J. Biol. Chem. Chron. **2018, 4***(1),* 01-07
ISSN (Print): 2454 – 7468
ISSN (Online): 2454 - 7476
www.eresearchco/jbcc/

Polylined Water Harvesting Tank Technique to Mitigate the Impact of Climate Change on Agro-economy in Rain Fed Conditions: A Case Study

Gulshan Kumar[1] and Hem Chander[2*]

[11]CSKHPKV Krishi Vigyan Kendra, Hamirpur (H.P.), INDIA
[2]Department of Bio-Sciences, Career Point University, Hamirpur (H.P.), INDIA
[*] Correspondence: E-mail: hemchander78@gmail.com

(Received 17 Dec, 2017; Accepted 13 Jan, 2018; Published 19 Jan, 2018)

ABSTRACT: Polylined water harvesting tank technique is very useful for meeting the scarcity of water in rain fed areas vis-à-vis to mitigate the impact of climate change. An analysis of capacity and usefulness of polylined water harvesting tank in village Mann of rain fed district Hamirpur (H.P.) was carried out. Very severe water scarcity persists in this village especially during summer period. Farmers have to carry water from far off places for domestic as well as for meeting the minimum critical water needs of agricultural cash crops like tomato, cucurbits, capsicum etc. The top most priority of the present study was to way out the source of water for meeting minimum critical water needs of vegetable crops and maintenance of nutritional gardens. Six polylined tanks were constructed. These tanks were constructed on farmer's field to harvest runoff water for meeting the critical need of irrigation. Trapezoidal shaped silpauline lined tanks having depth of 1.5 m, length of 10 m and width of 6 m, at bottom each and side slope of 1:1 were constructed for lining the tanks, a blue colored UV stabilized, multilayered cross- laminated sheets were used. Class one bricks 4800 nos. of each tank were used for lining the polyline sheets. The storage capacity of this tank was approximately between 60000-70000 liters in each. After construction of rain water harvesting structures, the farmers are using harvested rain water for irrigation by ridges and furrows method. This technique has resulted in an increase in irrigated area. The increase in irrigated area after using this technique has enhanced production of crops/vegetables and also boosted their income. This observation has clearly shown that rain water harvesting offers a viable solution to the irrigation problems of the farmers in rain fed areas.

Keywords: Climatic change; Sustainable development; Rain-fed; Runoff and Biodiversity.

INTRODUCTION: Rain water harvesting refers to collection and storage of rain water, activities of *in situ* soil water conservation, prevention of unproductive losses through evaporation and seepage including hydrologic and engineering interventions, aimed at conserving and efficient utilization of the limited water received from a physiographic unit called water shed. The climate change issue is global, long term and involves complex interaction between demographic, climatic, environmental, economic, health, political, institutional, social, and technological processes. It has significant international and intergenerational implications in context of equity and sustainable development. Climatic change will impact social, economic, and environmental systems and shape prospects for food, water, and health security. Socio-economic and resource development technological characteristics of populations strongly affect emissions, explaining the pace and capacity of societies to adapt to and mitigate climate change. In addition, extreme climate events are registering an increasing trend. For a long time, climate of the Holocene epoch (~ 11 kyr BP to present), compared to last glacial period (widely accepted dates for the Last Glacial are ~ 74 kyr and 14 kyr ago as given by the Intergovernmental Panel on Climate Change), was considered to be stable.[1] Indeed, pace of the Holocene events and of abrupt climate shifts during the last glaciation has been suggested to be statistically the same; together, they make up a series of climate shifts with a cyclicity close to 1470 ± 500 years.[2] Some proxies representing local climate at different places across the world reveal that the 20th century is probably neither the warmest nor a uniquely extreme climatic period of the last millennium.[3] A variable sun through changes in solar irradiance and processes such as biological regime shifts may have caused the observed climate variability and climate fluctuations over much of the Holocene.[4,5,6] Indeed, geophysical, archaeological and historical evidences support a solar output model for climate change during a large part of the Holocene.[7] The major advantages of rainwater harvesting are that

it is simple, cheap, replicable, efficient, sustainable and adaptable.[8] Eris (traditional water tank) have played several important roles in maintaining ecological harmony as flood-control systems, preventing soil erosion and wastage of runoff during periods of heavy rainfall, and recharging the groundwater in the surrounding areas.[9] Climate fluctuations are not necessarily anthropogenic as inferred from biological and geological proxies, terrestrial paleo-temperature may have been higher due to natural variability.[10]

Approximately one-third of the irrigated area is watered by eris (tanks) in Tamil Nadu.[11] The potential of agriculture to contribute to growth and poverty reduction depends on the productivity of smallholder farmers. And raising that productivity will require a much higher level of adoption of new agricultural practices and technologies than presently observed in the smallholder farming population.[12] Certified organic agriculture and polylined tank techniques must meet certain standards in the production, processing and handling which developed in accordance with basic standards established by the International Federation of Organic Agriculture Movements.[13,14] It would be useful investing in decentralized facilities, efficient technologies and policies, and human capital to improve overall productivity rather than to find new sources of water supply.[15,16] Traditionally, such systems have been integrated with agro-forestry and ethno-forestry practices and remain useful in contemporary conservation and ecological restoration of degraded ecosystems.[17,18] The low external input and sustainable agriculture (LEISA) approaches involve limiting the use of external inputs such as inorganic fertilizers and pesticides as well as rain harvested water through polylined tanks relying more on local and naturally available resources and a combination of traditional and improved methods to manage soil fertility, water, pests and other agronomic needs.[19]

Organic agriculture through rain harvested water is based on minimizing the use of external inputs and avoiding the use of synthetic fertilizers and pesticides. Based on certification, price premiums of 10 to 50 percent are common for developing country exports of organic products.[20] Based on this fundamental principal we should strive to collect and conserve the rain water falling on farm land, village, state and the country locally. In this way, we can improve our socioeconomic status and conserve our environment sustainably.[21, 22]

Different water harvesting structures viz. tied ridging or basin listing (formation of small basin) had been used at many places and found to be very effective in conserving rainwater in soil profiles and in increasing crop yields in Himalayan hills.[23] There is significant concern about the impacts of climate change and its variability on agricultural production and productivity Worldwide. Scientific assessment of the causes and consequences of climate change is important, but the real need at the local and national level is adaptation and Natural Resource Management technological development as well as mitigation measures. Ever increasing demographic pressure coupled with developmental activities are causing tremendous pressure in the utilization of these resources, leading to various kinds of problems such as droughts siltation of reservoirs, deterioration of water bodies and mainly loss of biodiversity. Resource conservation therefore, is an issue which concerns not only researchers and scientists but also planners and policy makers. Mittal and Sharma (1998) proposed watershed management plans in Shivalik foothills to avoid drought situations.[24] Tied ridging had been found beneficial for moisture conservation and in increasing yield of cotton.[25] Substance agriculture in hilly region could be successfully transformed into a profit earning enterprise by tapping and utilizing rainwater in limited quantities.[26]

Himachal Pradesh is comparatively a small hilly state in North-West Himalayas. Majority of the people are engaged in farming profession. The population has grown more than 2.5 times in a period of last 50 years. Taking the present growth trend into consideration, the population of the state is expected to further rise to 98.61 lakh in 2031.[27] The traditional irrigation systems in the state have now fallen into disuse with the spread of piped water supply.[28] The water demand has risen many times. Most of the water sources are highly polluted.[29] Hamirpur district is situated in the sub tropical zone of Shivalik hills in North West Himalaya. There is great diversity of climate in the zone due to variation in altitude, topography and geographical location. In general the district is endowed with a wide variety of agro climatic conditions and soil types that enable the cultivation of various field vegetables and fruit crops. Total geographical area of Hamirpur district is 1, 11,800 ha, out of which mere 5% is under irrigation rest is under rain fed areas. Hamirpur district normally receives 1,100 mm/annum rainfall of which about 80% is received during monsoon months i.e. July to mid-September. Majority of farmers in this hill district have marginal and small land holdings averaging 0.40 ha consequently having a poor socio economic status. Irrigation of crops through canals,

tube wells is not feasible due to mountainous terrains and monsoon rainfall goes waste as runoff due to sloppy terrain of district Hamirpur. In this district, conventional irrigation methods like canals tube wells are not feasible due to mountainous terrains. Most of monsoon rainfall goes waste as runoff due to uneven and sloppy terrain of the region. The months of October, November and December are generally dry, due to which Rabi crops fail frequently and yield levels are very low. Under such circumstances, rain water harvesting remains only feasible option for meeting minimal irrigation needs of the crops, especially in upland areas. Because rain is the first and the ultimate source that feeds all rivers, lakes and ground water which are all secondary sources of water and hence remains ignorant of its value ,so it is necessary to understand the value of rainwater at the place where it falls. Rainfed agriculture is one of the serious constraints in district Hamirpur for sustainable agricultural production and climatic resilient agriculture. After launching of an ambitious ICAR funded NICRA project in Hamirpur District, rainwater harvesting polylined tank techniques was implemented in district Hamirpur, for sustaining crop diversity and transfer of traditional cropping system to cash crops.

MATERIAL AND METHODS: Present study was conducted in the 5 villages of Hamirpur district, Himachal Pradesh and was based on the primary and secondary data. Very severe water scarcity persists in these villages and district also during summer period *i.e.* mid-April to mid-June. Farmers have to carry water from far off places for domestic as well as for meeting the minimum critical water needs of agricultural cash crops like tomato, cucurbits, capsicum etc. thus water scarcity emerged as the major problem of the natives of Mann panchayat and Hamirpur district as well. The top most priority of the natives of study area was to have some irrigation water for meeting minimum critical water needs of vegetable crops. To select the sample households, random sampling procedure was followed. To begin with, 5 villages, namely Mann, Tareti, Jangloo, Ghumaharatsa and Kuthera were selected to represent different micro-climatic niches and cropping patterns. The pattern of precipitation of previous three years (2009-2011) was analyzed (Table 1). A sample of households was selected randomly from these villages through proportional allocation method. The data on different aspects of agricultural development, livestock rearing and natural resource management specially water and land, were collected through personal interview and semi-structured questionnaire method during March 2012 to February 2015. The data were analyzed using simple statistical tools like averages and percentages.

Table 1: Prerequisite rainfall data (in mm) of previous three years (2009 – 2011) through which researchers approach rain water harvesting Polylined tank for runoff water.

MONTHS	YEAR			AVERAGE RAINFALL
	2009	2010	2011	
January	17.5	15.25	33	**21.91**
February	12	46.5	132.5	63.67
March	5	22	40.5	22.5
April	53	-	38.75	30.59
May	34	27.75	35.25	32.34
June	28.5	134	133.25	98.59
July	206	202.25	221.75	210.0
August	374.25	441.25	317.5	377.67
September	165.25	214.5	102.5	160.75
October	13	14.5	-	9.17
November	-	12.5	-	4.17
December	-	77.5	-	25.84
Total	**908.5**	**1208**	**1055.4**	**1057.2**

Selection of site: Water harvesting tanks should be constructed on that piece of land where all type of waste water such as rainwater, runoff water channel can be collected easily. The catchment area of such tanks should be sufficient enough to have sufficient amount of runoff including rainfall. The catchment area should not be large enough as compared to the tank capacity, otherwise there is every - likelihood of excessive soil entering the tank, and more over the tank may be completely damaged through huge runoff

volume resulting from large catchment area. The construction site should be well above the land to be irrigated, so that irrigation can be easily provided through gravity system without the use of any power source. The capacity of tank depends upon the volume of water to be stored and the physical conditions of the catchment area. The rain fall amount, intensity and time also govern the run off volume from the catchments.

Laying the silpauline sheet: After digging the tank in trapezoidal shape, smoothen and level the four walls and base of the tank. For making the four walls and the base of the tank weed free, spray either glyphosate @ of 4 liters /ha or atrazine @ of 4kg/ ha. If small pebbles are present on the walls and bottom, try to remove them completely, otherwise there are chances of the sheet getting damaged. If the need be, the walls and the base may be leveled by spreading the fine screened soil. After this spray the weedicide on the four walls and base of the tank. The size of the sheet should be obtained by actually measuring the cross dimension i.e length and width of the already dug out trapezoidal tank including 85 cm of sheets which needs to buried at the top outer ends of the tanks.

Six nos. silpauline polylined tanks were constructed in NICRA villages i.e. Mann, Tareti, Jangloo, Ghumaharata and Kuthera in Nadaun block of district Hamirpur during project period (2012-2015). These tanks were constructed on farmer's field to harvest the run off rain water to meet the critical need of irrigation during on and off season vegetables and major crops. The tanks were owned by individual farmer but managed by group of beneficiary farmers. Trapezoidal shaped silpauline polylined tanks having depth of 1.5 m, length of 10 m and width of 6 m at bottom each and side slope of 1:1 were constructed for lining the tanks, a blue colored UV stabilized, multilayered cross- laminated sheets were used. Since, the class I bricks 4800 no. of each tank were used for lining the silpauline sheets (Figure 1). The silpauline sheets and bricks were provided to farmers from the project funds where as other jobs such as pond digging, smoothening, weedicide spray, sheet laying and bricks lining (completely loose, without any cementing material) have been done by the hard workers farmers by themselves. The storage capacity of each tank is approximately between 70000-75000 liters (Figure 2). The estimated cost of construction of these tanks was approximately 40,000 per tank. Each tank has the capacity to irrigate about 2 hectare agricultural land. Irrigation should be provided through siphon technique. Initially the water from the tank should be such in small length pipe and subsequently relatively longer pipe can be attached to it for irrigation the whole field by gravity method. Hence this irrigation technique will further enhance the life of the tank.

Figure 1: Construction of Silpauline polylined tank.

Figure 2: Harvested rain water in polylined tank.

Table 2: Details of the Polylined Tanks in Rain Fed Condition of study area.

Size of Each Tank			Capacity (Liters)	No. of Bricks Utilized in Each Tank	Cost (Rs)	Ownership
Top (maximum X minimum)	Bottom (maximum X minimum)	Depth				
13m X 9m approx.	10m X 6m approx.	1.5m approx.	70,000 approx.	4,800 approx.	48,000 approx.	Individual but managed by group of beneficiary farmers of adjoining farm lands.

RESULTS AND DISCUSSION: India has already established its leadership in different sector of information and communication technology and engineering but the present challenge is how to sustain the economic prosperity, particularly in remote rural areas. Therefore, rural development in the country requires priority because more than 65% of the population is still living in villages and over 85% of the rural people are dependent on agriculture for their livelihood. In the study area, most of the farmers are small and marginal holders with small production only for 2-3 months self consumption. The over-exploitation of natural resources with the population growth affects the quality of rural life in the rural areas. Hence, it is necessary to develop a suitable strategy to improve the economy of the rural households through agricultural development and sustainable use of natural resources. To achieve the goal of rural prosperity in this region, it is necessary that the development strategy should focus on improved agricultural production which provides gainful self-employment to the farmers. As agriculture and allied activities is the main source of rural employment, but being deprived of irrigation facilities, a majority of the small and marginal farmers are heavily under-employed in a year in this region while now MGNREG scheme of government provide an alternative for short time. Even under well established irrigated conditions of the area, the growth of the agriculture sector itself has been almost stagnant from the last 15-20 years. Therefore, the policy makers and agriculture experts have been urging to accelerate growth in the agriculture sector. Water is an important input required to enhance agricultural production. The soil profile stays moist for a longer time, which stimulates soil life so that the formation of stable humus, the nutrient availability and the water holding capacity are improved.[23,30] The hilly region is deprived of irrigation facilities but the sustainable use of all the available water resources should be ensured to improve the crop yields. In the absence of adequate water conservation measures, water scarcity is likely to be a serious bottleneck in the future. With increasing exploitation of natural resources and environmental pollution, the atmospheric temperature is expected to rise. If it happens, most of the rivers originating from the Himalayas may dry up and cause severe shortage of water for irrigation, suppressing agricultural production by 40-50%.[30] Now farmers have, besides advantages of greater water availability, big problems in keeping the land fertile.[21] Rainfall is expected to be erratic and the water requirement for crops is likely to increase due to a significant increase in evapotranspiration losses. Therefore, greater awareness needs to be created to make efficient use of water resources and to prevent global warming through environmental protection. In the study area polylined type of water harvesting structure were observed, but these structures were present in very small number only 6 tanks were observed in all the 5 villages. And all the structure supported by government under NICRA schemes. Low adoption may be due to lack of awareness among the people about water harvesting and sustainable use of water resources and high construction cost as farmers are poor. There is a scope for introducing new technologies in the following areas for efficient management of water resources in the region:

- Efficient rain water harvesting and storage of rain water through polylined tanks.
- Reducing loss of water by evaporation in reservoirs and tanks.
- Development of alternate and renewable sources of energy for rural uses.
- Technologies for low water consumption by crops and trees.

- Rain water harvesting and conservation through poly lined rain water harvesting tank provides a better option for enhancing irrigated area.
- This rain harvested water can be sustainably utilized for irrigation by using drip and sprinkler irrigation as well as poly mulching.

CONCLUSION: This observation has clearly shown that rain water harvesting offers a viable solution to the irrigation problems of the farmers of rain fed district Hamirpur. This can lead to sustainable management of biodiversity i.e. the fauna and flora of Hamirpur district and also lead to substantial improvement in the socio economic condition of the small and marginal farmers. This technique widens the area under irrigated agriculture and diverts the motives of farmers towards crop diversification for enhancement of agricultural income.

ACKNOWLEDGEMENTS: Authors are thankful to ICAR-NICRA (National Innovations in Climate Resilience Agriculture) for providing necessary grants for this investigation. We are also thankful to CSKHP Krishi Vishavavidayala, Palampur for providing logistic facilities.

REFERENCES:

1. Houghton J. T., Ding Y., Griggs D. J., Noguer M., van der Linden P. J., Dai X., Maskell K. and Johnson C. A. (2001) Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, p. 881.

2. Bond G., Showers W., Cheseby M., Lotti R., Almasi P., Demenocal P., Priore P., Cullen H., Hajdas I. and Bonani G. (1997) A Pervasive Millennial-Scale Cycle in North Atlantic Holocene and Glacial Climates, *Science*, 278(5341), 1257-1266.

3. Soon W. and Baliunas S. (2003) Proxy Climatic and Environmental Changes of the Past 1000 Years, *Climate Res.*, 23, 89-110.

4. Chavez, F. P., Ryan, J., Lluch-Cota, S. E. and Niquen, M. (2003) From Anchovies to Sardines and Back: Multidecadal Change in the Pacific Ocean, *Science*, 299, 217-221.

5. Speranza A., Van Geel B. and van der Plicht J. (2002) Evidence for Solar Forcing of Climate Change at ca. 850 cal BC from a Czech Peat Sequence, *Global Planetary Change*, 35, 51-65.

6. Rind D. (2002) The Sun's Role in Climate Variations, *Science*, 296, 673-677.

7. Perry, C. A. and Hsu, K. J. (2000) Geophysical, Archaeological and Historical Evidence Support a Solar-Output Model for Climate Change. *Proc. Natl. Acad. Sci. USA*, 97, 12433-12438.

8. Reiz C., Maulder P. and Begemann L. (1988) Water Harvesting for Plant Production. World Bank Technical Paper 91, Washington, DC, USA.

9. Bhalge P. and Bhavsar C. (2007) Water Management in Arid and Semi-arid Zone: Traditional Wisdom. Proceedings of International History Seminar on Irrigation and Drainage, Tehran-Iran, pp. 423-428.

10. Kowalski, E. A. and Dilcher, D. L. (2003) Warmer Paleotemperatures for Terrestrial Ecosystems, *Proc. Natl. Acad. Sci. USA*, 100, 167-170.

11. Agarwal A. and Narain S. (1997) Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems. Centre for Science & Environment (CSE), New Delhi, pp. 11-12.

12. De Janvry A. and Sadoulet E. (2002) World Poverty and the Role of Agricultural Technology: Direct and Indirect Effects, *Journal of Development Studies*, 38(4), 1-26.

13. Pender J. (2008) Agricultural Technology Choices for Poor Farmers in Less-favoured Areas of South and East Asia. The fifth discussion papers produced by the Asia and the Pacific Division, IFAD.

14. N.G. Hegde N.G. (2010) New Technologies to Enhance Agricultural Production and Sustainable Rural Livelihood. BAIF Development Research Foundation, Pune, p. 1-7.

15. Johnson N., Revenga C. and Echeverria J. (2001) Managing Water for People and Nature. *Science*, 292, 1071-1072.

16. Gleick P. H. (2002) Water Management: Soft water paths. *Nature*, 418, 373.

17. Pandey D. N. (2002) Sustainability Science for Mine-spoil Restoration. *Curr. Sci.*, 83, 792-793.

18. Pandey, D. N. (2003) Cultural Resources for Conservation Science. *Conserv. Biol.*, 17, 633-635.

19. Kilcher L., Huber B. and Schmid O. (2004) Standards and Regulations. In: Willer H. and Yussefi M. (eds.) The World of Organic Agriculture: Statistics and Emerging Trends 6th revised edition. International Federation of Organic Agriculture Movements, Bonn.

20. Scialabba N. and Hattam C. (2002) General Concepts and Issues in Organic Agriculture. In: Scialabba N. and Hattam C. (eds.), Organic Agriculture, Environment and Food Security. Envi-

ronment and Natural Resources Series 4, Food and Agriculture Organization of the United Nations, Rome.

21. Liaw, Chao-Hsien & Yao-Lung Tsai (2004) Optimum Storage Volume of Rooftop Rain Water Harvesting Systems for Domestic use, *Journal of the American Water Resources Association (JAWRA)*, 40(4), 901-912.

22. Jasrotia A.S, Majhi A. and Singh S. (2009) : 'Water Balance Approach for Rainwater Harvesting using Remote Sensing and GIS Techniques, Jammu Himalaya, India, *Water Resource Management*, 23(14), 3035-3055.

23. Tage Mamu, P. (2010). A Socio-Economic Institution of Apatanis in Historical Perspective. PhD Thesis, Rajiv Gandhi University, Arunachal Pradesh, India.

24. Mittal S.P. and Sharma J.S. (1998) Watershed Management: Experiences of Shivalik Foot Hill Region of Northern India, Proceedings of International Conference on "Watershed Management and Conservation", 8-10 Dec, New Delhi, pp 287-295.

25. Rao S. B. P. and Ramachandran K. (1974) Tied Ridging System Boosts Yields of Rainfed Cotton. *Indian Farming*, 24(5), 5-16.

26. Saha R., Ghosh P .K., Mishra V. K. and Bujarbaruah K. M. (2007) Low Cost Micro-Rainwater Harvesting Technology (Jalkund) for new Livelihood of Rural Hill Farmers, *Current Science*, 97, 1258-1265.

27. Sharma M. R. (2007) Depletion of Drinking Water Sources of Himachal Pradesh. Institute of Integrated Himalayan Studies, Centre of Excellence, H.P. University, Shimla.

28. Sharma M. R. (2006). Status Report on Traditional Drinking Water Sources in HP. Institute of Integrated Himalayan Studies, Centre of Excellence, H.P. University, Shimla.

29. Sharma M. R. (2004) Disease Outbreaks Caused by Drinking Water in Himachal Pradesh. *Nature, Environment & Pollution Technology*, 3(3), 293-297.

30. Saikia S.K. (2005) Diversity of Periphyton with Emphasis on Feeding Ecology of Fish in Rice-Fish Culture System of Apatani Platue Arunachal Pradesh. PhD Thesis, Rajiv Gandhi University, Arunachal Pradesh, India.