SUSTAINABLE APPROACH OF RAINWATER MANAGEMENT AND APPLICATION (SARMA)

FOR

MITIGATING ADVERSE IMPACT OF CLIMATE CHANGE

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BACKGROUND

Projection of monsoon precipitation of Northeast India using GCM has always been challenging because of the orographic arrangement, as these are not explicitly considered in the GCMs. Low density observed precipitation data also hinder the development of a reliable downscaling model. To have better model results through downscaling, Chair has taken up the task of collecting climatic data from various other sources like Tea Garden, Electricity Board, and Agricultural Department in addition to those available from IMD.

Based on the MoU made between B.P.Chaliha Chair and Tea Board of India, data from more than 200 observation stations has been collected with the understanding that Chair will also provide suggestions for mitigating some of the water related problem faced by the gardens. This has helped getting full cooperation from all the tea estate in the data collection exercise.

Accordingly, during the visit of the project team under B.P. Chahlia Chair to various Tea Estates and other organizations for collecting meteorological data, they had interacted with various authorities about the water-related problems. Emphasis was given on those problems, which may further deteriorate because of climate change impact. From the interaction, it was found that almost all gardens have shown concerns about their declining production. It was found that while some gardens are facing problem due to waterlogging, some are facing problem due to water stress during winter. It was found that pond constructed in suitable location can solve the problem of water crisis as well the waterlogging. It was also observed that many gardens have a natural pond or low-lying areas in their garden area, which can easily be utilized for harvesting water during rain. Therefore, to have multiple benefits from a pond B.P.Chaliha Chair and his team decided to design a water harvesting structure so that the available water can be managed and applied optimally to have an economic and environmental benefit at an affordable cost and with a quick breakeven point.

ABSTRACT

Rain water harvesting has been a tradition of the Brahmaputra Basin as the region is endowed with high rainfall in the monsoon season. However, a conventional rain water harvesting pond, though could meet the water requirement for some of the purposes, has failed to sustain its utility and people have filled it up to have a land surface to be utilized for other purpose. With introduction of water supply system, people are deriving more economic benefit by using the land area obtained for other purposes by filling up their old ponds. With more and more numbers of ponds getting converted to land, adverse impact on hydrological system is now becoming visible, as flood and drought both are increasing at an alarming rate. To derive its hydrological benefit along with others, a rain water harvesting system has been designed to have benefits from its multiple applications coupled with scientific management of the available water. This has been designed in a way that people can derive its benefit in a sustainable manner. The system is named as Sustainable Approach of Rain Water Management and Application (SARMA). Irrigation through recirculation, microclimate moderation, runoff reduction and groundwater recharge are some of the benefits that this pond system can provide. To examine benefits in practical field IIT Guwahati is working in close coordination with Dolowjan Tea estate of northeast India and some interesting result has been observed so far.

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1. INTRODUCTION

Climate change study conducted by the chair concluded that in the Brahmaputra basin, the intensity of rainfall will be increase in future which will lead to flood and erosion, and the dry period span will also increase leading to drought like situation. It was also observed that temperature might increase in near future by 1.5 to 2 degree Celsius under the impact of climate change.

Plants and animals can survive well within a certain range of temperature and other climatic parameters. It was observed that in many places of Brahmaputra valley, the maximum temperature has increased up to 38 to 39 degree Celsius in summer season in the recent years. This rise in temperature can adversely affect the plant growth, as the photosynthesis activity gets slowed down beyond 32 degree Celsius (Barua 1979) Although shed trees are used to maintain the temperature in tea garden, the high temperature rise adversely affect the crop production and might be a reason of present decreasing trend of tea production in many tea gardens of the reason. Waterlogged condition during monsoon and longer dry-spell recently experienced in this region during winter can also adversely affect the crop production. Water harvesting in a pond if done innovatively can address crisis both during flood and drought.

The pond culture has been a tradition of the Brahmaputra Basin and it evolved as a result of long experiences. With time the land value has increased a lot and economy of pond has gone down as traditional utility of the pond has lost its value. However, B.P.Chaliha Chair feels that the pond culture if can be brought back, with increased economy of pond, will also provide the benefit of creating favourable microclimate in its nearby areas.

Therefore a study was taken in hand to design a pond system that will provide multiple benefits and will help creating favourable microclimate for agriculture and plant growth. The design focuses on deriving multiple benefits from the rainwater harvesting in a sustainable manner so that construction of pond or artificial wetland become economically feasible.

Before describing the concept of newly designed pond, conventional advantages and disadvantages of rain water harvesting is presented briefly.

2. ADVANTAGES OF WATER HARVESTING

1. Easy to Maintain: Rain water harvested in the pond for favourable microclimate is easy to maintain. The water could be used for drinking and other household purposes as well.

2. Suitable for Irrigation: The rain water harvested in the pond could be used for irrigation during water stress period.

3. Reduces Demand on Ground Water: With increase in population, the demand for water is also continuously increasing. The end result is that many residential colonies and industries are extracting ground water to fulfil their daily demands. This has led to depletion of ground water which has gone to significant low level in some areas where there is huge water scarcity to an alarming situation. Harvesting of rain water reduce demand for ground water.

4. Reduces Floods and Soil Erosion: During rainy season, rain water harvesting tank/ponds (storage), enhance surface retention and thus the surface runoff gets reduced thereby reducing floods in general. It also helps in reducing soil erosion.

5. Reduces water logging condition: rain water harvesting in ponds reduces the water logging condition in agricultural fields and thereby mostly reduces secondary diseases of plants.

3. DISADVANTAGES OF WATER HARVESTING

1. Unpredictable Rainfall: Rainwater harvesting in pond is only suitable in those areas that receive plenty of rainfall but it is not suitable in the areas with unpredictable and less rainfall.

2. Initial High Cost: Depending on the water harvesting technology used, the initial cost may be high in some design.

3. Regular Maintenance: Rainwater harvesting systems require regular maintenance as they may get prone to rodents, mosquitoes, algae growth, insects, lizards and frog.

4. Storage Limits: The collection and storage facilities may also impose some kind of restrictions as to how much rainwater one can use. During the heavy downpour, the collection systems may not be able to hold all rainwater and excess water need to be drained out properly without adversely affecting the nearby areas.

4. NEED OF SITE SPECIFIC DESIGN

The study of special variation of precipitation in the state of Assam in Brahmaputra Basin has shown that a site specific design is necessary for pond in different areas. For carrying out this study, precipitation data collected from various organizations including tea gardens has been used and the gridded data of IMD has also been observed. To have a comparison of both the data they were rescaled to the same grid size and presented below:

4.1 SPATIAL VARIATION IN RAINFALL OVER ASSAM REPRESENTED BY IMD GRIDED RAINFALL OF 2009 (Rescaled to 0.1 Arc Second)

The variation in rainfall as per IMD data in 0.1 Arc Second scale has been regenerated from the available gridded data of IMD and is presented in figure 1.

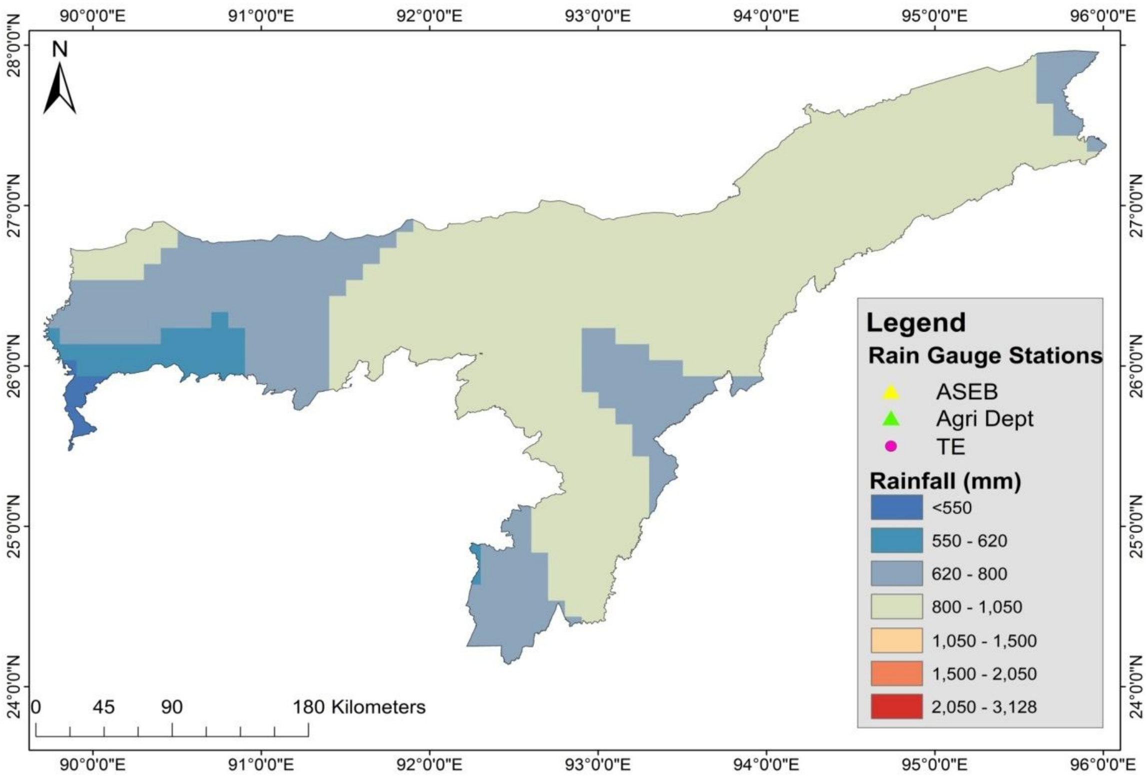

Fig 1: Spatial variation of rainfall of Assam by IMD gridded rainfall

4.2 SPATIAL VARIATION IN RAINFALL OVER ASSAM REPRESENTED BY RAINFALL DATA OF DIFFERENT ORGANIZATIONS OF 2009

Data collected by B.P.Chaliha chair from various other sources like Tea Gardens, Assam State Electricity Board, Assam Agricultural University, Department of Agriculture, Assam are presented in figure 2 in 0.1 Arc Second grid size.

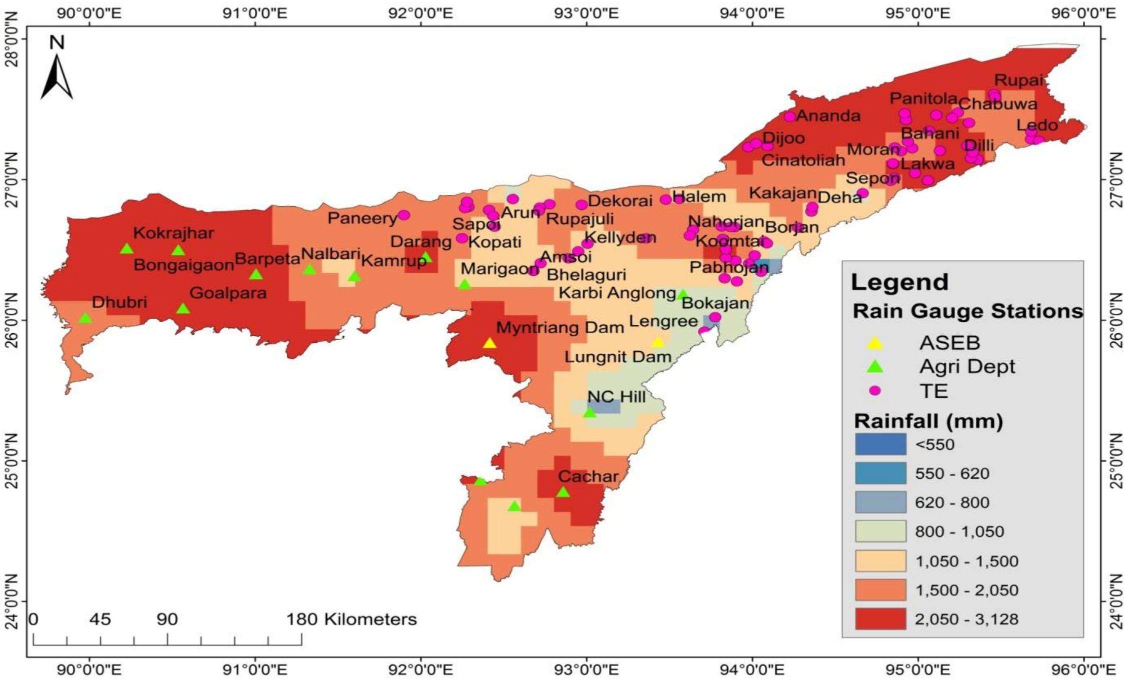

Fig 2: Spatial variation of rainfall of Assam by rainfall data from different organizations

4.3 COMPARISION OF DATA

From the above figures it is seen that the rainfall in different district of Assam is not uniform and therefore harvesting pond has to be designed to meet the requirement. As the gridded data of IMD, though is an authentic data, is generated from low resolution observed data. On the other hand the gridded data generated from other sources are based on high resolution observed data. The gridded data presented shows only the annual figure, however, actual daily data is available with the Chair and depending on the need these data can be provided through a MoU. As the data of figure 2 is based on closely spaced observed data, they can be considered to be more practical.

5. DESIGN FOR WATER HARVESTING FOR IRRIGATION IN TEA AND AGRICULTURE

The proposed water harvesting system named as **S**ustainable **A**pproach of **R**ainwater **M**anagement and **A**pplication (SARMA) has been developed in a way that the rainwater harvested during the period of high rainfall can be used for irrigation in a recirculating manner. The same recirculating system also help in dewater the field to prevent water logging in the rainy season. Figure 3 shows the schematic diagram of the system. The space of the tank/pond is divided into two storage spaces; 1) Utility storage and 2) Flood cushioning storage. The water from flood cushioning storage can also be utilized and it helps in recharging ground water. Potential of pond in carbon sequestration has been established in different literatures. Apart from these, the pond can serve various other purposes including pisciculture. The structure is designed by using the materials which are easily available at low cost so that it can be used by cultivators, small tea growers and small tea gardens. Apart from these obvious benefits, the pond also provides the benefit of microclimate moderation to have a favourable condition for agriculture. The benefits to be derived from the SARMA method are listed below.

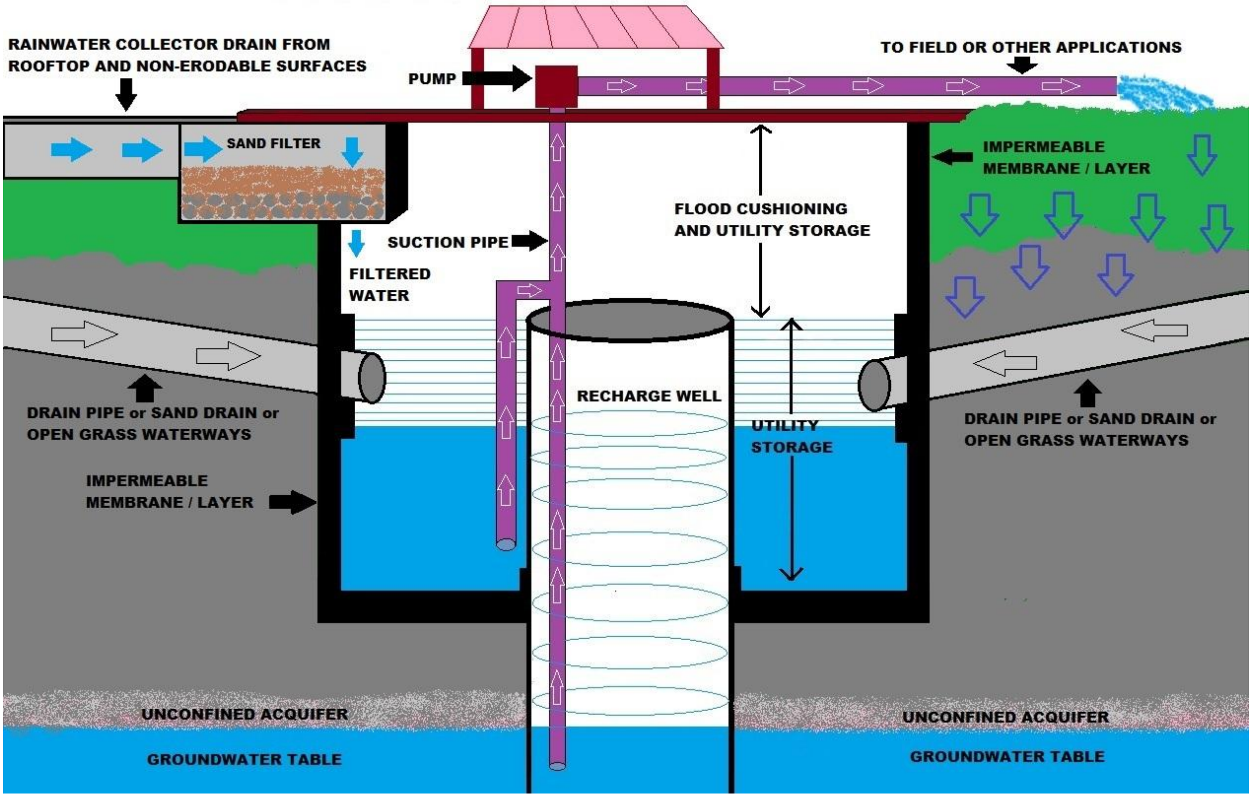

Fig 3: Schematic diagram of the water harvesting structure by SARMA method

6. BENEFITS OF THE PROPOSED METHOD

The proposed method can provides benefits of

- Water utilization for household application.
- Irrigation in water stress situation.
- Flood moderation.
- Groundwater recharge.
- Pisciculture.
- Reducing water logging.
- Carbon sequestration.
- Reduction in power consumption and hence carbon emission.
- Micro-climate moderation for increased productivity and favourable working condition

While most of the above benefits are well understood, the benefits of microclimate moderation need more experimentation to establish it. Therefore, a detail monitoring has been done in one of the tea gardens come forward for the experimentation.

7. SCOPE OF MICROCLIMATE MODERATION

Dalowjan tea estate of Golaghat District of Assam was identified to study the impact of water harvesting as they opted to take up the project with their own fund. Initially they had one pond near the factory and it was observed that temperature near the pond was less than the surrounding area. This was discussed with the management of the garden and advised if it is possible for them to create few more ponds to harvest rainwater to see the impact of micro-climate in the garden. The garden management created another four ponds in their garden and observed that there is decline of temperature in summer season. Thereafter they created another four ponds in the garden i.e. a total of 9 ponds created and it was observed that the garden have favourable micro-climate reducing the temperature 1.5^0 - 2.0^0 C. Now management have decided to create another few ponds in suitable places which will be identified during next winter season. The temperature were recorded till December, 2017 and the temperature near all the ponds were recorded everyday and it will be recorded throughout the next year so that it become possible to make a conclusive remark as regards number and size of pond that will be required for a 100 hectares garden and for small cultivators of two hectares.

The outcomes of the above study till December, 2016 have already been communicated to the various sectors of economy including Tea and Agriculture. A map of Dalowjan Tea Estate, representing all the nine ponds created, is shown below in figure 4, 5 and 6.

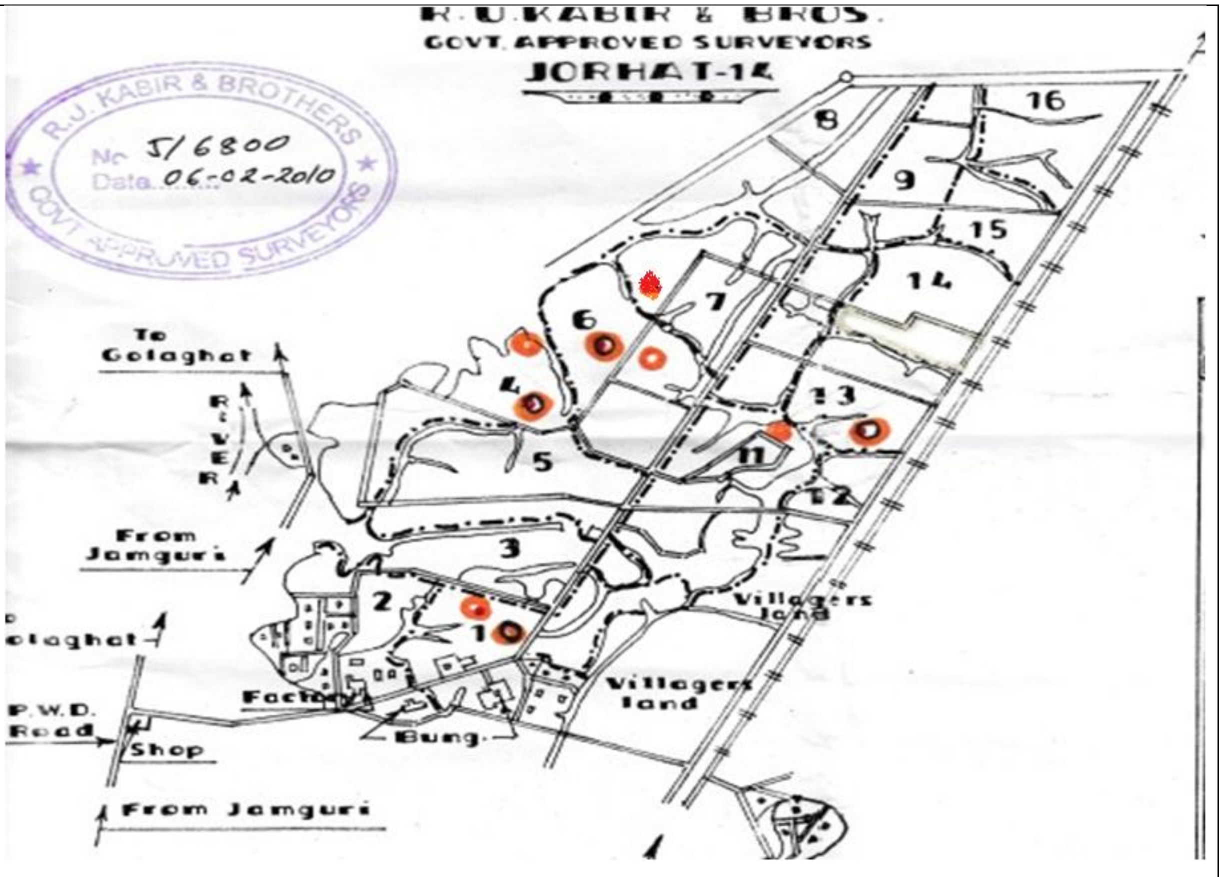

Fig. 4. **WATER HARVESTING STRUCTURE (POND ONLY) OF DALOWJAN TEA ESTATE**

Fig 5: Two views of the pond: size (20.11 m x 13.41 m)

7.1 FAVOURABLE MICRO-CLIMATE DUE TO RAINWATER HARVESTING

Change in temperature due to installation of water harvesting pond is presented month-wise from July 2016 to Dec 2016. The contour plot presented here has clearly demonstrated that there is a visible change in the temperature contour near the ponds.

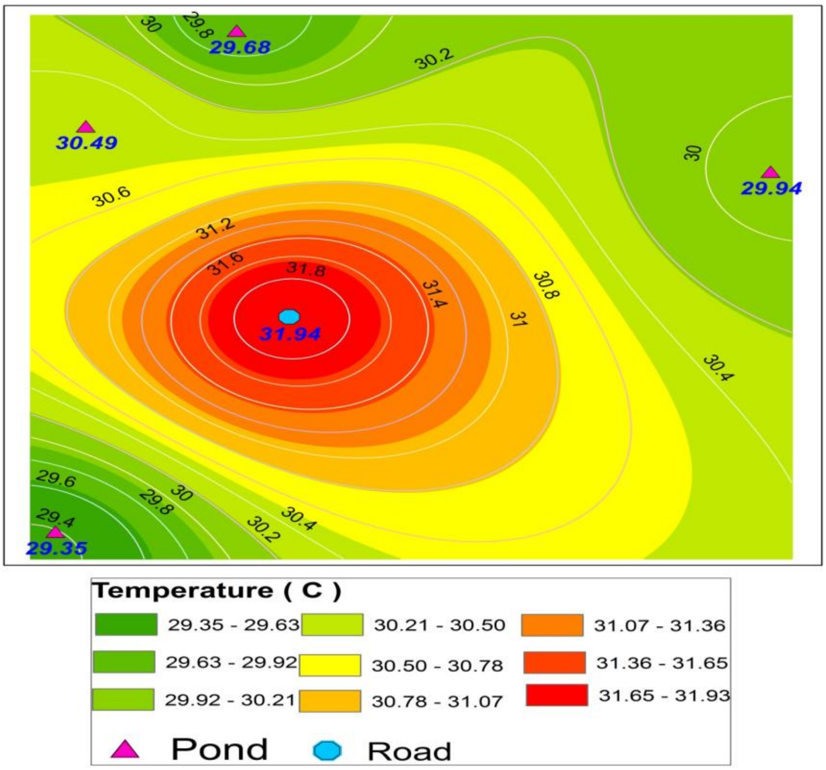

Fig 6: Contour plot temperature variation for the month of JULY 2016

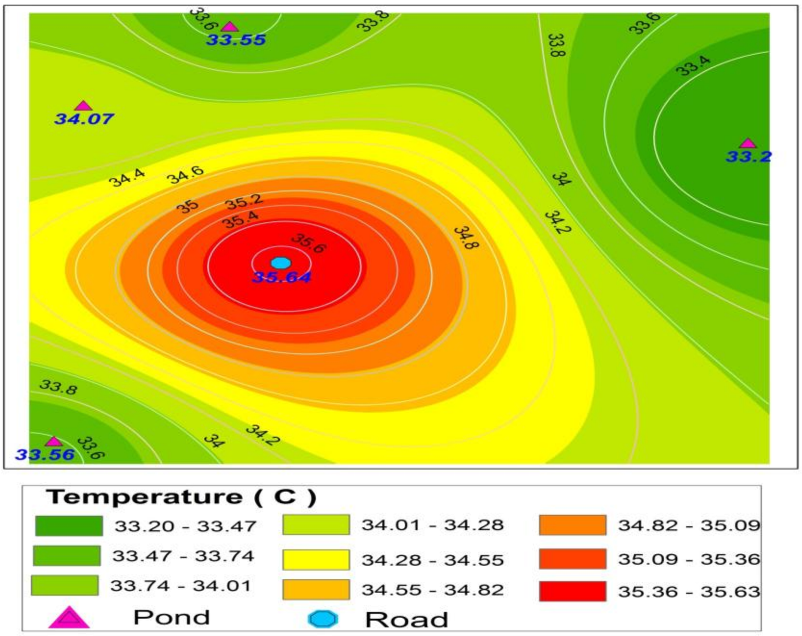

Fig 7: Contour plot temperature variation for the month of AUGUST 2016

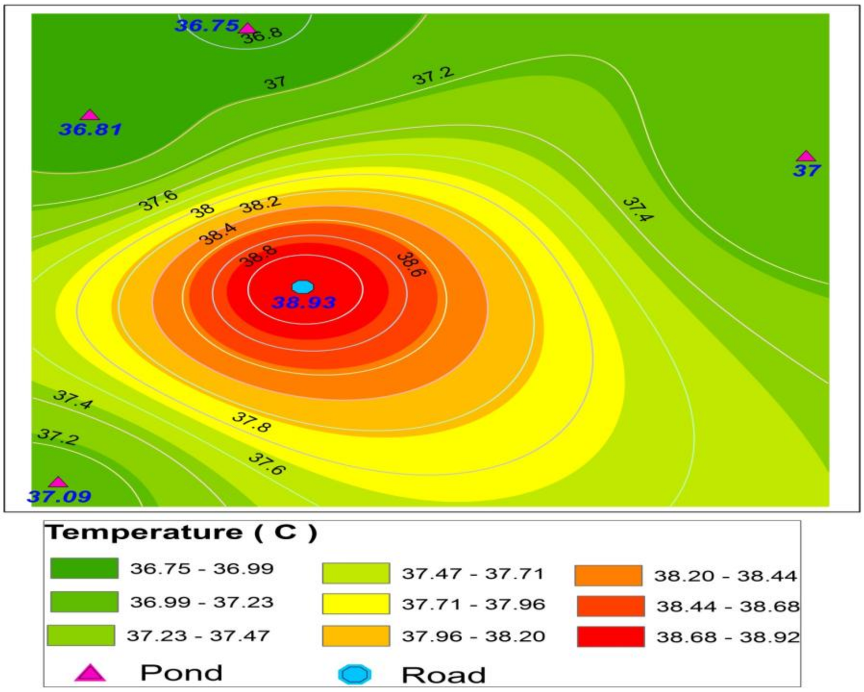

Fig 8: Contour plot temperature variation for the month of SEPTEMBER 2016

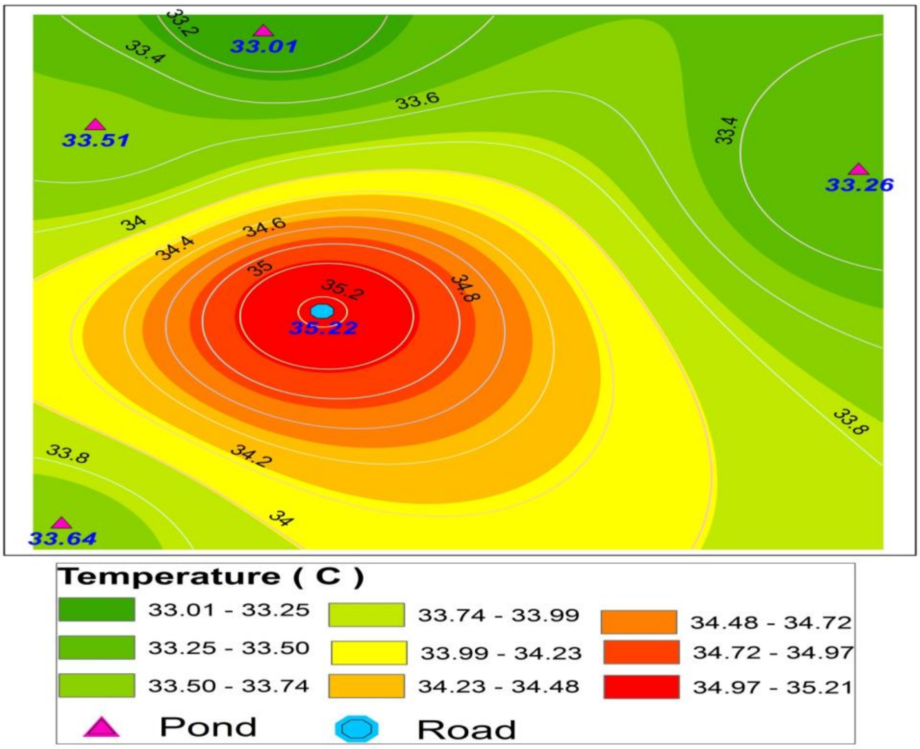

Fig 9: Contour plot temperature variation for the month of OCTOBER 2016

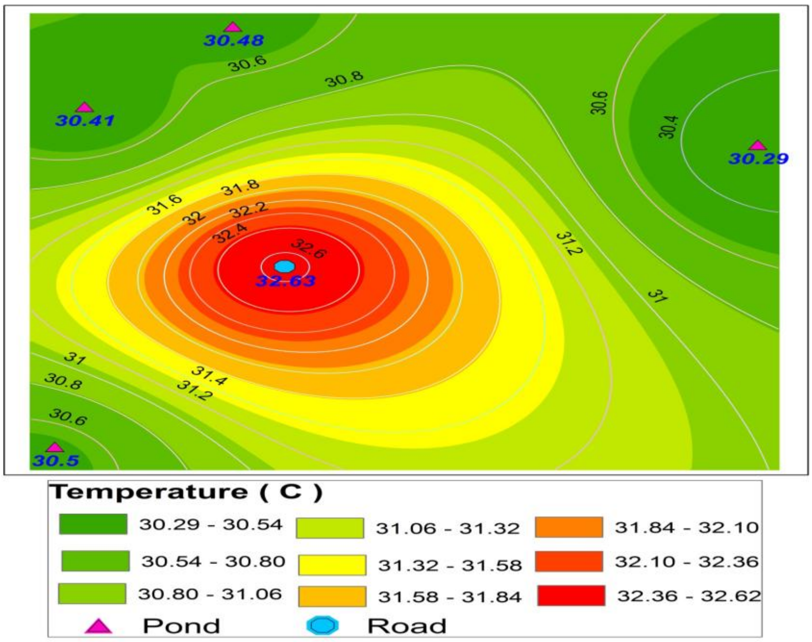

Fig 10: Contour plot temperature variation for the month of NOVEMBER 2016

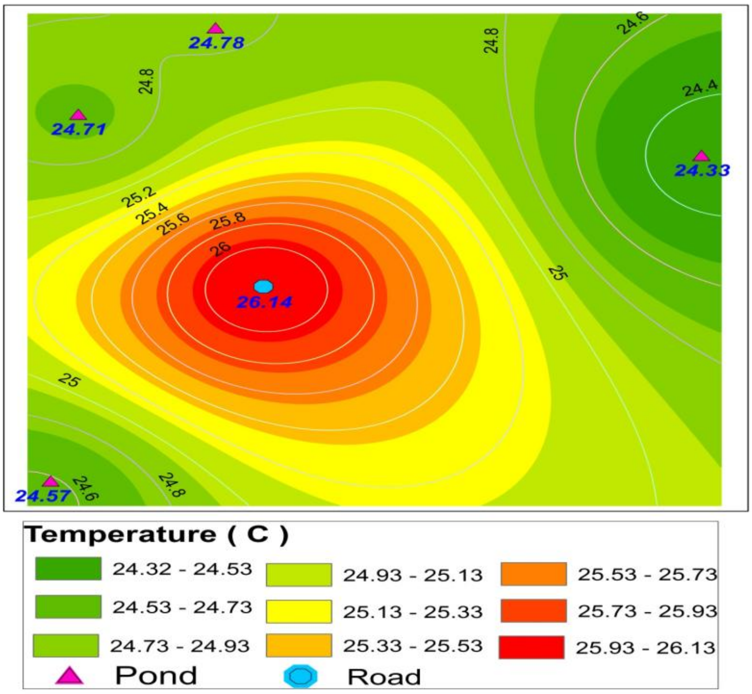

Fig 11: Contour plot showing temperature variation for the month of DECEMBER 2016

From the above observations it is seen that temperature was reduced by 2 degree Celsius during hot summer days. As reported by the garden authority the production was also little higher than last year till august, 2017. The quality of tea was also improved in 2017 compared to 2016 but the actual reason is yet to be ascertained as various other factors of manufacturing also contribute towards making quality tea. The workers were also working under favourable micro-climate condition, as such the productivity of workers also expected to be increased. Scientific analysis is on for ascertaining these additional benefits.

8. INVESTIGATING SCOPE OF RAIN WATER HARVESTING FOR TEA CROP

Tea research association found out the requirement of water for tea plants. Following pie diagram shows the requirement of water per month for tea plants (as per TRA) and rainfall received per month at Golaghat district (data collected by IITG).

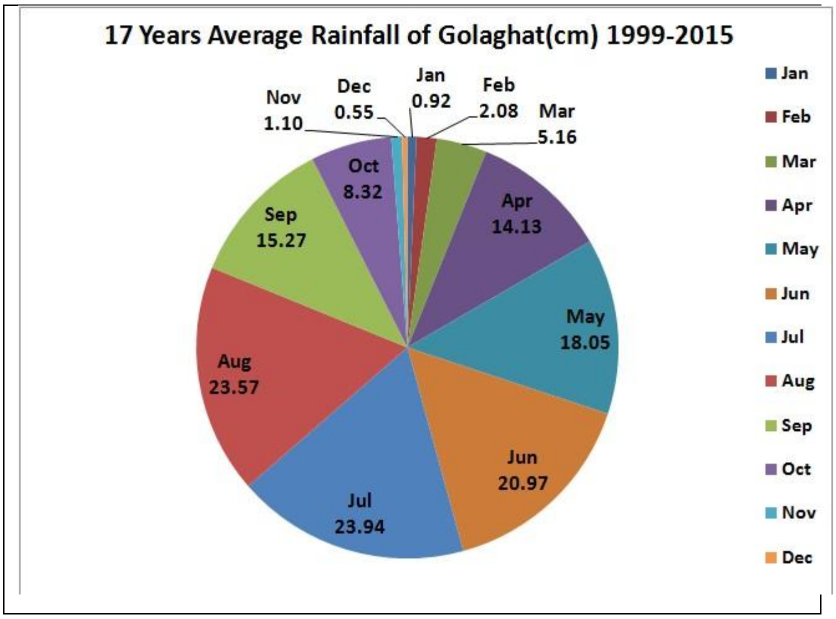

Fig 12: Pie Diagram of 17years average rainfall of Golaghat

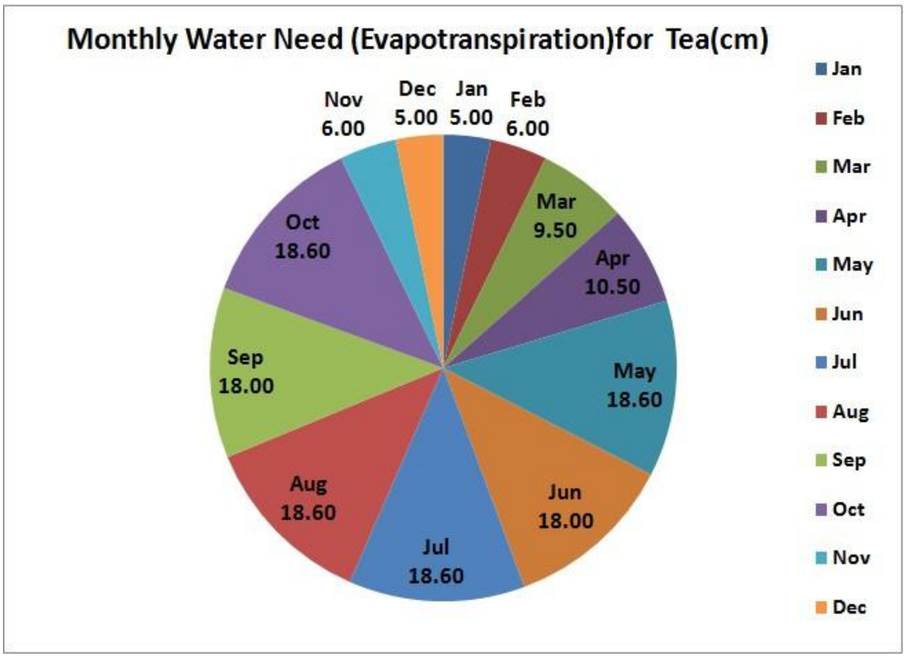

Fig 13: Pie Diagram of Monthly Water Requirement for Tea Plants

From the above pie diagram it is seen that Golaghat district requires water for tea plants in month of November, December, January, February and March and in other months water is available in excess which can be harvested and stored for future use. However, one need to look into the opportunity of creating required storage, so that the water of summer can be stored. In absence of such huge storage it is advisable that the excess water can be harvested for recharging ground water using SARMA method. Also the water available during the water stress period can be applied repeatedly by using SARMA method to have optimal benefit. Rainwater harvesting thus can help mitigating the water crisis scenario provided it is used in a scientific manner.

9. COST OF THE PROJECT (SARMA METHOD)

Estimated cost for creation of pond, boring well, filter, ring well and irrigation pipes are calculated and shown in the table 1. For convenience of local user units are used in FPS system.

TABLE 1: CREATION OF POND					
LENGTH (ft)	BREADTH (ft)	DEPTH (ft)	AREA (cft)	UNIT COST	TOTAL COST (Rs)
60	40	5	12000	3	36000

TABLE 2: BORING WELL		
ITEMS	NUMBERS	AMOUNT
6 inch pipe (pvc)@ 2450 per piece	8	19600
6 inch filter @ 2850 per piece	3	8550
submersible cable@95 per meter	40	3800
steel rope @ 60 per meter	30	1800
pump (1.5Hp or @ 2Hp)	2	50000
6 inch well cover		800
Clamp		1000
column pipe (pvc) @570 per piece	8	4560
labour charge (for 100 ft) L/S		28000
sand for packing L/S		5000
Total (Rs)		**123110**

TABLE 3: FILTER		
ITEMS	NUMBERS	AMOUNT
RCC filter size (1.5x1.5x1)meter with sand and stone filling- L/S	1	50000
connection pipe 6inch (pvc) with pond and boring @2450	4	9800
T' (pvc)	1	900
Total (Rs)		60700
18% GST		10926
Total (Rs)		**71626**

TABLE 4: RING WELL		
ITEMS	NUMBERS	AMOUNT
Rings @900	20	18000
Labour charge	20	28000
sand/ cement L/S		8000
Total (Rs)		54000
18% GST		9720
Total (Rs)		**63720**

10 Hectares Portable Sprinkler Irrigation Set						
Quotation						
Sl. No.	**Description of Material**	**Qty.**	**Unit**	**Total Amount (Rs.)**	**Unit Rate (Rs.)**	**Total with break up (Rs.)**
A	**MAIN LINE WITH PREMIER SL SYSTEM**					
1	75 mm X 6 mtr SL HDPE Pipe (3.2 kg/cm²)	70	Nos.	83160	1188	
	Cost of Pipes for Main Line					**83160**
2	75 mm SL Pump Connecting Nipple	1	Nos.	2044	394	394
3	75 mm X 90° SL Bend	2	Nos.		386	772
4	75 mm SL Tee	2	Nos.		439	878
	Cost of Fittings for Main Line					**2044**
B	**SPRINKLER LINE WITH PREMIER SL SYSTEM**					
1	63 mm X 6 mtr SL HDPE Pipe (3.2 kg/cm²)	12	Nos.	9504	792	
	Cost of Pipes for Sprinkler Line					**9504**
2	63mm X 20mm SL HD Coupler + Batten	6	Nos.	13244	394	2364
3	75 mm x 63 mm SL Reducer Complete	2	Nos.		418	836
4	20 mm Dia. x 1 mtr Riser Pipe with Tripod	6	Sets		1653	9918
5	63 mm SL End Stop	2	Nos.		63	126
	Cost of Fittings for Sprinkler Line					**13244**
1	Sprinkler Model : 110 ST (7/32" x 1/8")	6	Nos.	9012	1502	
	Cost of Fittings for Sprinklers					**9012**
	Total Cost of Portable Pipes, Fittings with Sprinklers					**116964**

TABLE 6: BREAKEVEN POINT	
Additional crop from the project due to use of Irrigation	
Month	**Green leaf/Hectare (Kg)**
February	200
March	600
April	600
November	200
December	50
Total	1650
Extra earning by making Rs 6.00 profit/ kg	9900
Extra earning from 10 hectares (Rs)	99000

The total estimated cost of all the items will be the sum of cost of pond, ring well, boring well, filter and irrigation pipes i.e. Rs (123110+71626+63720+36000+116964) will be Rs.4,11,420.00

TABLE 7: BANK LOAN RETURN STATEMENT							
YEAR	**Liabilities beginning of the year**	**Subsidy 25% (Rs)**	**balance cost (Rs)**	**Interes12% (Rs)**	**Total cost (Rs)**	**Extra earning form additional crop (Rs)**	**Liabilities at end of the year (Rs)**
1st year	411420	102855	308565	37027.8	345592.8	99000	246592.8
2nd year	246593	0	246593	29591.16	276184.2	99000	177184.16
3rd year	177185	0	177185	21262.2	198447.2	99000	99447.2
4th year	99447	0	99447	11933.64	111380.6	99000	12380.64
5th year	12380	0	12380	1485.6	13865.6	99000	(+) 85134.4 (Liabilities are cleared)

Breakeven point will reach on the 5th year. However, if the growers do not get the subsidy an additional 1 year will be required to breakeven the expenditure.

CONCLUSION

From the above study it can be concluded that with the change of climate i.e. due to increase in temperature, high intensity rainfall and long drought period, it is necessary to create favourable micro-climate for the growth of plants and for comfort of human being. Water harvesting system as mentioned above will create favourable conditions for tea and agricultural organizations and will also help solving other water related problems like water logging. In addition this will also help indirectly in reducing carbon generation as power requirement for pumping will be less with this new system. Through accumulation of sediment in the pond, it will also help carbon sequestration.