EFFICIENT WATER MANAGEMENT UNDER HILLY TRACT OF DARJEELING HIMALAYA OF WEST BENGAL

Dhiman Mukherjee

Regional Research Station (Hill Zone), Uttar Banga Krishi Viswavidyalaya,
Kalimpong (Darjelling), West Bengal -73430, India
E.mail : dhiman_mukherjee@yahoo.co.in

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ABSTRACT

Water is a precious commodity of the earth. Its role in the production of crops is next to none. Nearly 70% of India~ agriculture is rain fed. Thus collection or harvesting of rain water through different techniques and its conservation for the efficient use in crop production is the urgent need of today particularly in hill. Darjeeling Himalaya aagriculture is the focal activity of hill dweller but scarcity of water is a big issue and challenge. Darjeeling hill, though endowed with high rainfall, suffers from water shortage during the dry months particularly in hilly areas and urban areas. Approximately half of the rainwater infiltrates into the soil. Because of high intensity of monsoon rains coupled with poor infiltration rates of soils, there is a heavy run-off of water. The various indigenous techniques of soil and water conservation developed in the region (in some pockets) by the local people are based on local conditions and resources. They are exiting in the region from the time immoral and they are socially accepted and suited to local condition too. Still there is a scope for improving efficiency/productivity of these system using modern scientific methods. An efficient system of collecting, storing and reusing run-off water is one of the most important issue for water conservation in high altitude range. Darjeeling-sikkim himalaya has a traditional artificial recharge practiced here are the Zabo and Bamboo-drip Irrigation. In high sloping area , contour trenching on hilly slopes, bench terracing, stone terracing at steep slopes, diversion channels across slopes and afforestation are best way for conservation of water. However under moderately sloping area, contour or graded bunding, gully protection, nala bunding and check dams, etc. were found to best option.

Darjeeling himalaya suffers from a vicious cycle of development process. Along with a burgeoning population, there has been a constant increase on the area under subsistence crops followed by an increased dependency on livestock farming. Such sequences intensify the demand on the fragile mountain land. Excessive encroachment of forest lands to meet the mushrooming demands for fodder, fuel wood, and other requirements has led to unprecedented damage to forest lands, livestock grazing more than often in this fragile environment has led to overgrazing impacting the environment (Satapathy, 2001). This will ultimately affect the various water resources and their effective utilization. Darjeeling is a small mountainous hill characterized by rugged topography with series of ridges and valleys. Agriculture is the focal activity of hill dweller all through the region. The topography of the region is highly rugged. In the region, the altitude varies from 500 to > 3000 m above mean sea level. The climate of the region ranges from subtropical plains to temperate hills with average annual rainfall varying from 1000 to 4000 mm and temperature ranges from below 0^{o}C to above 28^{o}C (Mukheree and Moktan, 2008). The various rock types prevalent in the state are Pelitic and carbonate rocks. Springs are the main source of water. Water and soil conservation is a challenge for existence of Darjeeling hill in present situation. Land and water are natural resources that are essential for the existence of life and are the two variable factors for which management has become most essential. Land provides food, fuel, fodder and shelter besides supporting secondary and other economic life supporting system. However there has been a continuous depletion of land resources and the quality of land is deteriorating due to various factors like soil erosion caused mainly due to shifting cultivation, high rainfall, large scale deforestation, reckless mining activities, overgrazing, general mismanagement, etc. Such soil erosion leads to degradation of soils' physical

property and loss of plant nutrients It takes nature 600-1000 years to build 2.5 cm of top soil but get displaced in a year only due to misuse. It has been reported that 6000 million tones of productive soil are lost every year from about 80 million hectare of cultivated land alone in India. It has also been proved that soil lost from unprotected land is about 120 tonnes /ha/yr and may go as high as 300 tonnes /ha/yr. Thus, a part from depletion of fertile soil erosion results in the loss of runoff water, plant nutrients and micro flora, siltation of reservoirs and riverbeds thereby adversely affecting irrigation and power potential, causing floods in plain and valley which damage crops, animals, habitation, communication, etc. But most of them adversely affect agricultural production, forest productivity and availability of water both for irrigation and drinking besides bringing about a disturbance in the soil and water balance

The term water management is often found interpreted differently by different people. It is required to understand some basic concepts, in order to understand water management. The term management is defined as *"a skilled handling of something; the executive function of planning, organizing, coordinating, directing, controlling any project or activity with responsibility for result; and judicious use of means to accomplish an end".* Water management for agriculture could, therefore, be interpreted to imply skilled and responsible handling of water and judicious use of it for *sustainable agricultural* production purpose (Mukherjee, 2012). Thus, water management is a means and not the end in itself. The fundamental objective of managing agricultural water is to produce more profitably. This implies that water has an economic value, a condition that is a prerequisite to applying management concepts. However under hilly region water is one of the important water resource and its proper management play important role in human life. This paper attempts to briefly look into the above stated issues and concerns. The paper should not be seen as a problem solving technique; rather it is an attempt to highlight the major technique which play important role for enhancing water productivity per unit area through efficient management practices.

Material and Methods

Darjeeling district is the northernmost district of west Bengal. It is located on the lap of the Himalayas. The Darjeeling Himalaya mainly comprised of Darjeeling Sadar, Kalimpong and Kurseong. Darjeeling Himalaya forms a part of eastern Himalayan ranges and is bounded by Sikkim, Nepal and Bhutan on the north, west and east respectively. The area covered by Darjeeling Himalaya is about 1721 Sq. Kms. while the total area of the district is 3202 Sq. Kms. Darjeeling Himalaya consists of a portion of the outlying hills of lower Himalayas and a stretch of territory lying along the base of the hills known as the Terai. The Terai is only 91 meters high above the sea level but there are parts of the districts, which are as high as 3660 m. at Sandakpu. River Teesta is the master stream in the area while the Rammam and Rangit are the two important tributaries of the Teesta. Al these water sources are out of reach of common people for their agricutue practices. They mostly depend on rain water source, which mainly confined to only four month (i.e. second fortnight of June to first fortnight of September). Water is big issue for agriculture as well as for human being. Keeping the above aspect in mind a research work was conducted during the year of 2009-11 at Regional Research Station (Hill Zone) under the aegis of Uttar Banga Krishi Viswavidyalay, Kalimpong to know the various effective metholodology for optimum utilization of available water resources along with indigenous management practice. In this paper proper documentation of optimum use of water for agriculture purpose is being made based on our day to day survey along with various feedback from farmers at different altitude level (Lava, Rishav, Sandhapukh and Phalut).

RESULTS AND DISCUSSION

Our observation revealed that agriculture is the main occupation of the traditional rural communities in contemporary time and the paddy and maize are their main crops. In the hills three types of soils are generally recognized-black, white and red. Black soil is most fertile of the three, red is of intermediary type and white the poorest among them. Red soil requires a good amount of manuring to produce a yield equal to that of black soil and it is suitable for dry crops, such as, maize and millet, on account of the rich vegetable mould. These crop were very efficient and optimum utilise the water resources and reduced runoff loss as well.

Hard worker farmer of Darjeeling hill cultivate *chaul* (paddy), *mookai* (maize), *kodo* (millet), *Adrak* (ginger)*, phapar* (buckwheat), *eilachi* (cardamom) as their main crops. Besides these local hill people produce a large variety of *Sabji* (vegetables) like *Raisak*, *Torisak* (mustard leaves), *Squash*, *Golbhera* (tomato), *Farsi*(pumpkin), *Kuvindo* (cucumber), *Aalu* (Potato), *Kobi* (cauliflower), *Bandakobi* (Cabbage), *Gaajor* (carrot), *Mula* (radish), *Beet* (beet), *Booigun* (brinjal), *Koirala* (bitter gourd), *Boori* (bean), *Painjj*

(onion), *Loosun* (garlic), *Khursani* (chilli) etc. They utilized the land in such a way that minimise the water loss and increase crop productivity per unit are (Mukherjee, 2010a). The major source of water supply is springs or small rivulets locally known as *Jhoras* with only limited discharge available during post monsoon period. The irrigation facilities exist only in 8 - 10% of the cultivated land predominantly from perennial *jhoras* and river lift irrigation in the foothills. Altogether, the cropping intensity in Darjeeling district is as low as 10%. To improve the present level of cropping intensity and productivity in the hills; there have introduced various soil moisture conservation treatments for hill watersheds, such as, bench terraces in lower hill areas and contour hill trenches on steep slopes. Bench terraces and contour trenches are well sufficient for stability of sloppy lands and stream training works during cultivation process. Besides these, small water harvesting tanks with hand pack retaining walls are increasingly becoming popular in this region. This system is very useful water harvesting structure on the inherent topographic features and steep slopes of the mountains. These tanks are generally filled with water from the nearby springs using siphon pipes. For providing stability to the small water harvesting tanks, hand-packed rough walls are usually made with locally available stones/boulders from the foundation level and also soling of pond base. The stored water is utilized for giving life saving irrigation to maize, cardamom and vegetables, which are grown extensively in the region. On the basis of water availability irrigation system can be classify on the basis of my observation from farmer field.

- Irrigated in whole year: situated comparatively lower part of the villages in valley areas or near the river/stream. That type of land is suitable for cultivating paddy seedlings;
- Irrigated in near about 6 months: contains a small patch in opposite side of the hill in the hilly slope. Generally paddy, squash, green chilly, tomato, *raisak¸* zinger etc. are produce in this type of land;
- **I**rrigated only rainy season: grows the crops not need much more water, like maize, millet and also some tomato, zinger, green chilly, cauliflower, cabbage etc. along with a little bit of paddy;
- Fully non-irrigated: land located at the top portion of the hill, cultivated the crops which need a very less amount of water, like millet, maize etc.

Efficient water management system in Darjeeling hill : These include mainly the indigenous methodology practice since long back. Mainly these are as

1. **Multi purpose water management system :** Here integrates land, water and farming systems by protecting soil erosion, conserving water for irrigation and paddy-cum-fish culture. This is practice under mid to high altitude range (1400 – 1600 m asl) where combination of flat and raised bed are available. In this system, every stream rising from the hill is trapped soon after it emerges from forest, channelised at the rim of valley and diverted by network of primary, secondary and tertiary channels. This system is quite similar to apatani system of water management of arunanchal Pradesh.
2. **Bamboo drip irrigation system:** This is a very common practice in throughout Darjeeling hill. Water application on hill slopes for irrigation of plantation crops poses serious problems of soil erosion. The tribal farmers have developed the indigenous technique of Bamboo drip irrigation (Mukherjee, 2010). In doars area where, betel vines planted with arcanut as the supporting tree are irrigated with this system, in which water trickles or drips drop by drop at the base of crop. In this system water from the natural streams located at higher elevation is conveyed with the use of bamboo channels, supported on ground surface by wooden or bamboo supports, to the site of plantation through gravity flow. Discharge of water upto 25 liters/min can be easily managed by manipulating the distribution systems. Water distribution is done with the use of bamboo channels, bamboo supports; water diversion pipes and strips. The whole system enables in distribution of 15 to 25 liters of water without any leakage at point. There may be several diversion at each stage depending on the availability of water resources and number of the plants to be irrigated. The system is laid out in such a way that ground clearance of channels reduces from few meters to 10 cm to 15 cm and this is done by reducing the height of channel supports (Borthakur, 1992).
3. **Roof top water harvesting:** In Darjeeling-Sikkim Himalaya range most of the hills are steep having slope more than 50 per cent and are separated by deep river gorges. Despite of heavy monsoon rain, the people face acute water problems every year in the dry season. The geological formation does not permit water retention; runoff is quick and springs and small streams dry up when there is no rain. Roof top harvesting structures for drinking purpose have been developed locally and now spread in the entire Darjeeling hill. The impact of recharge through these structures to ground water regime is local, but if implemented on a massive scale, it can raise the water level remarkably and increase the sustainability of

water supply through shallow depth ground water structures. It has proved to be quite successful. Most houses are built with sloping roofs with galvanized iron sheets to be quite successful. Most houses are built with sloping roofs with galvanized iron sheets which are conducive to rain water harvesting. A common method of storing rain water is to place horizontal rain gutters along the sides of sloping roof, which is normally made of corrugated iron sheets. Rain water pours into a pipe connected to the tank which is mostly made from GCI sheets or galvanized plain sheets. But many people have started using reinforced cement concrete tanks, located in the court yard or under the house.

4. **Indigenous techniques of soil and water conservation :** Bench terraced land cultivation system is widely practiced in some parts. Farmers are doing cultivation in bench terraces from the time immemorial upto 100% slope and more and even rocky lands having hardly 10 cm to 15 cm depth of soil. In this system the hill streams are tapped or near the source of emergence the water is channelised to irrigate a series of terrace in such a way that water continuously flows from the upper terraces to the lower ones without soil erosion and maintaining a desired level of water (5 cm to 8 cm) in the terrace. Terrace risers are usually maintained with stones. In the terraced field, agricultural operation starts in the month of December and January with the digging of fields with the help of spades. Puddling operation start in the month of April. After that farmers start allowing water to enter in the terrace. They are full of water by the first week of June. In the same month seedlings of paddy are transplanted.
5. **Agriculture with *alnus nepalensis* (Alder) tree :** In some pockets of Lava (Kalimpong Block II) the farmers use *Alunus nepalensis* (Alder) tree for agriculture (Mukherjee, 2008). In this cultivation system the *Alunus nepalensis* (Alder) seedlings are planted on the sloppy land intended for cultivation and the alder grows fast till attain six to ten years old. At this stage initially the trees are pollarded, the leaves and twigs are burnt and ash is mixed with soil to prepare it for raising crops. Subsequently also pollarding is done once every four to six years. Under this process coppice are cut except five to six on top of the main trunk and crop schedule is followed including fellow period of two to four years. The bigger branches stripped of leaves are used for fire wood, while the root of the tree develop nodules (colonies of Frankia) responsible for fertilizing the soil where as spreading nature of the roots helps in preventing water and soil erosion in slopes.
6. **The zabo system of farming :** “Zabo” is an indigenous farming system of Nagaland. The word “Zabo” means impounding of water. Presently this kind of practice also being follows in Darjeeling hill. It has a combination of forest, agriculture and animal husbandry with well-founded soil and water conservation base. Water resource development, water management and protection of environment are inherent aspects of the system. The beauty of this system is that each and every farmer takes care of his own land with his or her ingenuity skill and natural resources.
7. **Paddy- cum-fish culture :** This kind of practice is most common in Mirik region of Darjeeling district. This is an efficient system of conservation of water by digging soil at different depth for fish production. Majority of the farmers practice paddy-cum-fish culture. A small pit is dug in the middle of rice field. The fish fingerlings are put in the fields. When the water is drained out from the fields before harvesting of paddy crop, the fish remain in the water of pit in the fields. Through this technique farmers generally harvest about 50 kg to 60 kg of fish per hectare as an additional output.

Preparing fields for high water use efficiency

In Darjeeling hill few of the farmer low altitude zone practice present modern technique of water management and our observation revealed that this kind of practice, surpass the old age indigenous method of water conservation aspect. The modern techniques are mainly:

1. **Surge Flow**

Surge flow irrigation is a type of furrow irrigation that applies surges of water intermittently rather than in a continuous stream. These surges alternate between two sets of furrows for a fixed amount of time. The alternate wetting and “resting” time for each surge slows down the intake rate of the wet furrow and produces a smoother and hydraulically improved surface. By doing so, the next surge travels more rapidly down the wet furrow until it reaches a dry furrow. Surge irrigation provides more uniform water distribution, limits deep percolation, and can reduce tailwater runoff. Water infiltration varies substantially based on the type of soil, soil compaction, and soil preparation. Surge flow does not work well on compacted soils, so it is more effective during pre-plant irrigation and the first seasonal irrigation following cultivation. Surge flow can cut water losses by up to 30% in clay soils and can save more than 35% of energy costs compared to simple furrow irrigation.

2. **Drip Irrigation**

Drip irrigation applies small amounts of water frequently to the soil area surrounding plant roots through flexible tubing with attached emitters. Subsurface drip irrigation (SDI) delivers water underground directly to roots. Since water is applied directly to individual plant roots, SDI minimizes or eliminates evaporation, provides a uniform application of water to all crop plants, and applies chemicals more efficiently. Drip irrigation also reduces plant stress and increases crop yield. A carefully managed amount of water is applied, thereby avoiding deep percolation and runoff, while reducing salt accumulation. Since a constant level of moisture is maintained around the root zone, with less surface moisture present in between rows, weed growth is reduced. Water contact with crop leaves and fruit is also minimized, making conditions less favorablen for disease. Drip systems are the only type of irrigation that can use water efficiently on steep slopes, odd-shaped areas, and problem soils.

Conclusion

Although Darjeeling region of India is characterized by heavy rainfall, yet the concentration of precipitation is primarily limited to few months from June to September. Due to hilly topography most of the rain water is wasted as runoff and lot of soil erosion also occurs. Shifting cultivation is practiced in most of the region. The irrigation system in the entire region has not been developed in most of the area. The various indigenous techniques of soil and water conservation developed in the region (in some pockets) by the local people are based on local conditions and resources. They are exiting in the region from the time immoral and they are socially accepted and suited to local condition too. They have got sustainable base. Still there is a scope for improving efficiency/productivity of these system using modern scientific methods. Before developing or recommending any new farming practice/technique in the region, researchers and planner should consider these indigenous techniques of soil and water conservation into account for better implementation at field condition in the region.

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