoid leakage, the tanks are painted with three or four coatings. At the bottom of the tank, bitumen foil is used for sealing. The proposed site for the tank should be free from vegetation, loose surface soil, moveable rocks and root growth.

4.3.3: FINANCIAL ISSUES:

The capital cost of rainwater catchment systems is high compared with the maintenance cost. In Mizoram, rainwater harvesting system of roof catchment is one of the cheapest modes of water supply. The average cost for 10,000 litres capacity storage tank per household is as under:

Cost of Rainwater harvesting tank (10 cum)

* Site preparation & excavation of earth	Rs. 2965.13
* Bitumen foil for tank sealing	Rs. 120.00
* Cost of G.P. sheets including fixing , etc	Rs. 8706.71
* Painting of the tank	Rs. 1204.99
* Fixing of bibcock (tap)	Rs. 161.70
* Carriage	Rs. 600.00
Total	**Rs. 13758.53**
Per capita cost(for investment/capital cost)	**Rs. 1707.32**

(For 10,000 litres capacity, GP sheet tank @ 10 litre per capita per day for 8- persons in a family)

Cost of Piped water supply (Pumping system)

Capital cost of the scheme	Rs. 180,000,000
Per capita cost(for investment/capital cost)	**Rs. 2250**

(N° of people being served by the scheme, consumption)

There is not much difference in per capita cost; however, the operation &maintenance cost is very high in pumping system. The cost can be much higher if there is a major break down in pumping machinaries and pipe materials. The revenue is only Rs10 million a year, and where as the O & M cost is Rs.25 million

5.ANALYSIS OF SUSTAINABILITY OF THE SYSTEM: -

The analysis of sustainability of the system in Aizawl with respect to its acceptability, affordability, replicability, operation & maintenance, manageability of the consumer is discussed below.

5.1: ACCEPTABILITY:

The success of any rainwater catchment system programme ultimately depends on the interest, enthusiasm and active support of the community for the technology and the quality. The people of Aizawl City accept the technology. But there are different opinions on the water quality. Some people accept the water for drinking purposes without any treatment, but some do not. The reason for not accepting the quality is thinking that rainwater is unsafe for drinking as mosquito larvae develop sometimes and which are visible with naked eyes. These can be removed by simple chlorination or can be prevented by covering the storage tank. The taste and odour of the chlorinated water are unaccustomed by the consumers. However boiling and filtration method are

practised for drinking. Nevertheless, the majority of the urban people accept it for domestic uses. (Drinking, cooking, washing, bathing)

5.2: AFFORDABILITY:

The affordability differs by family. The rich families can afford to construct large capacity of rainwater storage tank. Whereas for the poor, they can not afford the common materials and often used metal drum (barrel). Some can afford but due to negligence they often have a smaller tank capacity than required. On the other hand, some households have given priority on rainwater collection though they can not afford the required capacity; they start with the smaller tank and add some more when they can afford them. Due to the limited area of their compound some households have problem in space for the storage tank. More efforts by households would have been given if they were aware on the importance of rainwater collection. But it is a surprise in Aizawl to see a household without any storage tanks.

5.3: REPLICABILITY:

Rainwater catchment from the roof for the individual household programme is easier than a community shared tank. The problem of promoting roof catchment system for individual household programme is that responsibility of construction, maintenance, etc is depending on each household. As far as the design and the technology are concerned, the present one is the most suitable in Mizoram. There is high replication on the programme since this is one of the cheapest and easiest ways to get water.
Organising training and awareness among the household which can further promote the system. For wider replication the government and voluntary organisations should have taken interest and initiative. In urban areas people are more literate and easy to make them understand. So far nobody has taken initiative in order to get more benefits for the consumers. Inspite of this, in Aizawl city rainwater harvesting system play a very important role. In the past 10 years the government used to take up the scheme in urban areas. But after introduction of pumping system it had to stop due to financial constraint.

5.4: OPERATION AND MAINTENANCE:

The simple operation and maintenance of rainwater catchment system is one of the most attractive aspects of the technology. However, care is still needed. The problems of O & M in the system are: -

- At the end of dry season, washing and scrubbing off the debris at the bottom of the tank are practised, but some families do not.
- Checking of different components before and after rains, are not practised. Before it rains a few household check only the downward pipes whether it is in the tank or not. As for the consumers the quantity that counts.
- Most of the household never has a habit of sweeping the roof before collecting the first rain. Some families have a habit of let it off the first rain until the run off is clean.
- When tanks need repair consumers do not pay much attention.
- Due to lack of maintenance, it might effect the quality. But never bothers about the quality.

The main causes of these problems are due to lack of awareness. Consumers are not realising the importance of maintenace in the system. Not checking the different components is partly the fault of the consumers. One of the causes of
leakage is due to the poor construction of the tanks. Sometimes after one or two years, the tank started leaking at the joints. However, the leakage can also cause by improper foundation.

In order to remedy these causes the first task is awareness campaign to the consumers. Let the consumers know about the importance of O & M. To get a better outcome, the state government should take actions. If the government make consumers aware that the usefulness and importance of rainwater harvesting in Aizawl City, it would have increased the percentage of coverage.

There are expert persons who can construct the galvanised plain sheet tanks. However the workmanship is not good enough though they have the skills. These skill labours must train them to promote better construction work.

5.5: MANAGEMENT:

Management is one of the criteria for sustainability of the system. The rainwater so collected is used only for drinking and cooking purposes. The rate of supply is very limited and also households do not have the required capacity of rainwater storage tank, for washing and bathing, consumers fetch water either from spring sources or hand pump. Sometimes clothes are washed at a small natural stream, which are not even fit for bathing. Even for washing of clothes it is not advisable. But people still go for it due to the scarcity of water problems in Aizawl City. There is also a public point of water supply system where they can draw water. But there is a restriction that each consumer must have a card to collect certain amount of water from the public point. In this way the household manage during dry season. Even this dry period usually there is a rainfall and they can refill their tanks again.

Before commissioning of the pumping system in 1988, people used to steal water from the storage tank. In order to prevent, tap had locking facilities. But nowadays there is no problem anymore.

6.CONCLUSIONS:

It may be concluded that there are advantages and disadvantages of rainwater catchment system for domestic purposes.

The advantages are: -

- It is convenient due to provision of supply at the consumers' point.
- The operation and maintenance is very low almost negligible.
- The introduction of this scheme doesn't damage any environmental impact or future water supply,
- The quality is relatively good compared with traditional sources.
- The construction system is simple.
- Poor household can start with a single small tank and add some more when they can afford them.

- Rainwater collection from roof is to supplement the water supply of the short fall and it is an alternative source.

The disadvantages are: -

- The initial cost is very high compared with other methods and limited supply.
- In this case the supply is @10 litre per capita per day for the driest period of 120 days.
- The systems of rainwater catchment from roof houses are unattractive to policy makers and bureaucrats, as it is cumbersome to administer than a large single such as a dam.

RECOMMENDATIONS:

Rainwater resources both surface and under ground are depleting rapidly due to developmental activities. Environmental pollution is increasing day by day which adversely affect the water quality. Use of rainwater has to be encouraged by all water users. Rainwater catchment system is a simple technology appropriate to developing countries. It is economical as well. The government of India and of the state should take action to revive the use of rainwater for solving the urban water supply problems. There are some other options to meet the requirement of water supply.

One-Hand Pump Tube well, where boreholes were drilled and draw the water at the ground surface.

Two-Traditional spring sources are normally contaminated and fit for cooking and washing purposes. It can be used for drinking after boiling

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DETAILED ESTIMATE FOR CONSTRUCTION OF RAIN WATER ROOF CATCHMENT TANK 10,000 LITRES CAPACITY.

Sl.No.	Description	Unit	Rate	Amount Rs. p.
1.	Site preparation	L.S	L.S	100.00
2/8(b)	Earthwork in excavation in foundation trenches or drains including dressing of sides and recovering of bottom lift upto 1.5m etc.			
	$\frac{3.14(3.2^2 - 2.6^2) \times 0.60}{4} =$	0.82m³	@ Rs. 33.80/m³	27.72
3/65	Regular coursed rubble masonry with fine dressed hard stone in foundation and plinth in cement mortar 1:6 including curing etc.			
	$\frac{3.14 (3.2^2 - 2.6^2) \times 0.6}{4} =$	1.64m³	@ Rs. 1655.00/m³	2714.20
4.9	Filling available excavated earth in trenches plinth, sides of foundation etc. in layers not exceeding 20cm. in depth. Consolidationg each deposited layer by ramming and watering etc.			
	$\frac{3.14 \times 2.6^2 \times 0.30}{4} =$	1.59m³	@ Rs. 14.60/m³	23.21
5.	Providing tarfelt for tank sealing	L.S	@ Rs.120.00	120.00
6.	Providing and supplying 0.63mm thick G.P.Sheet 8" long.			
	Walling 7 Sheets Top & Bottom 7 Sheets Total = 14 Sheets =	1.68 qtls		
	Add 5% wastage	0.08 qtl 1.76 qtls	@ 11.97 kg/sheet	5786.88
7.	Assembly of G.P.Sheet to required shape and size including cutting, bending, riveting complete.	L.S	L.S	1900.00
8/209	Providing and fixing 15cm wide and 45cm overall semi-circular 0.63 I.S. Thick Plain G.I.Sheet gutter iron brackets 40mmx30mm size bolts and washers etc.			
	Gutter 9.5 Rm.		@ Rs 107.35/Rm	1019.83

Sl.No.	Description	Unit	Rate	Amount Rs. p.
9/276	Painting two or more coats on G.I.Sheets with anti-fungus red roof paint of approved brand and manufacture on new work to give an even shade.			
	Wall(Inner& Out) $2x3.14x2.6x2.3 =$	$37.55m^2$		
	Top & Bottom $\frac{4x3.14x2.6^2}{4} =$	$21.23m^2$		
		$58.78m^2$	@ Rs.20.50m^2	1204.99
10/437	Supplying and fixing of brass bibcock of approved quality.			
	(b) 20mm nominal bore=	1 No.	@ Rs.161.70	161.70
11.	Carriage of Materials from Aizawl to Worksite.			600.00
			Sub-Total	**13,758.53**
	Add 5% for W/C Establishment & Contingencies=			687.93
			Grand Total	**14,446.46**
			Say	**14,500.00**
			(Rupees fourteen thousand five hundred)only.	

11/8/98

(H.DUHKIMA)
Assistant Engineer,PHED,.
Mizoram:Aizawl.

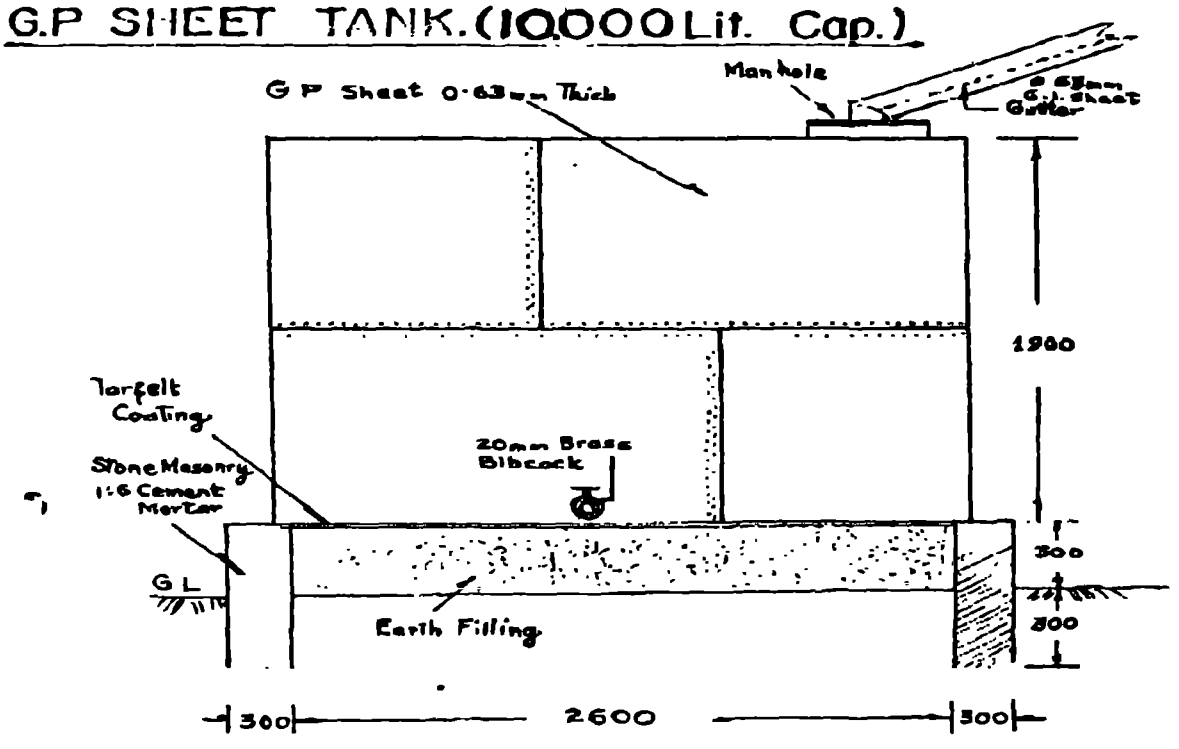
11/8/98

(C.LALLUNGHNEMA)
Executive Engineer,PHED,.
Mizoram:Aizawl.

11/8/98

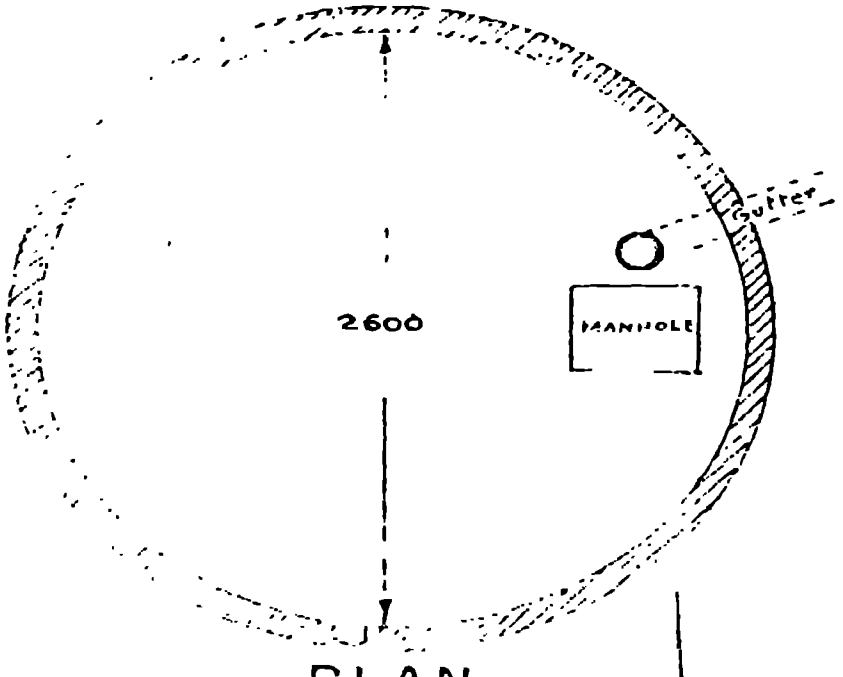
(M.DAWNGLIANA)
Chief Engineer,PHED,.
Mizoram:Aizawl.

DRAWING FOR R.W.H.S ROOF CATCHMENT G.P SHEET TANK. (10000 Lit. Cap.)

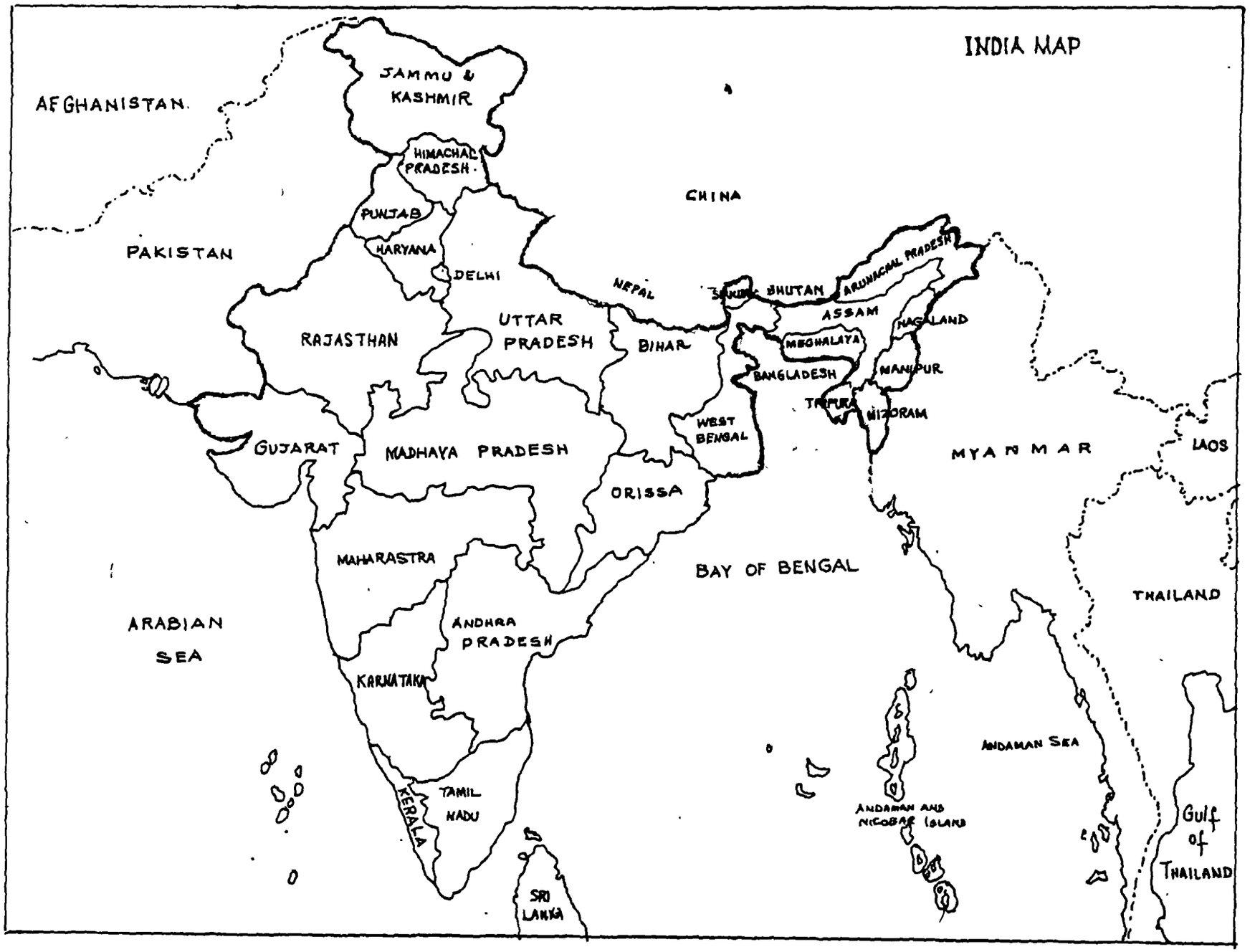


SECTION

Note: All Dimensions in mm.
NOT TO SCALE



PLAN


INDIA MAP
AFGHANISTAN
JAMMU & KASHMIR
HIMACHAL PRADESH
PUNJAB
HARYANA
DELHI
PAKISTAN
CHINA
NEPAL
SIKKIM
BHUTAN
ARUNACHAL PRADESH
ASSAM
NAGALAND
MEGHALAYA
MANIPUR
TRIPURA
MIZORAM
BANGLADESH
RAJASTHAN
UTTAR PRADESH
BIHAR
WEST BENGAL
GUJARAT
MADHAYA PRADESH
ORISSA
MYANMAR
LAOS
THAILAND
MAHARASTRA
BAY OF BENGAL
ARABIAN SEA
ANDHRA PRADESH
KARNATAKA
KERALA
TAMIL NADU
SRI LANKA
ANDAMAN SEA
ANDAMAN AND NICOBAR ISLAND
Gulf of THAILAND