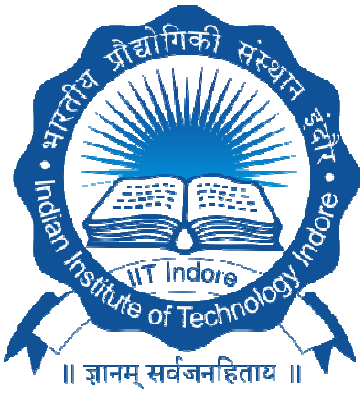
B. TECH. PROJECT REPORT

On

Confronting India's ubiquitous drinking water scarcity: A comparative study of water governance in Rajasthan and Meghalaya

BY

Deepesh Gothwal



DISCIPLINE OF ELECTRICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY INDORE

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Confronting India's ubiquitous drinking water scarcity: A comparative study of water governance in Rajasthan and Meghalaya

A PROJECT REPORT

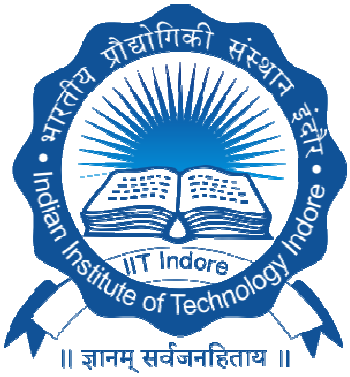
Submitted in partial fulfillment of the requirements for the award of the degrees

of
BACHELOR OF TECHNOLOGY
in

ELECTRICAL ENGINEERING

Submitted by:
Deepesh Gothwal

Guided by:
Dr. Neeraj Mishra



INDIAN INSTITUTE OF TECHNOLOGY INDORE
December 2016

CANDIDATE'S DECLARATION

I hereby declare that the project entitled **"Confronting India's ubiquitous drinking water scarcity: A comparative study of water governance in Rajasthan and Meghalaya"** submittedin partial fulfillment for the award of the degree of Bachelor of Technology in 'Electrical Engineering' completed under the supervision of **Dr. Neeraj Mishra, Assistant professor, discipline of Sociology,** IIT Indore is an authentic work.

Further, Ideclare that I have not submitted this work for the award of any other degree elsewhere.

Signature and name of the student(s) with date

CERTIFICATE by BTP Guide(s)

It is certified that the above statement made by the students is correct to the best of myknowledge.

Signature of BTP Guide(s) with dates and their designation

Preface

This report on "Confronting India's ubiquitous drinking water scarcity: A comparative study of water governance in Rajasthan and Meghalaya" is prepared under the guidance of Dr. Neeraj Mishra.

Through this report, I have tried to give a detailed analysis of my work on water governance in the two states of India Rajasthan and Meghalayaand try to cover social as well as technological aspects.

I have tried to the best of our abilities and knowledge to explain the content in a lucid manner. I have also added various graphs and figures to make it more illustrative.

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Acknowledgements

I wish to thank Dr. Neeraj Mishra for his kind support and valuable guidance. It is his help and support, due to which I became able to complete the report. He gave memoral support and guided me in different matters regarding the topic. He had been very kind and patient while suggesting me the outlines of this project and correcting my doubts. I thank him for overall supports.

I am grateful to Dr. Prasenjit Biswas (Associate professor, department of philosophy, NEHU Shillong) who helped me a lot in gathering different information and guiding me from time to time in making this project and despite of his busy schedules, he gave me different ideas in making this project unique.

I am very thankful to everyone who supported me, for completion of my project effectively and moreover on time.

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Abstract

Water in the twenty first century is equivalent to the value of oil in the twentieth century, a commodity and a resource that will determine the wealth of a nation in coming years. Due to both climatic and human factors, the supply of freshwater is decreasing at a rapid rate on this planet.

Along with the scientific reasons for the decline of freshwater availability in India, an understanding of water governance systems is also the need of the hour. As noted by the Prince of Orange in Accra in 2002 "The world water crises is a crisis of governance, not of scarcity", we must also look for some of the answers to our water problems in the improved ways of governance, made possible by the availability of improved ICT and geospatial devices.

In 2010, the United Nation adopt resolution 64/292 that "Recognizes the right to safe and clean drinking water and sanitation as human right that is essential for the full enjoyment of life and all human rights".

Many parts of world specially India faces water scarcity beside it has one of the world's highest water potential. In term of water availability two states of India which receive the least and highest rainfall are Rajasthan and Meghalaya respectively. But due to mismanagement or wrong practices the condition of water availability in the Meghalaya has become worse than Rajasthan in terms of water prices at the time of water scarcity. All these things indicate the need to study different water governance practices in each region and understand how water can be managed in a better way within that specific context, with the help of minimum usage of technology.

Field visit of western Rajasthan and East Khasi Hill district of Meghalaya was conducted to collect ethnographic data and understand the various strategies, action taken by the local people, administrative departments and NGOs to meet the water needs of the people. The field visit was used to identify different problems faced by the people in different parts of India and how it can be improved by means of various technologies (electrical engineering).

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INTRODUCTION

70 percent of the earth's surface is covered with water, out of which 97 percent is salty and about two percent is in the form of snow. This leaves only about one percent of water available as fresh usable water (drinking and non-drinking purposes) which include all sources such as ground, under-ground and rain water.

This one percent water is being used all over the world to satisfy the needs of about seven billion people, various plants and animals. With increasing population water availability per person has decreased and situation is even worse in developing countries with high population growth rate such as India (annual growth rate 1.2 percent with estimate that India would be world's most populous country by 2022[1]).

Lack of proper water management is one of the key reasons for water problems all over the country. Every monsoon India faces floods in all of its major rivers, and at the same time all major cities of the nation face water scarcity and drought in non-monsoon seasons. At a time when India is facing water crisis, huge amounts of water is being wasted due to the negligence, government and an overall failure to employ good water governance.

'Lack of water is a key risk to global stability. In past, it was conflicts over oil that drove nations to war. In the future, it would be water, or lack of thereof. India in particular, is at high risk, given the rapid decreasing ground water level as well as non-efficient ways of using water'.[2]

India has one of the largest water reserves in Northeast India, where places like Cherrrapunji and Mawsynram in Meghalaya hold the Guinness world record for the highest monsoon rainfall in a single month as well as a single year. These regions receive as much as 11,872 mm rainfall average in a year and yet suffer from water scarcity during non-monsoon periods. Water scarcity in the region can be explained by putting the fact that many times people have to buy water to practice their day to day needs during non-monsoon season.[3]

A place which receives the highest rainfall faces water scarcity during non-monsoon period. Even during the monsoons, the condition is not comfortable at all. Every year we hear about flood situation in northeast

[1]Available at (https://en.wikipedia.org/wiki/Demographics_of_India)
[2] Thirsty nation: priorities for India's water sector (J.P. Quinlan, S. Sen, K. Nanda)
[3]Available at (

region of India. About more than one lakh people suffer every year in that region and many lose their life. **T**his is not a situation of any particular year, every year condition is more or less the same all over the region.

Water resources in Northeast India are in abundance, where we have high rainfall and a system of various regional rivers. These alone are not enough to hold the water present inthe region. One of the main factors being that the run-away water loss is very high. One cannot doubt the extreme physical condition in the region, but now in twenty first century it cannot be excused as we have various technologies and researches going on and so these things could have been solved by now.

At the time when Saudi Arabia, which does not have any water resource has made canal systems throughout the country and water is being supplied by purifying the sea water, water problem in region with such a high water abundance can be solved by using the right management approach and by using various technological advancements made in the world today.

The main aim of this study is to understand the mechanisms that have been devised by the people to cope with water scarcity in two states of India with very different climatic and biophysical conditions. This project compares the water governance strategies of the people in Barmer district of Rajasthan with the governance strategies of the people in the Shillong region of Meghalaya to explore how people in different states of India counter their drinking water problems during the non-monsoon months.

The North-Eastern part of India is abundant in water and constitutes about 34 percent of India's total surface water resources, but occupies only 7.9 percent of the total Indian landmass.[4] The per capita and per hectare availability of water in India is the highest in this region.

It may be hard to believe that many states in the Northeast suffer from severe water scarcity during the summer and winter months. Many are forced to buy the water from open market, either in tankers or the bottled water. The poor are left to fend for themselves and unable to afford pure water at the market rates, often consume contaminated water and remain vulnerable to diseases and health hazards.

Rajasthan is considered to be the desert state of India and has the least availability of drinking water and the least reliable supply, according to a World Bank report. The importance of water conservation by using indigenous technologies was recognized in Rajasthan even during the pre-independence period, which is reflected in numerous old structures like *Tankas, Khadins, Johads, Bawaries,* that have helped this dry state of India to achieve an impressive level of water security.

[4]Pranjal Kumar Phukan (2016) , **Water resource management in Northeast India;** nelive

The logic behind the selection of these two states is to develop a comparison between a place which receives abundant rainfall (highest in the world) with a place that receives lowest rainfall in India.

BUILDING AN ARGUMENT: WATER SITUATION IN INDIA

India is an agriculture based country. About sixty to seventy percent of India's population is engaged in agricultural practices and so the dependence on water is also high. In such circumstances, the water needs of India are not only limited to drinking or household or industrial use but a lot of water is required for irrigation also. Whenever there are droughts, the most affected population is that of farmers.

Last year i.e. 2015 alone more than 3000 suicides have been reported, which can be conceived as a blot to India's image as an emerging global market having economic growth rate of about seven to eight percent. When we talk about India as a whole, the water condition is not as it should be. We face acute water scarcity in different parts of country during summer season and floods during monsoon season. Any major city, be it Mumbai or Delhi, most of the cities face either water scarcity or flood situation every year. Claims are being made by local municipalities but all seems to be vain when the city is hit by monsoon rains. All these things not only make people suffer but also put development in the backseat.

In a country that believes in:

Not the donation of land, not the donation of gold,

Not the donation of cows, not even the donation of food,

Donation of water is greatest of all donations in this world, the throes of evolving into a developing nation is making India water scarce, where an average villager walk about 2.5 kilometer to get clean drinking water. Despite the abundance of resources, Indian states stands at economic crossword of inability to share water equitably[5].

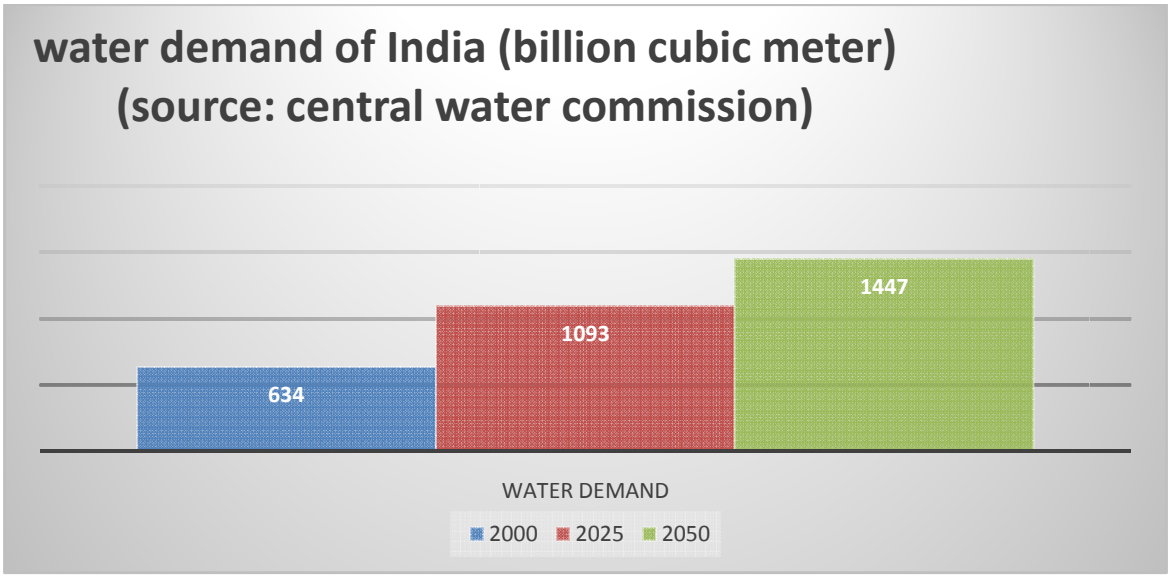
_ NamitaVikas

[5] Thirsty nation: priorities for India's water sector (J.P. Quinlan, S. Sen, K. Nanda)

It is not that nothing has been done till date in this regard. Many projects have been established in due time such as Indira Gandhi Canal which has been very successful in providing the water to many places in Rajasthan including Jodhpur, Jaisalmer and various remote places through which it passes. At the same time, we also have many villages in which people have to walk many kilometers to get drinking water.

Today water has become such an important tool that in due time it is for sure that water governance is going to play an important role in politics and economic state of country. At present also there has been dissent among the various states over the water issue and cases relating to water usage are pending in the courts.

India has a population of about 1.21 billion and still increasing. It is to be estimated that by 2050 India is going to import water from other countries[6]. But the question is after all those consecutive warnings, are we seriously working on it or just waiting for the D-day to come.



Above chart shows the water demands of India and its rise in future years. Also we have reports suggesting water import in nearby future. All these things and reports added up to need of conservation of water resources and is proper management.

India's dependence on water is critical owing to its large agricultural base, the water needs of its billon-plus population, and the recent economic growth trends. Despite the plethora of material on environmental law, legal scholarship on water law in particular has been negligible[7].

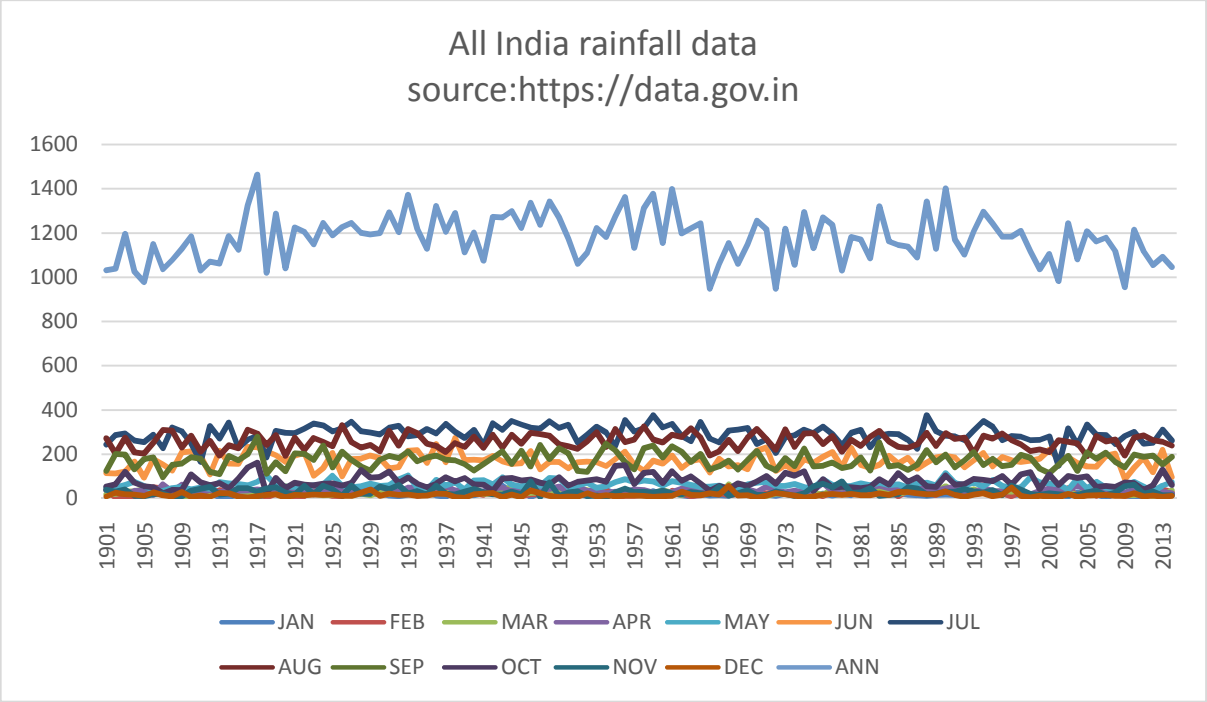
Water laws in India (oxford university press)

[6] Available at (http://timesofindia.indiatimes.com/india/By-2050-you-may-have-to-live-on-imported-water/articleshow/51935321.cms)
[7] Water laws in India: an introduction to legal instrument (P. Cullet and S. Koonan)

For example, in the 2016 monsoon itself the state and cities which before a few months were suffering from water scarcity faced flood situation[8] and most of the water being wasted due to mismanagement.

Water is a state issue as provided by the constitution of India (schedule seven of Indian constitution). Every state in India has a right to make laws on water governing in that state. Though this could be used as a competition between the governing bodies and each state should have been in position to compete with its neighboring state to provide quality water for its citizens but present scenario reflects a different picture.

Instead of working together to provide quality water to citizens, various state governments are indulging in the interstate water dispute. There is need of providing uniformity of water distribution and one step in this regard may be river linking project i.e. joining of Himalayan rivers with peninsular river to form uniform water system all over India so that to tackle down the state of drought and floods to a minimum extent. The project has been discussed many times by various governments but has not yet started.



On looking at the rainfall trends in India for past one hundred and thirteen years, it clearly seems that there is no such big variation of rainfall overall however, the difference in intensity may be. As the chart shows the overall rainfall of country annually and monthly is more likely the same. There may be variation of rainfall pattern within a particular place or state but as a nation we are receiving the same amount of rainfall.

[8]Available at
(http://www.ndtv.com/india-news/15-dead-in-madhya-pradesh-due-to-floods-heavy-rains-continue-in-state-1429836)

This fact somehow concludes the overall effect of climate change on India as a whole in terms of rainfall. What we need is need is a proper management system to solve water crises of India whether it is flood or scarcity. One parameter of water management is control over the water resources. Here we will see how the water controlling body effects the distribution of water in an area by analyzing the example of western Rajasthan and Northeast India (Meghalaya state).

WATER CONDITION IN NE (NORTH-EAST) INDIA AND RAJASTHAN

North east India consist of seven states namely Arunachal Pradesh, Nagaland, Manipur, Sikkim, Assam, Tripura and Meghalaya. Physical condition is more or less the same in all these states with small variations and so are the water conditions. The region gets highest rainfall throughout the monsoon as compared to other part of the country (Cherrapunji being the wettest place). The extent of rainfall can be estimated by the fact that the region has potential of about 34 percent of countries' total water wealth and 37 percent of total hydropower potential (Water resource management in NE India, nelive. Jan 6, 2016)[9]. This much amount of water resource has been packed up in a region which estimate only 7.9 present of total mass land of India. But besides all these physical condition and monsoon presence, the region faces water scarcity in non-monsoon periods.

To understand the water problem, we can divide the water situation in two categories or two ways i.e.

- Drinking water condition
- Non drinking water condition

On focusing along the drinking water conditions, beside the enormous water resources present in the region, the region faces acute water shortage in non-monsoon seasons. This situation can be understood by bringing to light the fact that the region being a hilly area with mountains spread all over, the run-away water loss is very high. Every year water scarcity is common in these areas. Reports shows Mawsynram, 80km from Cherrapunji, the place which once held the record of wettestplace on Earth suffers from water scarcity during

[9]Phukan, P.K. 2016. *Water resource management in Northeast India.* (Available at: http://www.nelive.in/north-east/opinion/water-resource-management-northeast-india)

non-monsoon season and that people have to walk long distances to get water, or get water for about only an hour or less in a day[10].

Sometimes people have raised the demand to declare the region a drought hit region.

Water scarcity in Manipur is a recent example where drinking water has reached to an extent that state govt. asked union government to declare it drought hit state. This can be seen as a serious event as states with highest rainfall asking for declaring themselves as drought hit. All this shows the need of extensive research and need of proper management of water resources in the NE (northeast) states.

Every monsoon the region faces a highly destructive flood which affects lakhs of people in the region, especially in Assam. During monsoon the rain water washes away thousands of villages with it and leaves behind the tragic stories and death counts due to this.

Here the monsoon affects the region very badly. Well not only in monsoon, the problem of flood is very common in those areas. Floods in Assam (April, 2016) is a recent example. This pre-monsoon floods in Assam not only affected lakhs of people and made them to migrate but also led to deaths of many individuals[11]. Also we had flood in Meghalaya during 2014 which kill about 52 people there[12].

So from all these follows the need of water governance of both potable and non-potable water at all levels i.e. at government, at people and at administrative level in the area.

[10] Available at: (http://www.timesofindia.indiatimes.com/home/sunday-times/Why-the-worlds-wettest-place-gets-thirsty/articleshow/52812313.cms)

[11] Available at (http://indianexpress.com/article/india/india-news-india/assam-floods-affect-92000-arunachal-district-cut-off-2769996/)

[12] Available at (http://indianexpress.com/article/india/india-others/meghalaya-flood-toll-52-waters-recede-a-week-after-calamity/)

1 Week of Flooding Leaves 88 Dead in Meghalaya and Assam, India

29 SEPTEMBER, 2014 BY RICHARD DAVIES IN ASIA

Just as the flood water in Jammu and Kashmir started to recede, heavy rainfall caused widespread flooding across the north eastern states of Assam and Meghalaya.

The heavy rain first began around 21 September 2014. The city of Gauhati in Assam saw 203 mm fall in just 24 hours between 21 and 22 September. By 22 September, at least 100 villages were flooded in the state of Meghalaya. Flood water has remained in vast areas of both states for 1 week and has left 88 people dead and over 1 million displaced.

Hundreds of relief camps have been set up for the flood victims. Teams from India's National Disaster Response Force (NDRF) and Border Security Forces have been deployed in rescue and relief operations. Currently focus is on relief work since the majority of rescue operations where over 6,000 were rescued, have been completed.

The worst hit areas are thought to be Goalpara, Kamrup and Boko in Assam, and Tura and Garo Hills in Meghalaya. Landslides caused by the heavy rain and flooding, have been a major threat, especially in the more mountainous parts of Meghalaya.

http://floodlist.com/asia/floods-88-dead-meghalaya-assam-india

THE WIRE

Nearly One Lakh People Affected by Floods in Assam

BY THE WIRE STAFF ON 28/04/2016 • LEAVE A COMMENT

All India United Democratic Front chief Badruddin Ajmal has asked the Centre to release 1,000 crore rupees for relief efforts.

Villagers commute in boats in a flooded village. Credit: PTI

Dispur: Bringing up the ongoing floods in Assam during a zero hour in parliament on Thursday, All India United Democratic Front chief Badruddin Ajmal said that the Centre should release a minimum of 1,000 crore rupees to help the state with relief efforts. He also asked that the floods and erosion in Assam be deemed a 'national calamity',

Water condition in western Rajasthan:

Far away from the urbanization, the western part of India is not much influenced with the global trends of the Modern India. Villages of Rajasthan states are seemed to be living under the traditional culture with very less influenced with modernity. The traditional lifestyle can be easily sighted enhanced with the traditional culture. While there is a starting trend about the going to other places in search of work but the main occupation at present is traditional, mostly based on the community identity.

Water is extreme commodity but with time people there have evolved methods to store it and use it accordingly. The average rain in the Barmer region is about 250mm annually. Instead of this very less rain, which off course only during monsoon season, the people in rural areas have underground tank like structure in every household to store water which they call as 'Tanka'. Tankas are the underground water tanks used to store rain water with capacity varying from 20000 to 50000 litre.

METHODOLOGY

The main element of framework used in this research is boundary concept "WATER CONTROL", which was applied to capture three interlinked processes in water control: physical, organizational and socio-economic/political. The methodology of my research is based on the socio-technical framework described below[13].

Dimension	Means	Research object	Research techniques
Physical control (technical)	By means of physical infrastructure or technology	Physical shape, type and state of irrigation and drainage system and technologies	Walk-through surveys Direct measurements Expert interviews
Organizational control (managerial)	By means of skill, authority, command or domination	Institutions, organizations, management	Institutional mapping and analysis Surveys Participatory observation
Socio-economic and political control	By means of law, policy, regulations, incentives, or force	Social and governance structure (local and higher scale levels)	Surveys Stakeholder workshops FTI activities

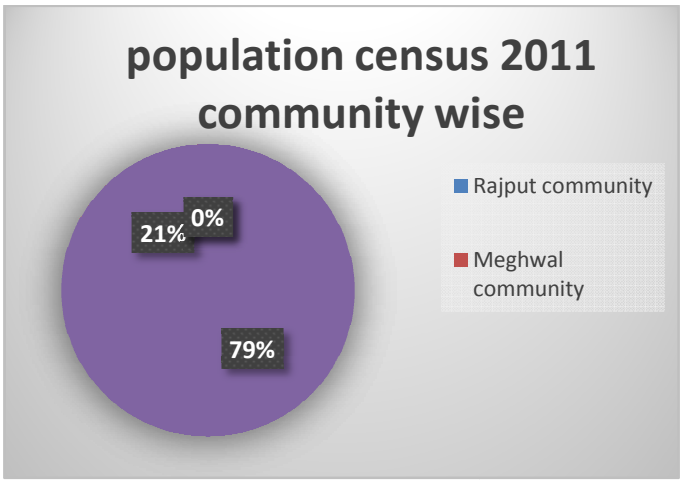
[13]IskandarAsdullaev and Peter P. Mollinga (2010). **The socio-technical aspect of water management: Emerging trends at grass roots level in Uzbekistan**

WATER GOVERNANCE IN RURAL BARMER (RAJASTHAN)

In the Barmer region of Rajasthan,the life in the rural areas are dominated by the traditional practice. The sense of identity is linked to the community to which the person belongs.

Rajput's are the most influential and dominating community. The Rajput are the community mostly associated with the kings and other influential post like officers in the army in pre-independence India period. The community has agriculture lands (only irrigated in monsoon region) of up to 500 acers. Rest other communities are associated with small piece of land (that too mainly as of various government acts to abolish Zamidari system).

Here I had focused my understanding on water governance in the rural Barmer by taking case study of village "JansinghkiBeri" a village near Barmer at a distance of about 75 kilometers from it.

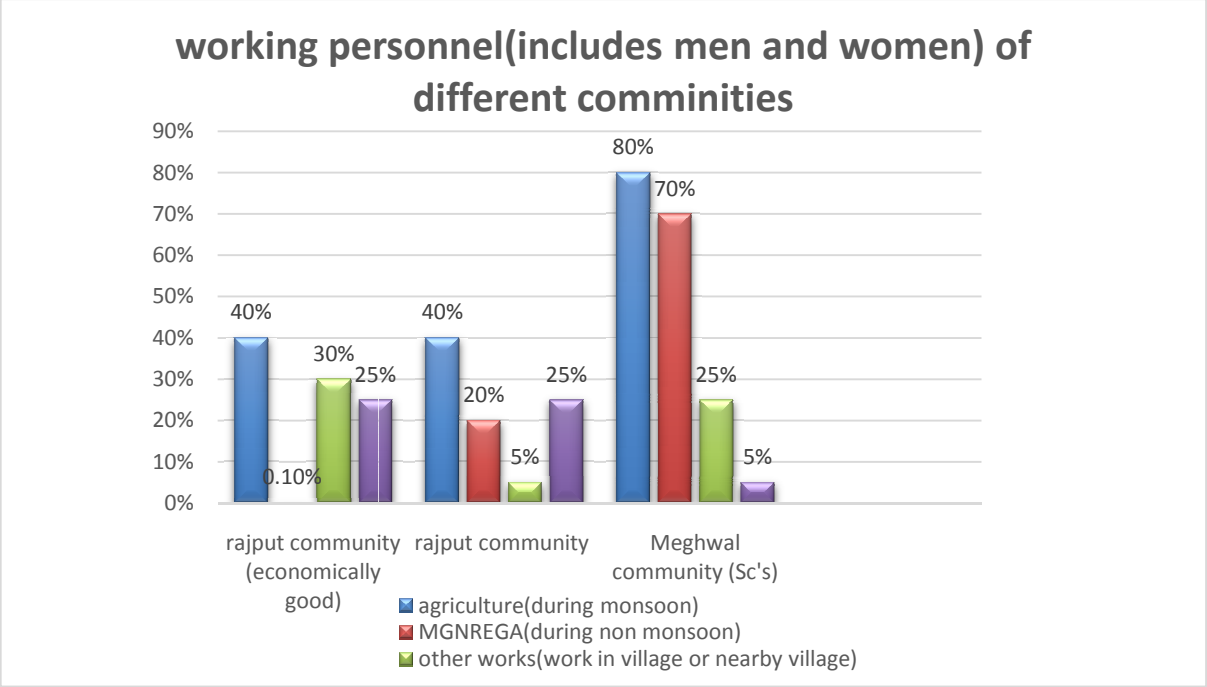


Total no. of household in the village is 169 with total population 948[14].

In the said village, there are about ninety houses with each house has five to six family members. Different community own different areas of village. The dominate community i.e. the Rajputs has land vary from four to five hundred acres of land. Others feed upon 10 to 20 acers. During monsoon period, major occupation is agriculture and about seventy to eighty percent of villagers are involved in this practice. Those who do not have land of their own or very less land works in fields of those who have large fields. During non-monsoon period the small land holders works under MGNREGA scheme of government.

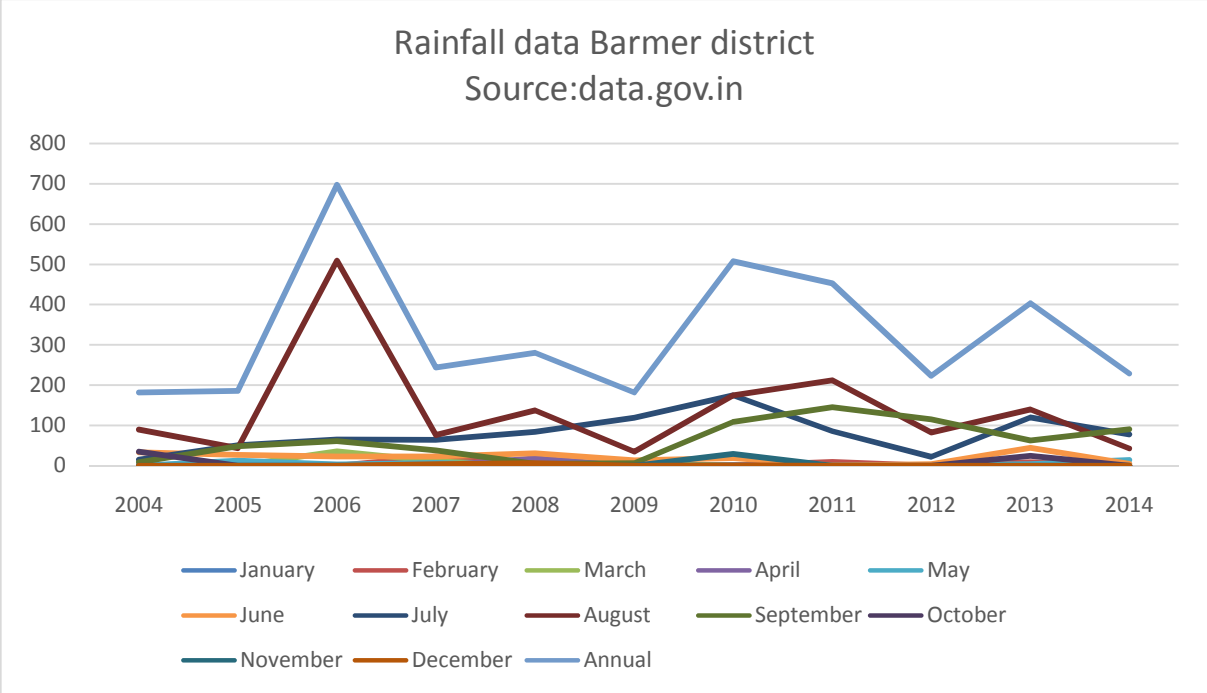
Water requirement of various communities is basically satisfied by the water collected through the rain. Agriculture is purely dependent on the monsoon rain. Water storage tanks, the tankas are very common sight seen. Water needs of all the schools, offices, household arder satisfy by tankas. However, the story behind the construction is not traditional but this all has started about two or three decades before. Before these tankas the water storing techniques are different and so are the ways to use it.

[14] Census of India,2011



Rainfall data and trends:

Following is the rainfall data of the Barmer district for past five years.[15]



If we read the graphs, it is likely the same rainfall patterns with average rainfall of about 350mm. (In 2006 Barmer had exceptionally high rainfall causing flood).

[15] Source: India metrological department

Historically evoluation:

About four to five decade before the water consevation techniques are totally different from what people using in the rural areas of Barmer. However, the water source is the same i.e. rain water but there were no such constructed storage tanks 'tankas' those days. While discussing the water situation in the region the locals describe the that people use to fatch water from the wells nearby. Water from wells are the primary source. This water from well is used mainly for drinking and needed household purpose.

Water needs for other uses and cattle are fullfilled by the pond usually known as 'Talai' in the region. The water source of talai is the monsoon rain itself. There were well maintained wells on every five fifteen kilometres and people of nearby village satisfy their water needs through it. The pet animmals like camel and donkey are being used to carry water for household purpose. Each household have pots of capacity about 50 litres each to store that water. This was the basic routine process which villagers use to get water.

Wells in the desert often belong to different communities. A woman hauls on a rope to raise water in a rubber pouch. Her husband then pours it into bags slung over their donkey.[16]

.

[16] Source: Spectrum, the tribune: September 15,2013

Talai (pond) in a village in Rajasthan Barmer village 'Jansingh ki Beri'.

[The land in Barmer region have solid plates under it that prevent water in talai to get absorb]. This was also the key reason for 2006 Barmer flood.

Slowly but gradually people start builting tankas(un derground tanks) to store water. Earlier the tankas are made of ashes of burned woods instead of cement as it was not in the domain of the villagers. These tankas had capacity of about one thousand to five thousand litres.

Although the primary source of water was wells as before but these tankas increased the storing capacity of water in houses. Now time period for carring water cycle increase from say five to six days to twenty to twenty five days. Also these were also useful in storing water during monsoon season.

This idea of tanka can be seen as a model evolve out of Bawries. Bawari in Rajasthan were large structures which are used in big cities or by big kings pre independence to store large amount of water. Bawaries also known as step wells were the large underground estiblishment build with proper architecture having stairs all around to go inside. It is well connected to get water form nearby areas during monsoon. Once filled fully it could be used to satify water needs of town or city throughout the year.

Off course, the construction of Bawri was limited to very influcial king and big cities. One can think of evolution of tanka for household as a model resulted out from Bawari.very influcial king and big cities. One can think of evolution of tanka for household as a model resulted out from Bawari.

Bawri in Rajasthan; today also these Bawries can be seen in different parts of rajasthan, it also represent the architecture present in India at very early stage of civilisation;

With changing times and adavncement with availability of cement, people then start building tankas of good quality and perfectly shape. With time period the water capacity of tanka also got increase. Now at present people have tankas ranging of capacity ranging from 20,000 liter to 50,000 litre. The ground coverage of such tankas are large and with that much ground sometmes these thanas get filled fully in one or two rains. And depending on the size of family these tankas last for about six to ten-twelve months.

Well dependence is now limited and people often uses them in pre-monsoon period when the tankas are out of water. These tankas can be seen in every households, school , offices in rural Barmer. There were schemes run by the government to susbsidized the making of tankas for economically inefficient and weak section of society. With government support and awareness among the individuals about the water and tankas made these structure a common medium of water for every household.The water from these tankas are mainly used for drinking and major household purpose. For other work water from talai is being used.

Now in recent years with houses made of RCC structure, people are looking forward toward roof water harvesting system. In roof water harvesting system there is a systematic connection between different outlets of water from roof to a separate tanka. The families which are

economically rich has develop this system. While most of the houses are not RCC structured but there is trend of changing housing pattern, although slow but gradually people are looking forward to use that method too.

The families using roof water conservation technique usually have two tankas, water of tanka connected to roof is being used for the drinking and cooking purpose after filtering through a cloth and for other household work water from other tanka is used which is basically the water cover of area which the tanka represent.

There are pre-monsoon preparations also that is usually done by every household like cleaning of ground surrounding the tankas and cleaning of tankas. Each member of family involves in this practice.

A women taking out water from tanka in Rajasthan, source:india water portal;wikipedia

Usually these tankas with capacity ranging from 25000 litre to 50000 litre last for about six to ten months depending on the family size and its uses. For the remaining period there is a tube well in the village constructed by village people through donations. There is also a connected pipeline system of water provided by government to most of the village. This water supply by government is referred as water box in the region.

Here the picture shows a water box. Water from government is supplied to these tanks through pipeline during pre-monsoon period.

And for those villages which are not connected by the pipeline, there is a system of water supply by government through water tankers. These tankers supply water in pre-monsoon period when there is water scarcity situation and tankas of most of the village personnel are water off.

The water supply by government by pipeline is poured in a cemented made which is specially made for this specific purpose. For the water supply through tankers there is a tanka specially made for this purpose. For all the sources either it is pipeline or tankers are supposed to be water needs of whole villages not for any particular community. Thus, during summer in pre-monsoon period the state government ensure water needs of the villagers to be satisfied.

The red circle shows the tankas in the villages. As seen there are many tankas to store as much water as possible.

source: google earth [26°00’42.68” N, 70°52’56.67” E]

Also, privately owned tankers are also available with capacity of about 5000 litre and price around three hundred per tanker. So, for families who are out of water and government water supply is not available the private owned system is being utilised. Thus, the water requirement of whole year in Barmer rural villages are satisfied by mixed efforts of people at individual level, as community, as villagers of a village and by government owned resources

Observation tables:

1. Methodology observation:

Dimension	Means	Research object	Research techniques
Physical control (technical)	Tankas (mostly controlled by individual villagers)	Tankas are the underground water tanks used to store rain water directly from ground by creating a slope towards tanka or by rooftop rain water harvesting system.	Based on various surveys of water storing system and interviews it was found that the capacity of tanka ranges from 20000 liters to 50000 liters. Present in every household, school, and administrative office.
Organizational control (managerial)	Water box and tanker supply by government (Government control)	Water supply by government either by connected pipelines or through means of water tankers in pre-monsoon period when there is huge water scarcity	Water boxes are stationed by government to feed water to villages in scarcity period. These water boxes are then connected to substation and these substations to villages.

Socio-economic and political control	Talai and tubewells (controlled by panchayats and the village community as a whole)	Talai or ponds are usually found in every village or two to three villages share a common Talai for water needs. Alongside Talai there used to be a tubewell as ground walter level is high in that particular area	Water from rain is directly collected in ponds like structure known as Talai. Talai are maintained by villagers through MGNREGA. Water of Talai is used by all villagers for cattle water needs.

2. Water quality of sources:

Sorce	TDS value	PH value	Comments
Ground water	Very high - not measured by meter	7.35	Water quality is very low, not fit for drinking and other household purpose. Values out of secondary drinking water limit i.e. 500 TDS
Tanka (Traditional way)	68	7.05	Rain water is directly stored so pure and clean. Fit for drinking and other household purpose.
Tube well	418	7.19	Though water is ground water only but placed near talai (pond). So, the quality is under permissible limit and can be used for household purpose.

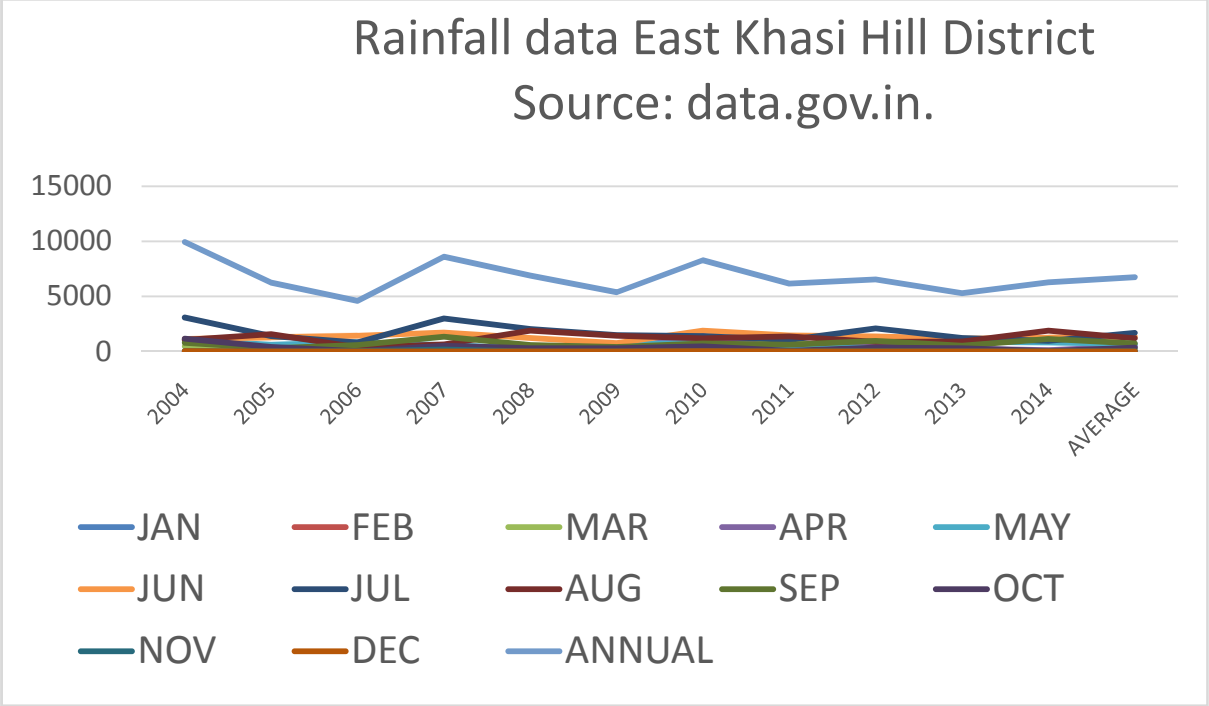
Water box (Government supply)	946	8.33	Water quality is not so clean and TDS value is very high. Quality check at treatment plant should be done.

WATER GOVERNANCE IN EAST-KHASI HILL DISTRICT, MEGHALAYA

Water governance in Meghalaya is different from what we have seen in the case of Rajasthan. Unlike in Rajasthan, in Meghalaya people do not have water storage tanks (Tanka) in their houses. My work on water governance in Meghalaya is focused on East khasi hill district of Meghalaya which have places like Cherrapunjee and Mawsynram which holds the highest rainfall record all over the world.

Traditionally the water governance was not a big issue here. But with increasing population, changing water uses activity and climate change, the water governance has emerged out to be an important factor in the region.

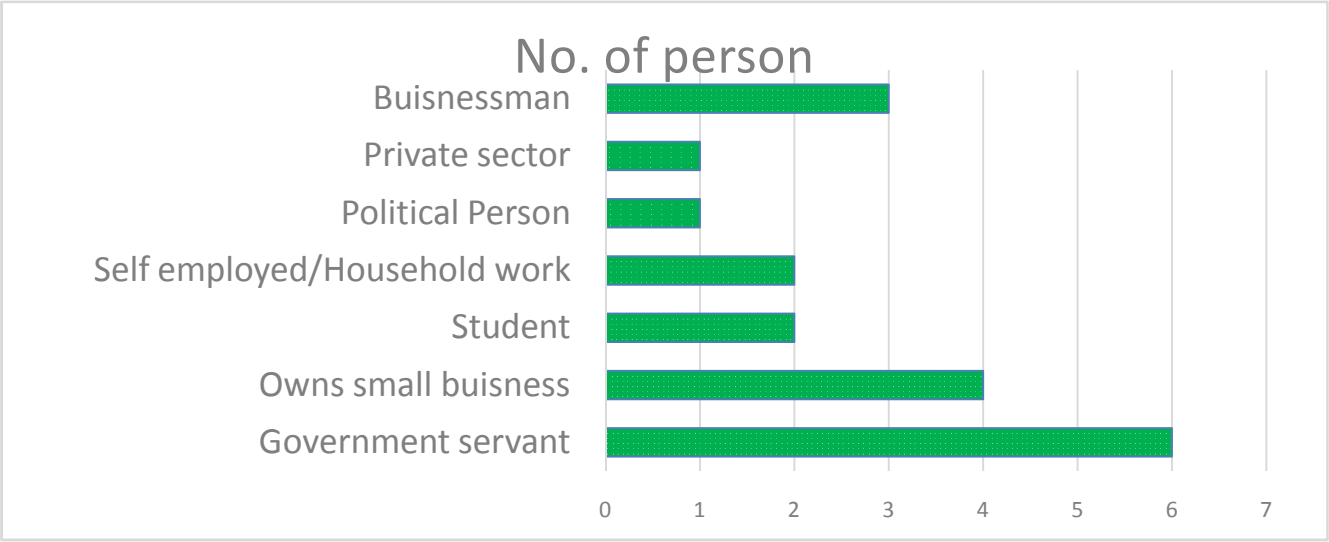
If we look at the rainfall pattern in the East khasi hill district of Meghalaya, the overall rainfall is nearly the same and however change in intensity may be. News of water scarcity in winter is common in the areas. But this thing cannot be taken normal as the situation is worsening every year with water increasing water problem in the region.



Field work in Meghalaya:

During my field work in Meghalaya, I had tried to get a clear picture of water governance by interviewing and meeting people from different societies and places. The fields work includes interviewing of businessman, students, political representatives. Also, it includes meeting with people working in government and private sector. To get a fair picture of things, I have interviewed people from different villages to get understanding between the people about the water governance. Below the table includes the

data of people interviewed: (self.. represent self employed)

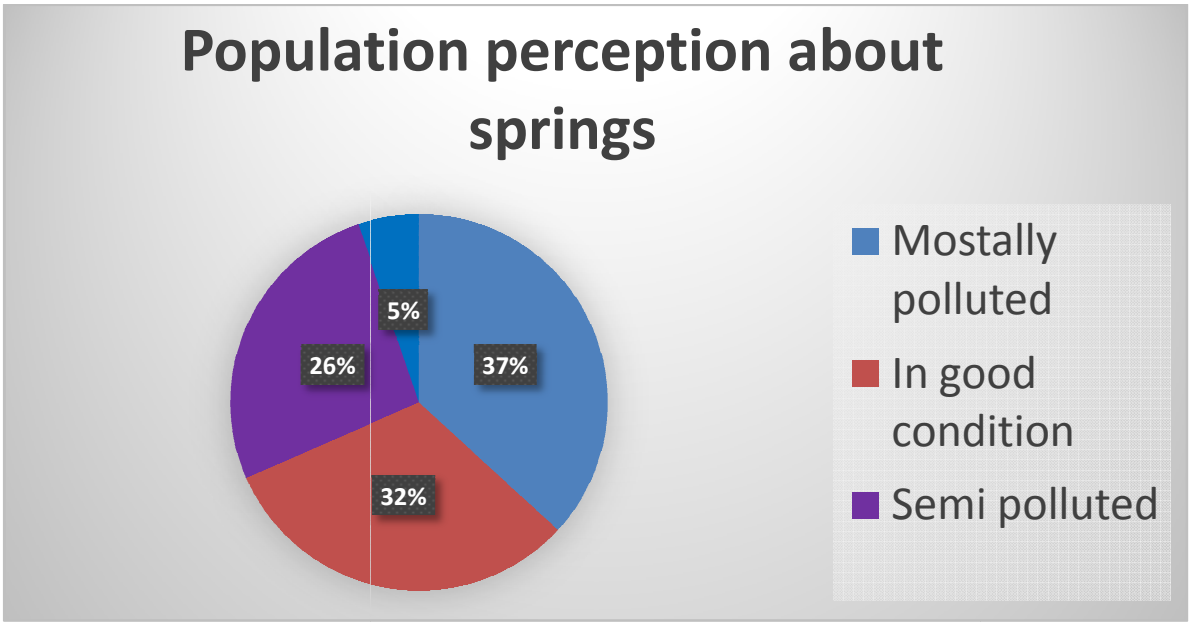


While interviewing the people about the traditional ways to get water and why they are not being used now, it came to my knowledge that the spring are being polluted by human activities and other industrial growth. The perception of people about the springs are changing which is not a health sign and indicating the negative growth in term of water governance.

Most of the people specially the young generation is unaware about the springs as a water source as

a) Water supply is mainly the pipeline water supply.
b) Most of the springs are getting polluted due to human interference.

Following is the graph showing the population perception about the springs:



As mentioned earlier the water governance techniques is different from what we have seen in Rajasthan. Here in Meghalaya, the water governance techniques cannot be summarized in a single methodology chart.

As per my observation the water governance techniques in the region can be divided in three types the Cherrpunjee water governance where the water dependency of water is purely dependent on the PHE (public health engineering) department, the villages which are fully independent of water supply from the PHE department and the villages with mixed water system the water from PHE supply and village springs.

Observations:

- **Water control in Cherrapunjee:**

Dimension	Means	Research object	Research techniques
Physical control (technical)	Dams/reservoir (control by PHE department)	There is no such system of household water collection in Cherrapunjee and people here are purely dependent on the water provided by PHE	Based of various interviews done on local people and with PHE department officers.

		department or else buy it.	
Organizational control (managerial)	PHE department	Water is collected through various streams and rain during monsoon season. This rain water is then send to treatment plant for purification and then to substations. From these substations water is then send to households	Meeting officers at PHE department. Visiting the Dam site and treatment plant site. The water from dam flows at a rate of 15L/sec to pipelines during monsoon season.
Socio-economic and political control	Not present today. Earlier people use to have such type of water control by means of springs/streams.	Generally most of the springs are own by private individuals who use the springs according to their personal use. Some springs were present earlier which are used by common people but the use of such springs have limited due to lack of water and unfit drinking water	Interviews various people from different background and visiting the spring sites.

Here in Cherrapunjee the water supply is totally dependent on the PHE department water supply.

- **Water control in MawsmaiNongthymmai:**

Dimension	**Means**	**Research object**	**Research techniques**

Physical control (technical)	Using small dams and check dams (at village level itself)	Water is stored in small dams made by PHE department during monsoon season and through various springs/streams. The water from these small dams are channeled to villages passing through various check dams constructed under MGNREGA scheme.	Meeting various section of people in the villages and meeting the Sirdar's (The head man of village). Surveying the check dams and small dams (Capacity around 50,000 to 1,00,000 liters of water).
Organizational control (managerial)	No organisational control present.	**********	**********
Socio-economic and political control	Storing water at village level,	The water management in the village is entirely socio-economic type of control where people without any help from government are managing the water sources and using water sustainably.	Here the research techniques involve meeting with village personal and headman of village, interacting with them and discussion about the same.

In villages like Mawsami, the water dependence is purely independent of PHE water supply and the whole system is managed by villagers is itself.

Check dam in Mawsmai village. These check dams are builds at about every 50 to 100 meters to control the flow of water. (constructed under MGNREGA scheme).

- **Water control in villages like Tryna:**

Dimension	Means	Research object	Research techniques
Physical control (technical)	Springs/streams	The main source of water is stream water near villages or soring water of private individual in the village.	Meeting village personnel. Visiting the springs and checking the amount and water quality.
Organizational control (managerial)	PHE department	Normally people get water from nearby sources. But now due to changing rainfall pattern many springs are dry so PHE department has connected the villages to far away springs via pipelines.	Meeting village personnel in Tyrna. Interviewing and discussing with PHE department oddicials.
Socio-economic and political control	Not present	**********	**********

In villages like Tryna the water control was same as thise in Mawsmai but in recent times the situation has changed. Many of springs of villages are dry up and water dependency on PHE water supply has increased.

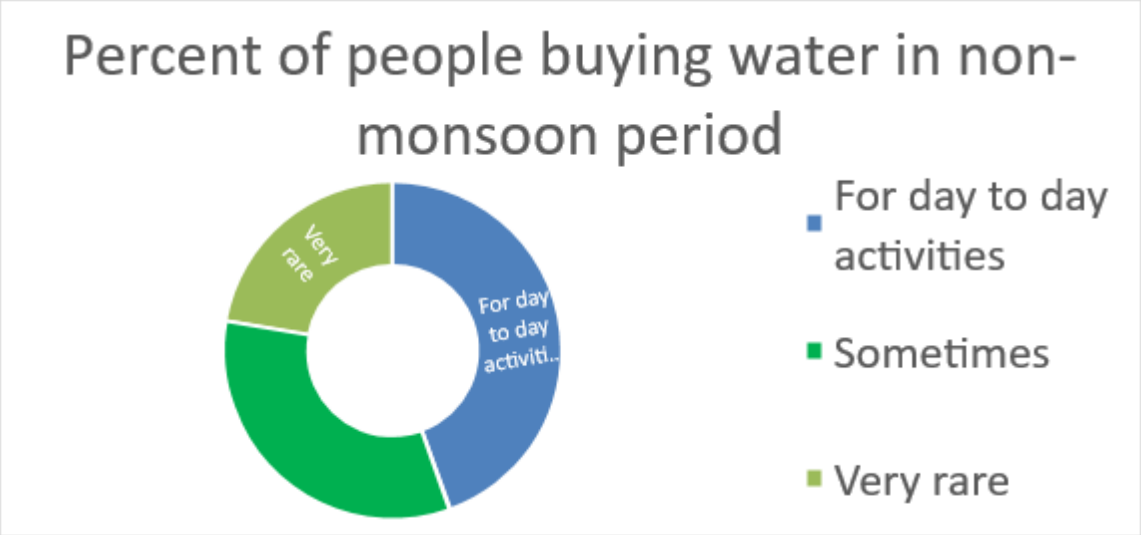
The PHE department has connected the village water supply to far springs but the future of these springs is uncertain.

There has been some cases where people have to migrate from one villages to other village due to unavailability of water and the same story prevails here. The PHE department as I talked to them are not in a capacity to supply water to such villages as the water storage of PHE department is not capable of supply water to Cherrapunjee itself.

Villagers are not sure about the water conditions and what next is being done when water supply get exhausted. Commercialization of water is new form of business that has taken its roots in the Cherrapunjee market, a place which receive the highest rainfall and is growing every year.

The extent of commercialization of water at present in the Cherapunjee can be estimated from the fact that during my field visit to Cherrapunjee, out of many people I interviewed about 30 to 40 percent agreed about buying water in winter season for day to day activities.

Below the chart shows the percent of people buying water in winter/non-monsoon period:



Water quality of sources:

Source	TDS value	PH value	Comments

Spring water (MawsmaiNongthymmai)	61	6.75	Spring water is very clean and fit for drinking and household purpose.
Government water supply	33	6.69	Very clean. Treatment plant installed are providing clean water.
Filter water	23	7.00	The filter installed at household level are environmental friendly and provide clean water.
Spring water Nongriathh village	26	6.89	Clean water, fit for drinking and other household purpose.

The water of overall sources is good as major water source being the rain. The problem is not about the quality of water but regarding the quantity of water.

COMPARATIVE STUDY OF WATER GOVERNENCE IN RAJASTHAN AND MEGHALYA

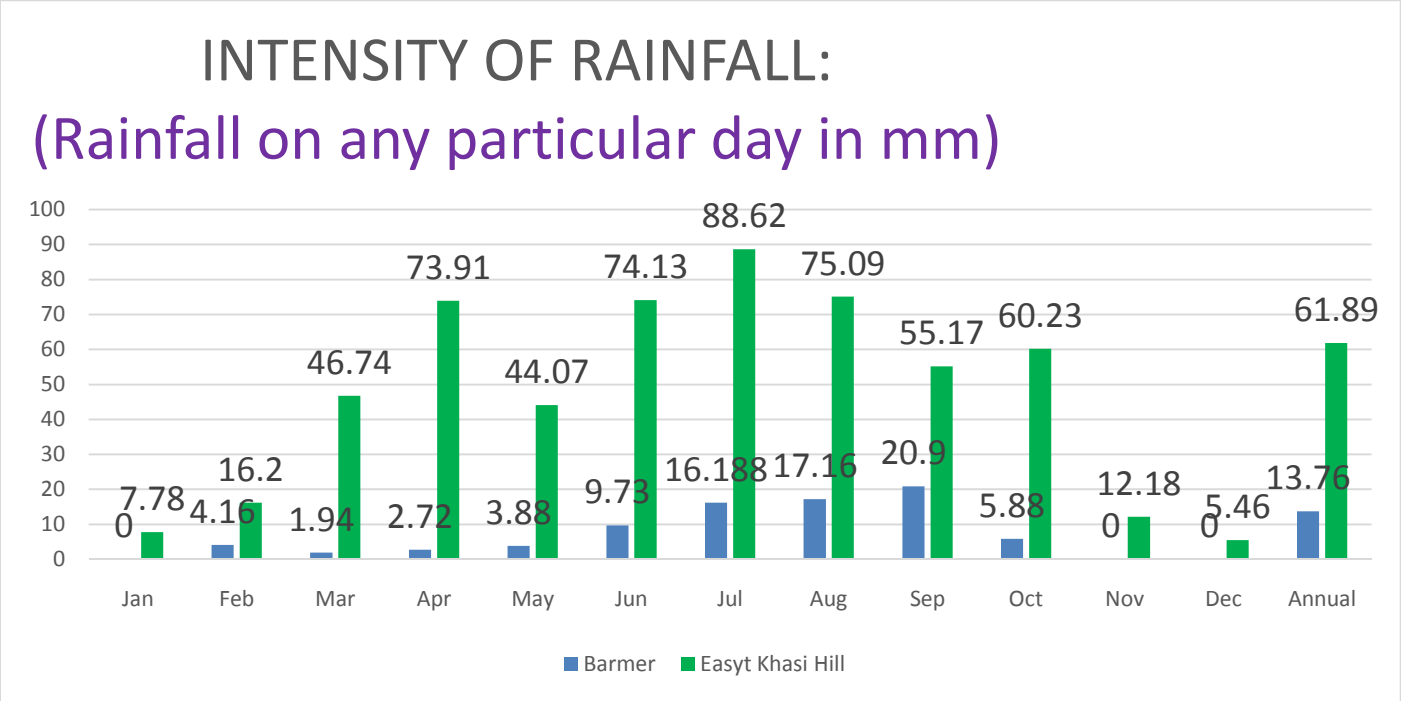
From various governmental sources, such as IMD[17] (India Metrological Department) and world climate guide[18] I had collected the rainfall data for past eleven years and analyzed it to find out the reason behind the

[17] Available at:http://hydro.imd.gov.in/hydrometweb/(S(bmcdym552mbee355ssscih2e))/DistrictRaifall.aspx

away water loss in Northeastern region. By taking rainfall data of every month of these eleven years (2004 to 2014) and studying it with no. of rainy days each month for these eleven years in the region East Khasi Hill district of Meghalaya I came to Intensity function.

Intensity function may be defined as amount of rainfall in any particular rain on an average per month i.e. Intensity= (average of rainfall in an area in a month) / (average no. of rain in the month)

The average intensity hence I get is about sixty-two millimeters which is very high and during monsoon it sometimes reaches to about eighty-nine millimeters on average. Such high intensity rainfall can be divestible in nature if not harnessed properly, also can be very useful in satisfying water needs of the region if proper infrastructure is present.

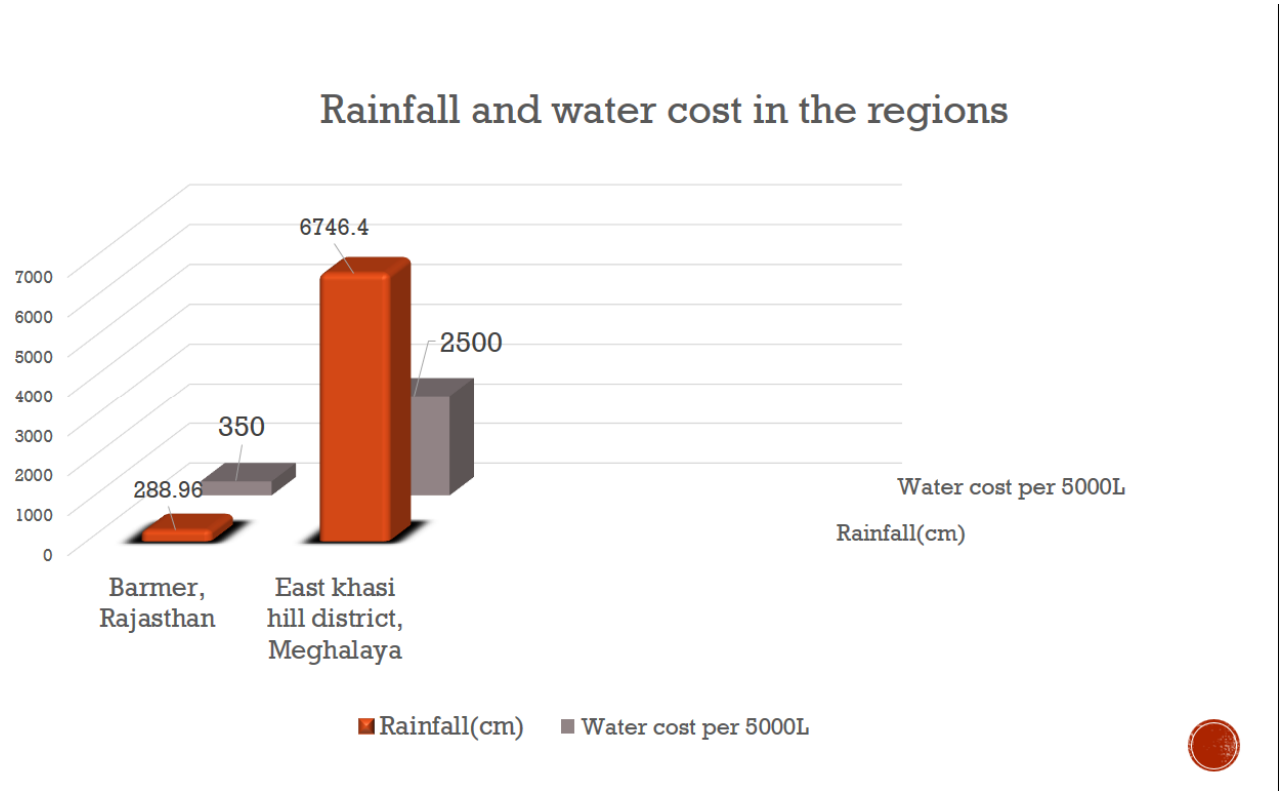


While looking at Barmer district's rainfall intensity, though both rainfall and intensity are very less as compared to East Khasi Hill in Meghalaya but the traditional water conservation techniques and active participation of the people and the government has made it feasible to get water for drinking and other household purpose.

[18] Available at:http://worldclimateguide.co.uk/climateguides/india/shillong.php#

As seen in the previous case it is very clear that water resources ae enormous in the Meghalaya but the management of sources has been being done in a sustainable manner as done in case of Rajasthan. The estimation of mismanagement and lack of general awareness among people can be understand by the fact that during the non-monsoon region the water cost per 5000 liters of water in Rajasthan is about 350 Indian rupees and surprisingly for the same amount of water the cost is as much as 2500 India rupees which is about seven times of that in Rajasthan. Despite an average rainfall of about 6746.4cm in the region the water cost is very high in case of Meghalaya.

Below the chart shows the comparative water cost and rainfall data:

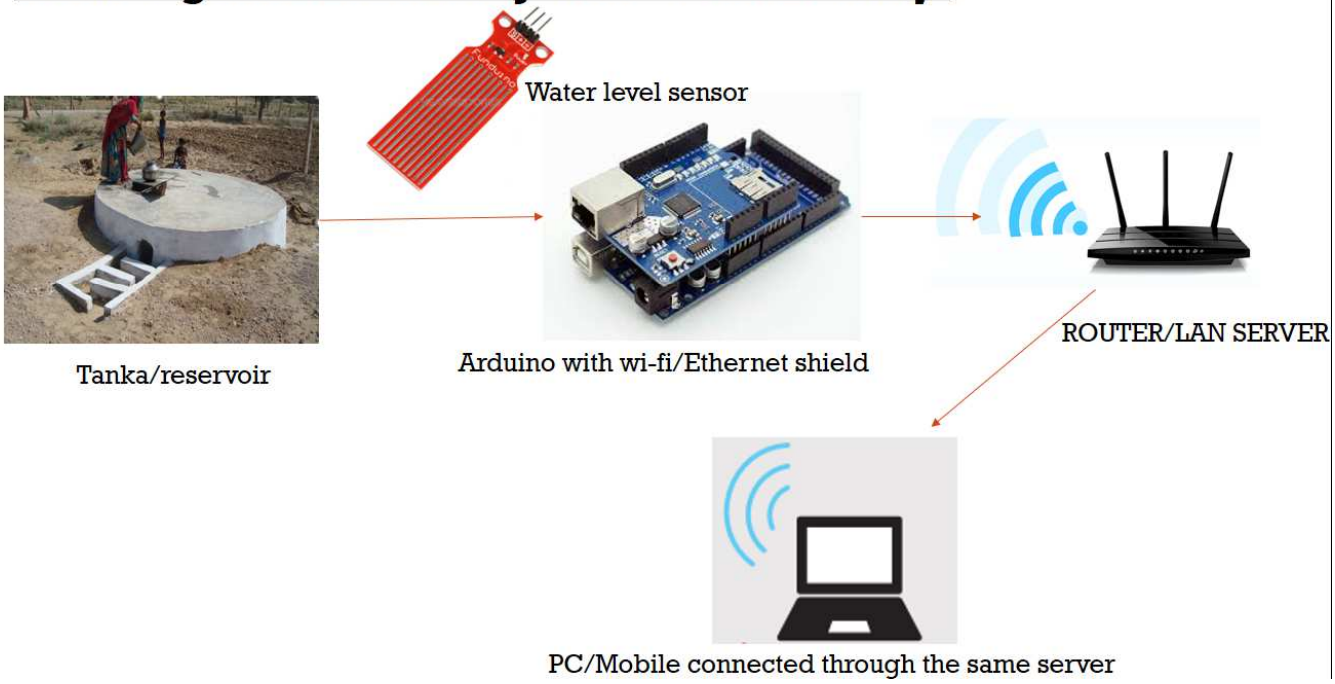


Conclusion and scope for future work

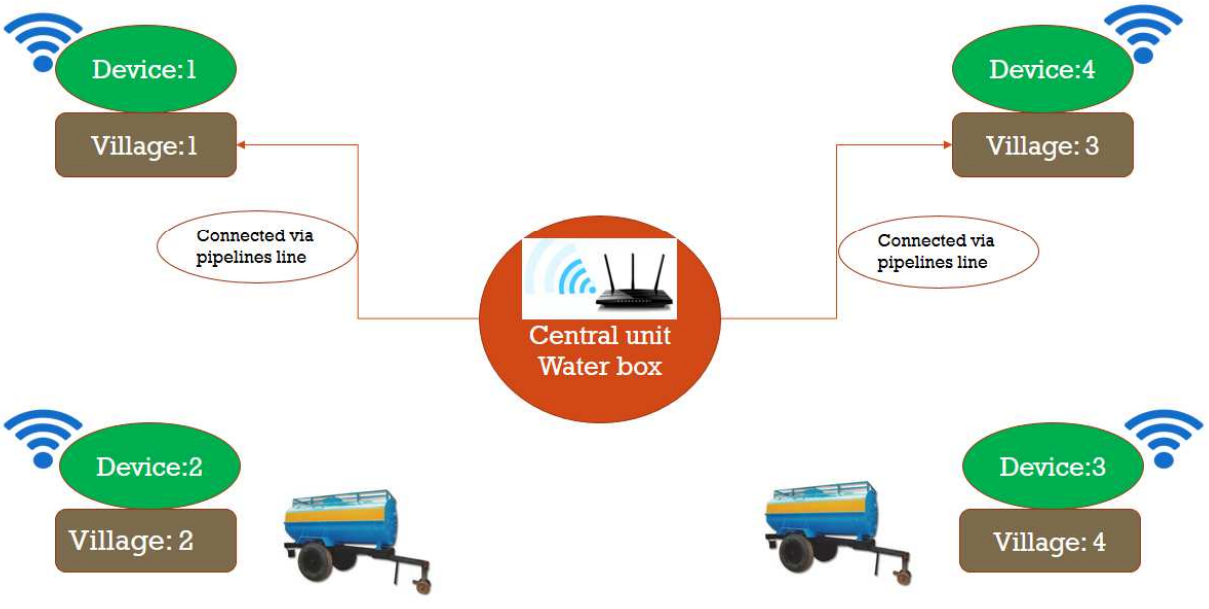
- Though water sources are limited in Barmer (Rajasthan) and it rains only about three to four times in a monsoon but with time people have evolved new techniques to store the available water to maximum extent.

- Opposite to what have done in Rajasthan, in Meghalaya, the region which receives the highest rainfall in the world the situation is leading toward to a dangerous path. The water scarcity in non-monsoon period has reached to a height that commercial cost of water is six to seven times that of Rajasthan indicating the mismanagement.
- As per how the things are going it will not be a surprise to say that if the good water management policies are not implemented as they have been done in Rajasthan then Meghalaya will be the new Manipur in coming days where people have to buy water on daily basis.
- In case of Meghalaya there is a need of more democratisation of water resources as we have seen in case of MawsnaiNongthymmai, where the whole water needs of water resources is managed by villge people itself.
- There is a need of looking towards condition of springs in case of Meghalaya and policies for safeguarding the spring from getting polluted by human activities. So that the water if these can be utilised in a much better ways.
- In case of Rajasthan, however the things are in control but can be made more user friendly my means of various technological advancement.
- One such technology that can be used is implementation of water level sensors in the water tanks constructed by the government for pouring water in non-monsoon period. These sensors can be used for real time monitoring of water levels in tankas at the central water unit.
- Water level of tankas can be monitored using these sensors and water can be send to villages when required via pipeline or water tankers.
- A working model is proposed here for the same. Here I have connected water level sensor to Arduino and the Arduino to the wifi/Ethernet shield. The signal can be send via this Ethernet shield to aserver and water level can be access through any mobile/computer connected to this server.

Working model for Rajasthan case study:



WORKING MODEL:



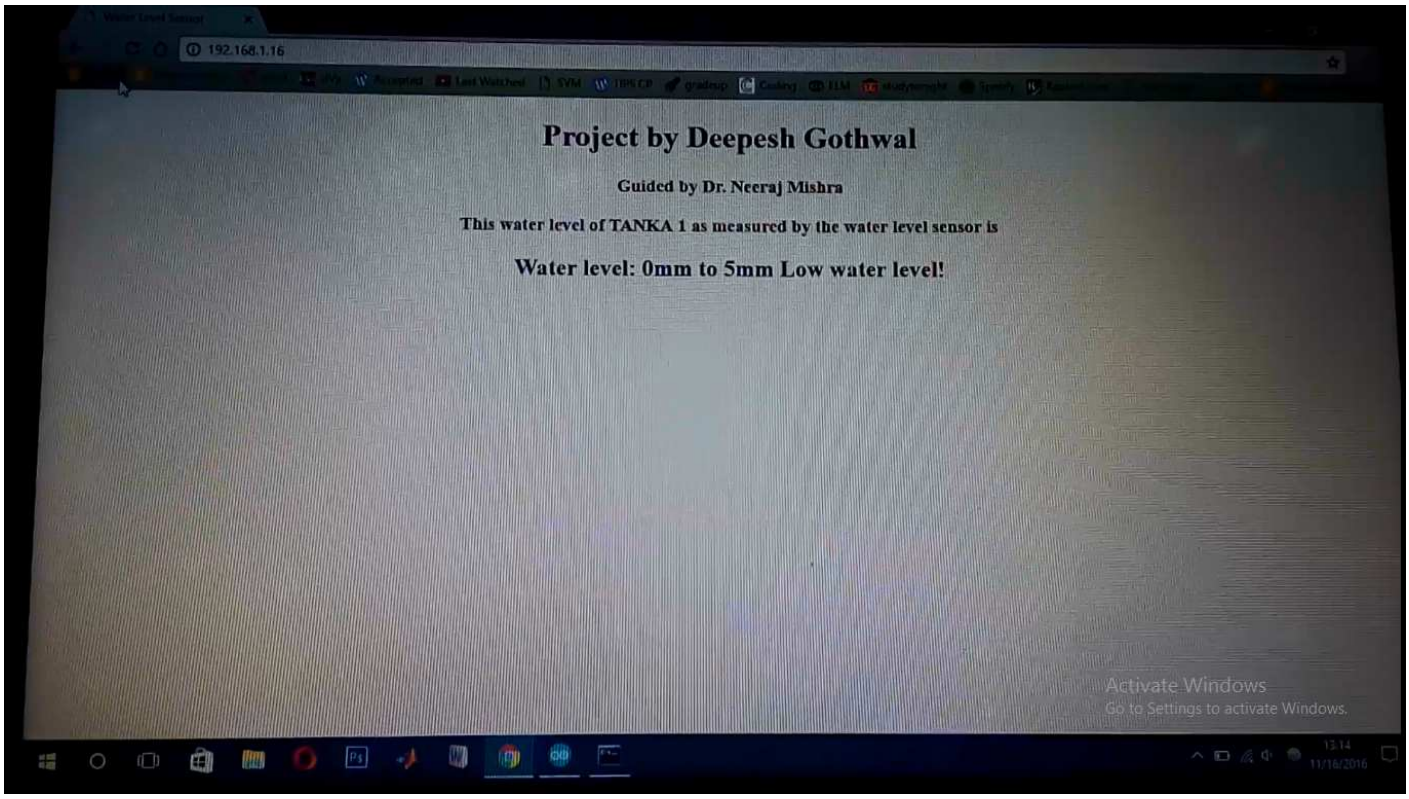
Below is the code used for the same:

```
#include <SPI.h>
#include <Ethernet.h>
byte mac[] = {
  0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED
};
IPAddressip(192, 168, 1, 16);
constint read = A0;
int value;
EthernetServer server(80);
void setup() {
Serial.begin(9600);
  while (!Serial) {
  }
Ethernet.begin(mac, ip);
server.begin();
Serial.print("Server is at ");
Serial.println(Ethernet.localIP());
}
void loop() {
EthernetClient client = server.available();

  if (client) {
Serial.println("new client");
booleancurrentLineIsBlank = true;
    while (client.connected()) {
      if (client.available()) {
        char c = client.read();
```

```
Serial.write(c);
      value = analogRead(read);
           if (c == '\n' &&currentLineIsBlank) {    //HTTP request has ended
client.println("HTTP/1.1 200 OK");
client.println("Content-Type: text/html");
client.println("Connection: close");
client.println("Refresh: 5");
client.println();
client.println("<!DOCTYPE HTML>");
client.println("<html>");

       if (value<=480){
client.println("Water level: 0mm - Empty!");
        }
       else if (value>480 && value<=530){
client.println("Water level: 0mm to 5mm");
        }
       else if (value>530 && value<=615){
client.println("Water level: 5mm to 10mm");
        }
       else if (value>615 && value<=660){
client.println("Water level: 10mm to 15mm");
        }
       else if (value>660 && value<=680){
client.println("Water level: 15mm to 20mm");
        }
       else if (value>680 && value<=690){
```

```
client.println("Water level: 20mm to 25mm");
        }
        else if (value>690 && value<=700){
client.println("Water level: 25mm to 30mm");
        }
        else if (value>700 && value<=705){
client.println("Water level: 30mm to 35mm");
        }
        else if (value>705){
client.println("Water level: 35mm to 40mm");
        }
client.println("</html>");
         break;
       }
       if (c == '\n') {
currentLineIsBlank = true;
       } else if (c != '\r') {
currentLineIsBlank = false;
       }
     }
     delay(1000);
   }
   delay(1);
client.stop();
Serial.println("client disconnected");
 }}
```

Here shows the output on the computer screen:


192.168.1.16
Project by Deepesh Gothwal
Guided by Dr. Neeraj Mishra
This water level of TANKA 1 as measured by the water level sensor is
Water level: 0mm to 5mm Low water level!
Activate Windows
Go to Settings to activate Windows.

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