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Water Resources and Management System of the Himalayan Region: Case Study of Mizoram, India

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ABSTRACT

The Himalayan region has been known as water abundant region in the form of innumerable natural water resources such as springs, streams, rivulets, etc. However, off late owing to climatic and anthropogenic reasons the entire region is soon turning into a water-deficit region leading to serious handicaps in undertaking the basic economic activities, affecting the diversity of livelihood and the drinking water sector. The problem becomes more acute in the dry season or non-monsoonal season. There seems to be a research void in the sustainable water resource planning of the Himalayan states. The present work is an attempt to study this research void through grass-root level analysis of the villages in Mizoram. Twelve villages of the Phullen RD block of Aizawl district, Mizoram were studied to understand the water supply and problems associated with water availability in the rural areas of Mizoram. In the villages of Mizoram, particularly the villages of the study area, Tuikhur or village spring source (VSS) and piped water supply constitute the main lifeline of water supply. Other sources of water include rainwater harvested and water taken from the stream or river. The springs which were once perennial have become seasonal owing to lack of spring shed management. Rainwater harvesting, barring inconsequential villages, is meagrely existent in this region of abundant rainfall with almost 130 days of rainfall. In the absence of proper water resource planning, there is a huge deficit of water every month with the average requirement of the study area being 2,49,148 gallons per month with a supply of just 2,14,248 gallons per month. However, water surplus was also observed in villages having a proper water management system in the form of rainwater harvesting and spring shed management.

INTRODUCTION

The Himalayan region, the source of innumerable water resources, is facing the problem of scarcity among plenty with an increased paucity of water owing to environmental and anthropogenic reasons. The countries in this region are facing newer and tougher challenges in meeting the basic requirement of water, food, and energy owing to rapid population rise and its associated phenomenon (Banerjee et al. 2015, Mukherji et al. 2015). With rising instances of human intervention in the natural environment, the various environmental cycles, particularly the hydrological cycle is getting affected (Biswas et al. 2019). To add to the woe, climate change, recent trends of rainfall vagaries, the geological structure of the aquifers, etc. have resulted in declining water availability in the many streams, springs, and rivers of this region (MoWR 2012, Gupta & Kulkarni 2018). Many such water resources of this region have lost their perennial characteristics. This has led to acute water shortages in almost all the cities and towns of the Himalayan region. The worst affected seems to be the rural regions where access to potable water is a constraint from both physical and economical point of view. Reduction in water availability is a major constraint for crop production, hydropower generation, and maintaining food security across the world (Magadza 2000). Thus, it is imperative to assess the socio-economic vulnerability linked to water shortage and livelihood diversification (O'Brien et al. 2004, Huq et al. 2015, Kinouchi et al. 2019, Kuchimanchi et al. 2019, Ramprasad 2018). In a report to the NITI Ayog et al. (2018) stated that almost half of the perennial springs in the Himalayan region have lost their perennial nature and have become seasonal. Severe water shortage has been reported from various regions like Kathmandu in Nepal, Darjeeling, Mussoorie, and Shimla in India, Thimphu in Bhutan and Kabul in Afghanistan (Snyder 2014). The National Water Policy of India (NWP) was adopted in 1987 and subsequently revised in 2002 and 2012 (MoWR 2002, Kumar 2017). However the same failed to address the deteriorating water reserves and supply primarily for the hilly regions. The potential of the innumerable springs in the Himalayan states for quenching the thirst of the region has been widely acknowledged. At present, the GOI through NITI Ayog has been emphasizing rejuvenation and recharge of these springs to bring about water sustainability. Spring shed management has been actively taken up by Sikkim through the initiative *Dhara Vikas* which is led by Rural Management and Development Department (RMDD) and other stakeholders utilizing the rainfall-runoff to recharge the spring sheds, thereby increasing the spring discharge and making them perennial. Such initiative through various NGOs is also seen in Uttarakhand where various springs have been rejuvenated and have regained their perennial status.

North-eastern India, especially the Himalayan state of Mizoram, comes under tropical monsoonal climate owing to which it receives ample rainfall. Further owing to its mountainous terrain, the region is blessed with numerous springs, streams, and rivers. Thus water was never a problem. However, in recent years, the acute shortage of water, particularly in the non-monsoonal season, is witnessed not only in the urban areas but also the rural areas with the drying up of a majority of water sources. Although schemes and initiatives like *Dhara Vikas* have already reached various Himalayan states of Himachal Pradesh, Nagaland, and Uttarakhand, the same is yet to be seen in Mizoram. There seems to be a research void in the socio-ecological situation of the region and an appraisal of the most important resource of humanity in this region of affluence. The present work is an attempt to study this research void through grass-root level analysis of the villages of Mizoram. 12 villages of the Phullen RD block of Aizawl district, Mizoram were studied to understand the water supply and problems associated with water availability in the rural sector of Mizoram. The main objective of such study is to understand and identify the socio-ecological gaps, identify ways and means for better governance of water resources and encourage the policymakers for a conservational and sustainable development approach of water resources particularly in the rural regions of Mizoram where most of the inhabitants do not possess access to the potable water supply. Further, once the rural belt is made sustainable, the urban regions will also be benefitted.

STUDY AREA

The study was conducted for the entire Phullen RD block of Aizawl district, Mizoram enclosed within 23°81'80" N and 24°06'89" N and 93°01'38" E and 93°14'57" E as represented in Fig. 1. The block is constituted of 12 villages namely Daido, Khawlian, Lamherh, Luangpawn, Tlangnuam, Khawlek, Phuaibuang, Phullen, Suangpuilawn, Thanglailung, Vanbawng and Zawngin. All the 12 villages are part of this research work. Phullen block, having a total area of 515 km² is situated in the north-east part of Aizawl district where it shares state boundary with Manipur and district boundary with Champhai in the East. Phullen RD block is surrounded by Ngopa RD block in the east situated in Champhai district, Thingsulthliah RD block of Aizawl district in the south, and

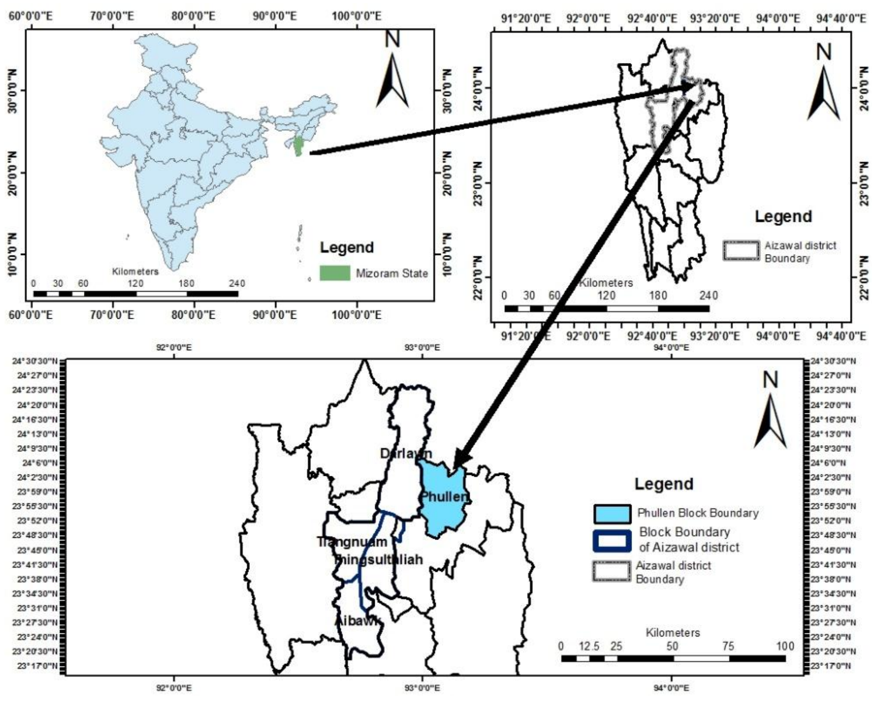

Fig. 1: Area of the study.

Darlawn RD block of Aizawl district in the west. The study area has a population of 13,303 according to the 2011 census. The elevation ranges between 269 MSL (Thanglailung) to 422 MSL (Phuaibuang). The literacy level of the study area is more than 90.73%. About 85% of the total population of the block is engaged in agriculture or related primary sector according to census 2011 data. Agriculture is primarily in the form of Jhum.

This mountain terrain, extending from north to south direction, is composed of predominantly sandstone and shale of the late tertiary period. The region has medium dense forest cover with the majority of the vegetation being of Bamboo variety which also serves as a resource for Mizoram. The climate is tropical monsoonal with a moderate climate throughout the year. Summer temperature ranges between 20°C to 29°C (March to May) while the winter temperature ranges between 7°C to 22°C (November to February). The region is under the influence of southwest monsoonal winds for the greater part of the year with an annual average rainfall ranging between 250 cm to 270 cm. Phullen block has two perennial rivers, Tuivawl and Tuivai. The rivers flow through the study area in a general south-north direction. Both the rivers are joined by several streams and rivulets both perennial and non-perennial. Every village has springs, locally termed as *Tuikhurs*, indicating that the region has good water potential.

MATERIALS AND METHODS

Qualitative and quantitative methodologies of a questionnaire survey and data analysis were carried out. Since the objective involves water resources, it was done through field observation, Google earth, and other android based processes like Geotagging through a mobile device.

At the onset, the various sources of water supply for each of the villages of the study area were investigated, followed by a questionnaire survey of the number of households that depend on various types of water resources, daily seasonal consumption of water per household in each village, water availability from various sources per month and the material used for collecting and storing of water.

Secondly, based on the demand and supply of water from the various sources statistical analysis was done on the constraints of sustainable livelihood maintenance through SPSS software and MS Excel. The analysis has been represented through tables and graphs.

The respondents of the survey ranged from the villagers, Village council president, BDO office of Phullen block and PHED (Public Health Engineering Department) officials. The respondents were categorized according to age and sex. A total of 100 respondents from each village were surveyed which included 50 males and 50 females. 50% of the respondents belonged to the age group of 18 to 30, 25% belonged to the age group of 31-50 and the rest 25% belonged to age group 51-80. Most of the respondents had their own houses (85%) while a few had rented accommodation (15%) in the entire study area. The education level of the respondents has been given in Fig. 2 while the monthly income levels of the respondent households of each of the village are provided in Table 1.

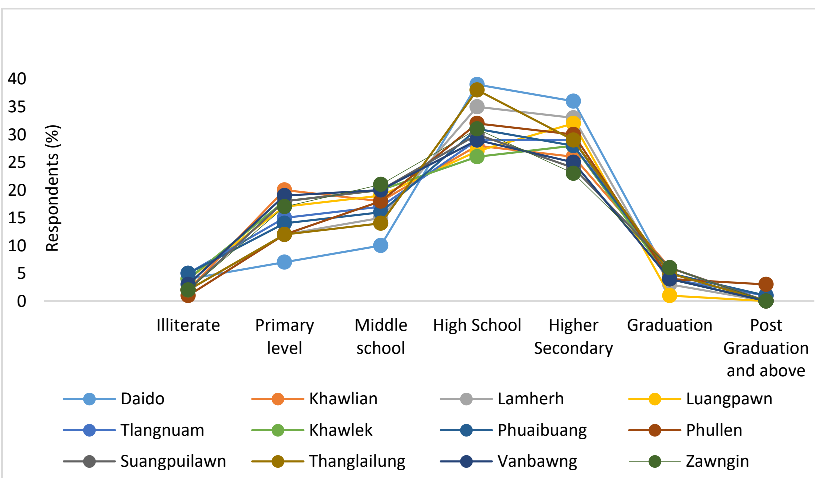

Fig. 2: Educational level of the respondents of the study area.

Table 1: Monthly income levels of respondent households in the study area.

Sr No.	Villages	Number of Households	Income categories in %			
			< Rs 8,000	Rs 8001-12,000	Rs 12,001-15,000	>Rs 15,000
1	Daido	95	23	42	31	4
2	Khawlian	420	22	44	32	2
3	Lamherh,	128	16	36	42	6
4	Luangpawn	99	14	37	39	10
5	Tlangnuam	98	11	34	44	11
6	Khawlek	151	21	38	39	2
7	Phuaibuang	430	13	41	38	8
8	Phullen	460	8	31	49	12
9	Suangpuilawn	450	14	43	37	6
10	Thanglailung	170	16	46	36	2
11	Vanbawng	243	9	46	41	4
12	Zawngin.	131	15	45	36	4

Source: Computed by authors based on field survey.

DISCUSSION

The study region which is part of Mizoram state has a bounty of water resources in the form of steams, rivulets, springs, and most importantly abundant rain for the greater part of the year. Ideally speaking thus, water should not be a problem in this region. However, climate change and anthropogenic activities along with lack of integrated watershed management have resulted in the water surplus regions of the Himalayan belt to water deficit region leading to serious handicap in undertaking the basic economic activities, affecting the diversity of livelihood and the drinking water sector (McPhillips 2017, Maplecroft 2011, Sharma et al. 2019, Kelly & Adger 2000, Shrestha et al. 2019, O'Brien et al. 2004). In general, the villages of the study area, as is elsewhere in Mizoram, is most affected during the non-monsoonal season/dry season. Hence the study has been specially conducted keeping in view the water availability during the season of scarcity.

Various Sources of Water in the Study Area

In the villages of Mizoram, particularly the villages of the study area, *Tuikhur* or village spring source (VSS) and piped water supply constitute the main lifeline of water supply. The Piped water supply is managed by the PHED department. Other sources of water include rainwater harvested and water taken from the stream or river. Water taken from streams is mostly done by private operators depending on the demand for water by the villagers. These are the important sources of water in rural areas obtained by the villagers for their daily uses. The various water sources in the study area (Fig. 3) have been analysed briefly in the following section.

Fig 3: Sources of water supply in the study area (clockwise from top left; PHED, Tuikhur, Rainwater harvesting, private operators).

Tuikhur

Till today, one of the most important sources of water supply in the rural areas can be considered as *Tuikhur* or village spring source (VSS). The villagers, especially the poor family greatly depend on Tuikhur water for their daily needs. Almost every village has access to such water sources. It is a perennial water source, however in recent times with rainfall variability and various anthropogenic reasons many of these sources either dries up or has reduced water quantity during the dry season or non-monsoonal season of Mizoram (Table 2). It is mainly used for drinking, cooking, cleaning and washing purposes. But during the scarcity of water, the villagers are prohibited from using *Tuikhur* water for cleaning and washing.

Piped Water Supply

Piped water supply or water connection involves drawing of water from the streams and rivers by PHED. In most of the villages, the pumping system is used for collecting water from the streams and river. The pumping system is the method of lifting water from the river or stream through high a lift pump driven by the power in which water is transported to the storage reservoir. The location of the reservoir is put at a higher elevation within the village so that distribution can also be done easily through the gravity feed system. The construction charge is generally borne by the government or sometimes by the individual Village councils. Water is hauled from the local streams/tributaries, Kawrawng, Leisang, Ramrikawn, Mauhar, Kawrte, etc. The private household connection, at Rs 300/month, given by PHED receives water for about an hour per week. The total amount of water obtained is about 2,000 litres per week. Certain villages also have public water distribution points supplied by PHED, where the total amount received is about 225-300 litres/month. The supply is highly irregular during the dry season.

Table 2: Spring water source of the study area.

Sr No	Villages	Springs/*Tuikhurs*	
		Total	Perennial
1	Daido	05	03
2	Khawlian	04	01
3	Lamherh,	04	03
4	Luangpawn	05	04
5	Tlangnuam	05	04
6	Khawlek	04	04
7	Phuaibuang	05	03
8	Phullen	07	03
9	Suangpuilawn	12	08
10	Thanglailung	04	02
11	Vanbawng	04	02
12	Zawngin.	05	04

Source: Computed by authors based on field survey.

Rainwater

Rainwater is harvested during the rainy season. Owing to climatic conditions the houses have sloping roofs with corrugated sheets, aiding in the collection of rainwater. The same is stored in barrels or large plastic containers. During the monsoonal season, the water is used mainly for washing purposes and watering individual kitchen gardens. Sometimes it is even used for drinking after filtering it. There is no definite data available for rainwater harvesting and water obtained from private operators. The total amount of rainwater that is stored by individual households is around 3000 litres/month. This is primarily stored for the dry months and lasts for about 2 months. The water obtained from private operators are need-based; as and when required. So far only Suangpuilawn village has utilized rainwater harvesting to a great extent.

Water From Stream

Water is pumped indiscriminately from streams or rivers during the dry season. The water is pumped into barrels or tanks of 2000 litres capacity and sold to the villagers by private operators. The price of water generally ranges from Rs 600 per 1500 litres to Rs 900 for 2000 litres.

Water Supply and Management System in the Study Area

As is observed from the preceding section, the study area does not have any fixed water supply system. It follows a 3 tier system of Public Health Engineering Department (PHED), Government of Mizoram; Village council level through the management system of Tuikhur; and private level through household rainwater harvesting and buying of water from private operators as and when the need arises. In certain villages like Suangpuilawn and Thanglailung community rainwater harvesting has been undertaken by the respective Village council on large scale for ensuring village level self-sufficiency. Water requirement, supply and management system differ quantitatively among each of the 12 villages owing to population size, water management system, the elevation of the village and monetary capacity of the residents.

Households and Water Consumption Pattern

The average amount of water available to the villages is around 2,14,248.6 gallons of water per month. This excludes the water obtained from private sources. Based on the total population of each village, the per head water availability was computed and is represented in Table 3. The per head water availability on an average stands at a meagre 21 lpcd or 5.63 gallons which is much lower than the minimum service delivery of 55 lpcd or 14.52 gallons as decided by Jal Jeevan Mission, under Ministry of Water Resources, India (https://pib.gov.in). The extreme scarcity particularly in the dry season forces the population to restrict consumption, stop agricultural practices and compels the women-folk to trudge daily in search of water from distant streams/springs and buy water from private sources at a high price.

Owing to scarcity, water is used in a very controlled manner in the dry season. The excess usage like watering of plants/kitchen garden is curtailed, recycling of available water is encouraged (reusing water used for washing vegetables/clothes) and a general restriction of water usage is practised as represented in Fig. 4. With decreased water supply from various sources during the lean period, PHED water supply becomes the major source of water for the study area as represented in Fig 4. With the unavailability of a community-based rainwater harvesting system and household rainwater harvesting system owing to financial reasons, the stored rainwater does not last long. Thus the share of rainwater in meeting water demand of the study area is too meagre as observed in Fig. 4. Water obtained at a high price from private operators comes to a close second for almost all the villages barring Suangpuilawn. The village is self-reliant concerning to meeting its water demand. Almost 25% of the water need of Suangpuilawn is met through planned community based and household rainwater harvesting system. The village has 5 large water storage tanks of 3000 litres each for community rainwater harvesting (Fig 5). Eighty seven households out of 450 total households of the village, constituting about 19.33% of the total population, have individual household rainwater harvesting systems each having storage tanks of 2500 litres.

Table 3: Water availability for the study area.

Villages	Total population	Water availability (gallons/month)	Water availability (gallons/per head/month)
Daido	615	80942.57	4.39
Khawlian	2400	396972.6	5.51
Lamherh	618	124451.8	6.71
Luangpawn	478	96449.52	6.73
Tlangnuam	440	94204.05	7.14
Khawlek	769	135256.5	5.86
Phuaibuang	2500	365879.4	4.88
Phullen	2700	402810.8	4.97
Suangpuilawn	2400	403814.7	5.61
Thanglailung	980	150076.6	5.10
Vanbawng	1255	206741.7	5.49
Zawngin	740	113383	5.11

Source: Computed by authors based on field survey.

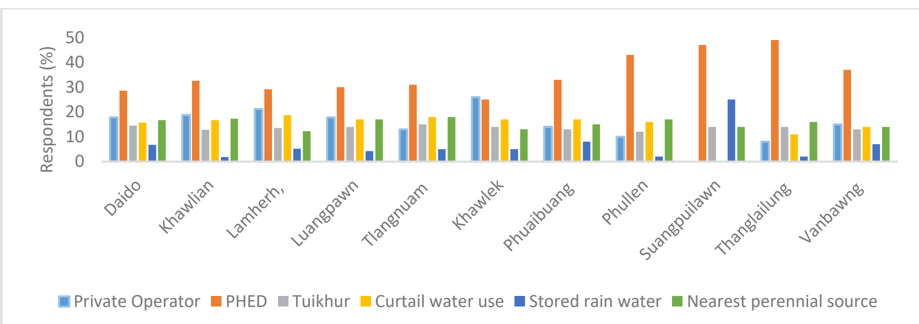

Fig. 4: Meeting water demand during the lean period for the study area.

Fig 5: Community rainwater harvesting tanks of Suangpuilawn village.

Demand-Supply Gap

The average requirement of the study area is 9,43,125 litres per month or 2,49,148 gallons per month with the highest requirement from Khawlian village (4,89,776.5 gallons per month) as visible from Fig. 6 and an average supply of just 2,14,248 gallons per month. However, the largest deficit is noticed in Phuaibuang village with a shortfall of 1,04,374.7 gallons per month of water. Suangpuilawn and Thanglailung are the only villages having NIL water deficit owing to wide-scale rainwater harvesting system and planned water management.

The total requirement of water for the entire study area is 29,89,777 gallons of water per month. The total water supply/availability from Tuikhurs, PHED and rainwater harvesting (including water haulage from distant streams/springs) is 25,70,983.3 gallons of water per month as represented in Table 4. Thus there is a total deficit of 4,18,793.25 gallons of water per month. This is predominantly during the dry season. A huge part of this deficit thus has to be filled by the private operators at a hefty price.

Table 4: Water supply details of the study area.

Village	Tuikhurs	PHED	Rain water
	Supply in gallons/month		
Daido	48977.65	26417.29	5547.63
Khawlian	82897.45	302742.1	11333.02
Lamherh	56031.07	62080.63	6340.149
Luangpawn	63559.99	29587.36	3302.161
Tlangnuam	61974.96	19020.45	13208.64
Khawlek	80044.38	45701.91	9510.223
Phuaibuang	101442.4	204998.2	59438.9
Phullen	130448.6	267078.8	5283.457
Suangpuilawn	91958.58	254398.5	57457.6
Thanglailung	40576.95	104876.6	4623.025
Vanbawng	69900.14	126274.6	10566.91
Zawngin	59755.9	42531.83	11095.26

Source: Computed by authors based on field survey.

To understand whether there is a significant difference between demand and supply of water among all the villages of the study area, a two-sample *t*-test was conducted. The statistical analysis yielded Pearson's correlation value of 98% and p-value of 0.006, indicating a significant difference between the variables, demand and supply of water.

To statistically analyze the level of significance between the various available water sources among the various villages, ANOVA was conducted and the result is presented in Table 5. The p-value of 0.001 represents a significant difference between the various water sources and their availability among the villages.

Issues and Challenges

The key challenge of the study area is the disparity between population and water availability per capita. *Tuikhurs* and rainwater harvesting systems are traditional systems while the PHED system is 30-35 years old. The topography of the region hampers water haulage which is being done by Gravity feed system and pumping system, thereby increasing the infrastructural cost. All the systems are quite old and are unable to cater to the population. Renovation of storage tanks, repair of pipelines, feeder lines, and rainwater harvesting systems are lacking in the study area. The region receives abundant rainfall from May to September (average 130 days/year) owing to its strategic location. One of the works of

Table 5: ANOVA test for various available water sources among the villages.

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F-crit
Between Groups	992000000000	2	496000000000	8.547011	0.001	3.28
Within Groups	1920000000000	33	58000000000			
Total	2910000000000	35				

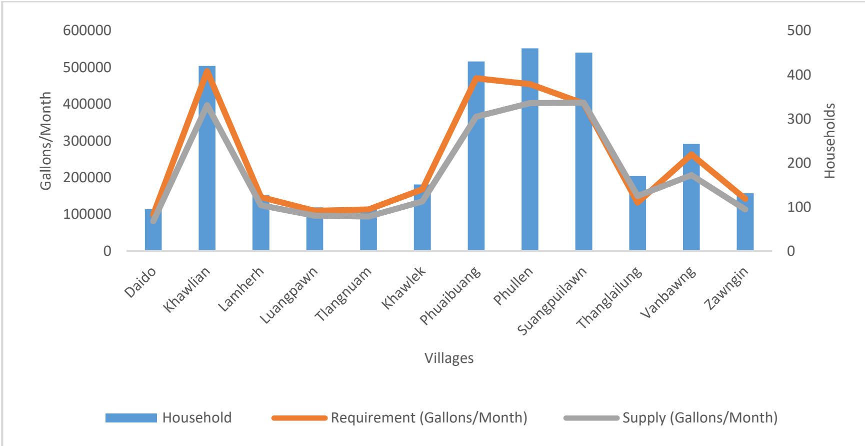

Fig 6: Demand and supply of water resource along with the number of households in each village.

PHED, Government of Mizoram is to undertake rainwater harvesting scheme, under various centrally (Government of India) sponsored schemes. Under this scheme, PHED must construct 7500 litres of storage tank for a family of 6 members for water availability of 10 lpcd for 120 days of the dry season. However, not a single such structure was found in any of the villages of the study area. In the absence of impounding of rainwater, which is to the extent of about 250-270 cm of annual average rainfall, the scope of catchment recharge of the dying and dried up springs/*Tuikhurs* and availability of water in dry season through individual/community rainwater harvesting is wasted and lost. Such anthropogenic callousness also induces environmental threats like soil erosion, run-off and increased instances of rainfall-induced landslides owing to slope instability triggered by enhanced run-off along the steep down slopes. Further, most of the villages do not have all-weather roads which hinder access to the surrounding rivers/streams (Tuivai river and Tuivawl river).

CONCLUSION

The study region is blessed with very heavy rainfall at an annual average of 250 cm to 270 cm. This is one of the highest in India. Owing to its mountainous terrain it has a plethora of water resources in the form of various streams, springs (locally called *Tuikhurs*) and a huge potential from rainwater harvesting system. *Tuikhur* forms the main lifeline of the study area encompassing 12 villages of Phullen RD block of Aizawl district, Mizoram. However, during the dry seasons, almost 50% of *Tuikhurs* in each of the villages dry up owing to lack of spring shed management. Thus, the water resources of the study area face a huge demand-supply gap particularly in the dry season (winter season) and are unable to meet the basic per capita water requirement of 55 lpcd as decided by Jal Jeevan Mission, under Ministry of Water Resources, India. The per capita water availability on an average stands at a meagre 21 lpcd. The short-fall is met by buying water from private operators at a very hefty price. Further, lack of all-weather roads hinders accessibility to the surrounding rivers/streams. The dearth of proper planning is one of the reasons for this huge demand-supply gap which is proved by the self -dependency of Suangpuilawn village with regard to the water resource. Proper management of spring shed and rainwater harvesting system has made this village self-sufficient in water needs throughout the year. The only way forward for the study region is to utilize and plan its already existing resource-rainfall, in such a way as to enhance spring shed management cum recharge, impounding of rainfall by constructing various water ponds and proper rainwater harvesting system both at the community level and household level.

The present study provides a grassroots level diagnosis of the present situation of the villages of Aizawl district.

However, one can find the same picture throughout the villages of the state as well as the other Himalayan states. As such studies like this will provide the pre-requisite ground-level data for further integrated water resource planning.

Spring shed management through rainwater harvesting is not a new concept in India. In Sikkim, through Dhara Vikas, an atlas of 700 springs have been created along with the rejuvenation of springs. Such initiatives have also been taken in Uttarakhand.

Taking cognizance of the gravity of the situation in this region of bounty yet scarcity of water resource, various stakeholders both at the government level and NGOs along with the academic body must take part in ensuring the basic need of humanity through proper planning.

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