

Ground Water Harvesting through Traditional Water Harvesting Technology: Adopting Himalayan Practices in Ethiopian Highlands

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Received June 8, 2013; revised July 12, 2013; accepted August 3, 2013

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ABSTRACT

The fresh water system is most critical for sustainability of life. In present days the world is facing a shortage of potable water. Though Ethiopia is known as “The water tower of East Africa” yet it is facing severe water shortage that leads to poor agricultural productivity and imparts serious negative impact on human lives. It is essential to develop water resources in a sustainable way to ensure food security and economic development. The water scarcity is due to the lack of resource management and due to the changes in environmental factors. In Ethiopia ground water is a major source of drinking water to vast rural population. The country’s perennial water budget depends on the ground and spring water system. The ever increasing population, mismanagement and global climatic changes are having an adverse impact on these resources. To harvest the available resources in a sustainable way will help to meet the needs of present era without compromising the future generation. The present study is an approach to compare and utilize the traditional water harvesting practices of Himalaya in Ethiopian highlands. A detailed study of the water sources and mechanism of ground water, geology and social management system of their water resources were studied booth side. Further application of the indigenous technical knowledge for sustainable of the ground water is proposed based on Himalayan practices. The Ethiopian “Minches” could be preserved and better utilized by adopting the merits of time tested indigenous management system of “Naule” of Himalaya.

Keywords: Ethiopian Highlands; Ground Water Harvesting; Himalaya; Minch; Naule; Water Management

1. Introduction

The water security can be termed as the nexus between availability, accessibility and utility of water. It denotes to the sufficient quantity and quality of water accessible for various purposes. The increased population led to competition and utility of water for consumption, irrigation, industrial use and power generation which in turn made fresh water a scarce source on the surface of earth. This further led to the conflicts over water use. The Inter-governmental Panel on Climate change (IPCC) predicts that there will be an increased water stress in coming decade due to the impact of climate change. It also states that the developing countries are at maximum risk due to climate change (IPCC, 2007 [1]; UNFCCC, 2007 [2]).

The water security in Horn of Africa should go beyond the simple assessment of number of households and

water access. In depth studies are badly needed for the impact of changing resource based on the life of native people; and measures are to be undertaken to secure the availability of such resources for now and in future. The water insecurity has negative impact on livelihoods, societal stability and overall security. The migration of population is a common practice all over Ethiopia especially from rural to urban areas. This migration aggravates the social conditions of the people, depending on the requirements. The requirements and supplies of water are not being managed in such conditions. In these situations the water services will not be able to reach up to the needs (Valerie, 2011) [3].

About twenty percent of world’s fresh water supply is by ground water. Fresh water stored in snow and ice pack makes an important natural storage and is used at the times of drought. The groundwater is the important component of hydrological cycle and it is replenished by

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surface water. The qualities of ground water like accessibility, convenient availability, and less capital intensive to develop make its use widespread (Calow *et al.*, 1997) [4].

The depletion of ground water is an inevitable and natural consequence of withdrawing water from an aquifer. Excessive depletion is affecting different parts of the world (Leonard *et al.*, 2005) [5]. The ground water sources are formed by percolation of surface water and its discharge or extraction to the surface is a complicated and sensitive process, controlled by several natural factors and human interventions. The main cause of depletion of ground water at different ecological zones in Himalayas and Ethiopian highlands is considered due to human activities. The unsustainable utilization of water by humans subsequently leads to reduction of ground water and depletion of the natural resources. Hence active plans are needed which should simultaneously go with traditional knowledge and application of modern techniques.

The occurrences of springs are controlled by the geological structure and physiography of an area. The hydrology of ground water is interesting and it is profusely studied in Central Himalaya by Waldia and Bhartariya (1991) [6], Singh and Rawat (1985) [7]. The role of aquifers, the setting of water bearing rocks (permeable) over non water bearing rocks (non permeable) and available proper obstruction or exposure to the surface as spring were discussed by these scholars. The significant role of structural factors for formation of spring is also studied in detail. Ground water is found to occur in varying components like thrust plains, strike slip fault, tensile joints, synclinal folds, tensile fractures, at the contact of two different rock formations, and in solution cavities and channels in carbonate rocks. In case of alluvial formation it is in the valley fill deposits, terraces, river terraces, glacial valleys, weathered rock cover, in moraines, and glacial deposits.

The hill slopes have ground water in the form of seepages, springs, oozing out water under gravity and favorable geological structures intercepting the topography. In Indian context the Himalaya is endowed with such rich resources of underground water. There is traditional method of ground water harvesting that is associated with culture and nature. This indigenous technology of water harvesting nurtures the lives with an auspicious environment. The Himalayan villages that are practicing the ground water harvesting through Naule and Dhare had played a key role in determining the human settlement. These sources of water are used for drinking, domestic purposes, for animals and micro irrigation. Further they are associated with traditions, customs and beliefs that make it nodal points for rituals and help to maintain the sources intact from the time they

were constructed and used.

The ground water resources are abundant and they form a major source of drinking water in Ethiopia also. The ground water fed river system and springs known as Minches are the main sources of perennial water supply to a large community. The Minches are ignored in present days due to various factors. This converted Minches into mere muddy water pit. Minches are diminishing and decreasing at a faster rate due to human interference, environmental deterioration, climate change and social ignorance. The water is oozing out into these pits that could be utilized by large number of people if they could be maintained with simple indigenous technologies.

The present study is a concept based on descriptive study which tries to imply the time tested indigenous technology of ground water harvesting in Himalayan villages to Minches in Ethiopia and there by sustaining the resources and supplying water to the surrounding areas of settlement. The concept is with the objective of implementing the Himalayan experiences in Ethiopian Highlands. This leads to a understanding of the mechanism of ground water and its difference in areas of sedimentary rock (Himalaya) and Igneous rocks (Ethiopian Highlands), assess methods to increase the capacity of recharge area, to identify measures for conservation of rock strata or transportation area, to develop and preserve the discharge area with suitability of harvesting structure, to know the causes of the depletion of the springs and the role of society in proper management of the developed resources.

2. Study Area

The conceptual debate of present study is confined with two distinct geographical areas of our globe—first, the Central Himalayan part of Indian Himalaya, specially the Kumaon Hills of Uttarakhand, India (South Asia) and second, the Western Central Part of Highlands of Ethiopia specially the South Gonder zone and West Gojjam zone in Amhara National Region State of Ethiopia (East Africa).

The Study area in Kumaon Himalaya falls in the Lesser Himalayan zone. The study was conducted in and around Almora city, and the rural areas of Almora District. The study area in Ethiopian comes under the Central Part of Western Highlands, covering the South Gonder and West Gojjam Zones, following the Addis-Matama National highway, especially around the towns of Gonder, Bahir Dar and Dangala.

3. Methodology

Present study is a concept based descriptive study, in which the conceptual model of ground water harvesting of Himalayan and Ethiopian Highland are being studied.

Through the generalized diagrams the common geological structures are being represented. Interview of experts and local social representatives was taken through structured questions. In social management the valuable experiences of Himalayan areas are being projected for the highland conditions of Ethiopia for a sustainable extraction of ground water.

The study use secondary information from varied sources for the discussion of geological aspect and represented it in the form of simple diagrams for the understanding. For social management of springs, a well structured questionnaire was drafted and primary information was gathered from 80 house holds (from 30 active Naulas) using the springs water. In similar way 55 households were surveyed (from 20 operational Minch) in the different part of Gonder-Gojjam area in Amhara National Region State, using the spring water. The springs were selected purposively (state of spring, users frequency, approach etc.) while household users were selected randomly. Five focus group discussion were conducted at Himalayan region while six such discussion were conducted in the Ethiopian side. Simple statistical techniques were used for data analysis and subjected information were carefully extracted from the statement of experts, group discussion and field observations.

4. Ground Water Harvesting System

4.1. Himalayan Ground Water Harvesting System

Slides 1(a) and (b) depicts the outer and inner structure of the famous constructed and preserved spring (*naula*) of Almora city of the Himalayan state of Uttarakhand of India. This spring is known as the “*Siddhi ka Naula*” dedicated to a historical saint of that area and so the spring is treated as temple in Hindu tradition. Besides being among the oldest *naula* of the city (Almost 450 years) it is located on the top of the ridge, supporting the population of the city’s upper part since the inception of the city in 1563 AD. Almora, the capital city of Chand rulers of Kumaon was fed by the water supply of these well constructed and well preserved naulas, historically reported 360, in and around the city. Naulas were nicely conserved seepage points of ground water.

The *Kund* or pond was constructed by dressed loose stones, so that the seepage channel should remain unchecked and easy to clean the silt and dirt. The total construction was in the shape of a temple and a statue of water god “Varun” or “Lord Vishnu” is placed on the wall of the Naula to give the sanctity of a temple. The consumption was strictly regulated by the social norms.

The Dhare and Naule have given a special architect, they are made in a shape of temple—a roof, walls and well builtup courtyard and chambers for the use of water



(a)



(b)

Slide 1. *Siddhi ka Naula* at Almora City of Kumaon, India. (a) The outer structure of Spring; (b) The inner structure of the spring.

to take bath and other works-keeping the main pond (*Kund*) clean. Some of the Naulas are the masterpiece of Kumaoni architect. The tradition is not confined only up to the cities or towns but it is a land mark of every village. In fact the location of rural settlement was largely determined by the location of these springs. The number of naulas in a village depends upon the size and social structure of the village. A large village may have up to a dozen of such nicely constructed and socially managed water points or naulas. Some of the well known naulas (*i.e.* the “*Ek Hathiya naula* of Champawet town) are the masterpiece of Kumaoni architect.

The net wok of Minch is quite common in Amhara and Tegaraie National regions, They are serving for the large rural population with drinking water and have enough potential to solve the rural water supply problem if they and managed properly (Hugo, 2003) [8]. During the field survey in the North and South Gonder Zone of Amahara National Region of Ethiopia; the water points locally known as “Minch” we observed were disappointing.

They were nothing more than the unprotected, unconstructed pits, which were filled fully or partially by the seeping ground water. In many cases the water was muddy and the pits were unprotected by the domestic animals. In rare cases we come across with sacred minch, associated with some sacred values as per the native Orthodox Christian tradition of Ethiopia; protected by the wooden fencing or loose stone walls. The best example of such minchs was the Gishe Abey Minch (**Slide 2(b)**) which is the source of river Gilgil Abey, located almost 30 Kms east from the Injibara town.

Both the Naules of India and Minches of Ethiopia can be compared and used in Ethiopian condition to bring about a continuous water supply to the population.

5. Result and Discussion

5.1. Basic Concept of Ground Water System

Ground water system is concerned with the percolation of precipitation into the subsurface rocks, their movement through the rocks and at suitable point or line, their discharge to the surface or base level water body.



(a)



(b)

Slide 2. The springs (Minches) of Ethiopia. (a) A common unprotected minch; (b) The protected minch (Famous Gishe Abey Minch) in ANRS of Ethiopia (East Africa).

5.2. Difference between the Geological Structure of Himalaya and Ethiopian High Lands

The basic differences between Himalaya and Ethiopian High Lands are the origin of rocks. Himalayan mountains are composed of Sedimentary Rocks while rocks of Ethiopian Highlands are Igneous by origin. Further they could be generalized as follows

5.2.1. Himalayan Structure

The Generalized model of rock structures shows that they are predominately sedimentary. They are alternative beds of Permeable and impermeable rocks and the ground water movement is mainly through the permeable rock strata. The rocks are folded—synclinal and anticlinal structures are common. The saturated permeable rocks are the source of springs “Naule” and “Dhare”. Wherever the saturated permeable rocks are exposed to surface, a spring is formed.

Himalayan areas. The alternative location of permeable and impermeable rocks plays an important role in the retaining ground water and their proper discharge. Anticlinal rock structure seems to be the very suitable for the formation of springs.

Figures 1(a)-(c) show the generalized model of some of the prominent geological structures in sedimentary rocks, supporting the formation of springs or Naulas in the Central Himalayan areas. The alternative location of permeable and impermeable rocks plays an important role in the retaining ground water and their proper discharge. Anticlinal rock structure seems to be the very suitable for the formation of springs.

In contrary to the sedimentary rock structures of Himalaya, the igneous rock structure of the Ethiopian Highlands shows different setup. Igneous rocks being impermeable rocks challenges for the ground water holding. It is further compensated by the formation of cracks, fishers and formation of intra-trappean layers between the rocks.

5.2.2. Ethiopian Highlands Structure

The generalized model of rock structure exhibits that they are predominantly igneous. Rock strata of different geological period may or may not separated by a significant layer of “intra-trapian materials”. Ground water movement is through the cracks-fishers-faults and “intra-trapian materials”. Ground water movement is through the cracks-fishers-faults and intra intra-trapian layer plays a significant role. Rocks are normally horizontal (in comparison to sedimentary rocks) with a smaller dip and strike angle. Water is moving horizontally through a least fractured rock strata and where ever it is exposed on surface, a spring or “Minch” is formed (**Figure 2**).

5.3. Major Threats for Ground Water System

Decreasing of ground water discharge is a universal

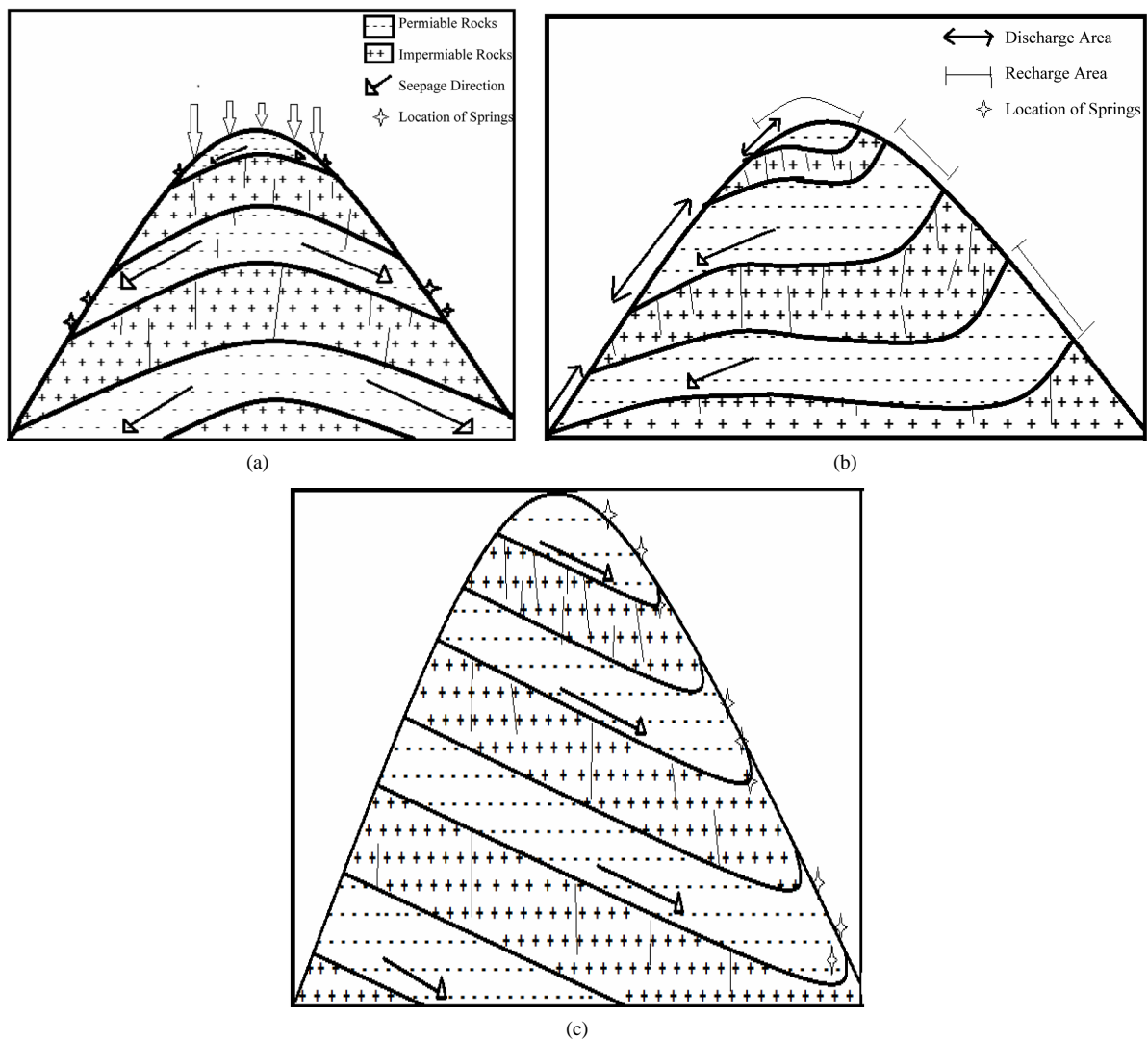


Figure 1. (a) Generalized model of ground water system in Himalayan Mountains (sedimentary rocks); (b) Ground water system in Himalayan area (sedimentary rocks), specific condition-1; (c) Ground water harvesting system in anticlinal rock structure of sedimentary rocks.

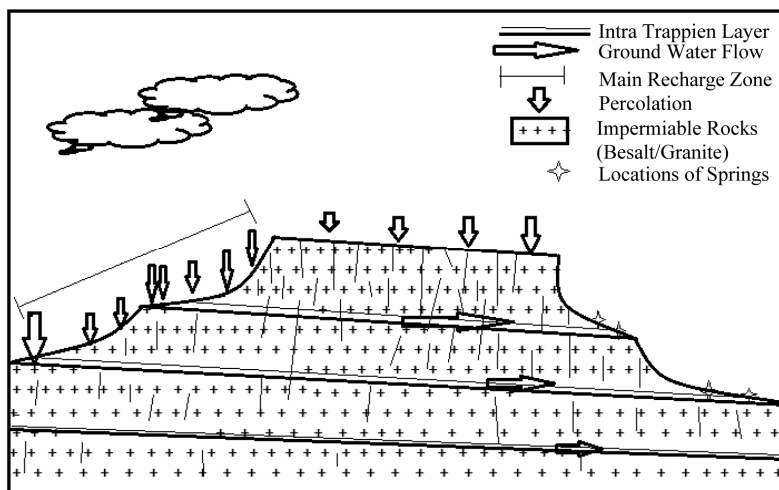


Figure 2. Generalized model of ground water system in the rocks/structure (Basalt/Granite rocks) of Ethiopian Highlands.

phenomenon. In both study areas the conditions are similar. The springs are diminishing, becoming seasonal and disappearing. Major threats for ground water system are more or less same for both the regions (**Figure 3**).

Figure 3 shows the four major factors responsible for the diminishing of the ground water discharge in Central Himalayan Region. Factors related with “Human Interference” and “Climatic Change” is largely affecting the recharge area of the ground water system. “Natural factors” are largely affecting the transporting (seepage) area and discharge area while factors related with “Social Management” are of concern with the discharge area.

5.4. Strategies to Counter the Challenges of Ground Water System: Using Himalayan Experiences in Ethiopian Highlands

In present study the ground water system is divided into three zones—recharge zone, transportation zone, and the discharge zone (**Figure 4**) and strategies for improvement are being discussed according to these zone:

5.4.1. Recharge Zone

This is the area where system receives the water from precipitation, percolates down to rocks and the aquifers gets recharged. The major problems of this area are deforestation, land degradation, forest fire, over grazing,

swift and unchecked surface runoff. To overcome these few management practices could be adopted.

1) The Land Use Management of Himalayan Villages

The land use pattern of Himalayan villages could be generalized into different land use belts. As **Figure 5** shows the reserve forest on top is presently controlled by the State Government, and Civil forests by the village body for forest (*Van Panchiet*). Further there is an extension of the cultivated area, settlement etc. Normally the springs are also located in this belt. The lower reaches or steep slopes etc are used for grazing. Community forests are also used for cultivation of grass (fodder for winters) and grazing. Using the indigenous knowledge this set land use is commonly followed which is tuned up with Ground water systems, and vis-à-vis. In similar way if in the Gonder zone the upper reaches of the plateau, or the head of the watersheds should be converted into reserved/community controlled forests and fully protected by human activities, specially cultivation will help a lot in improving the recharge areas; work of soil and water conservation activity may bring additional result.

2) Identification of Ground Water Sanctuary

The complete unit-system of spring including recharge, transportation and discharge could be defined as ground

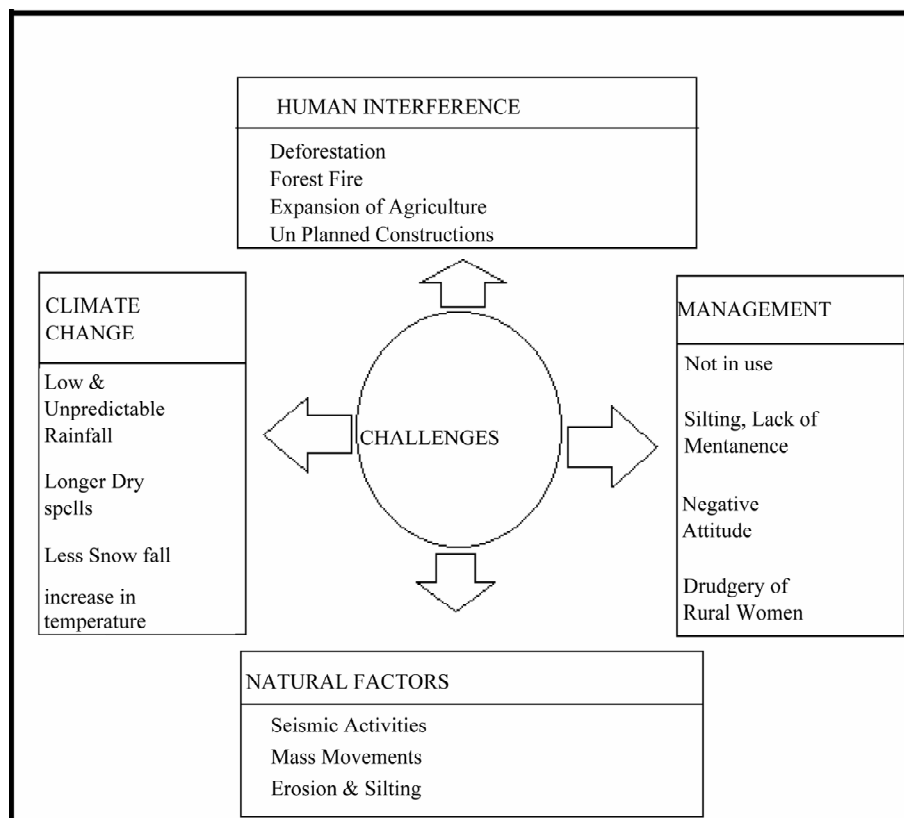


Figure 3. Challenges for the ground water systems.

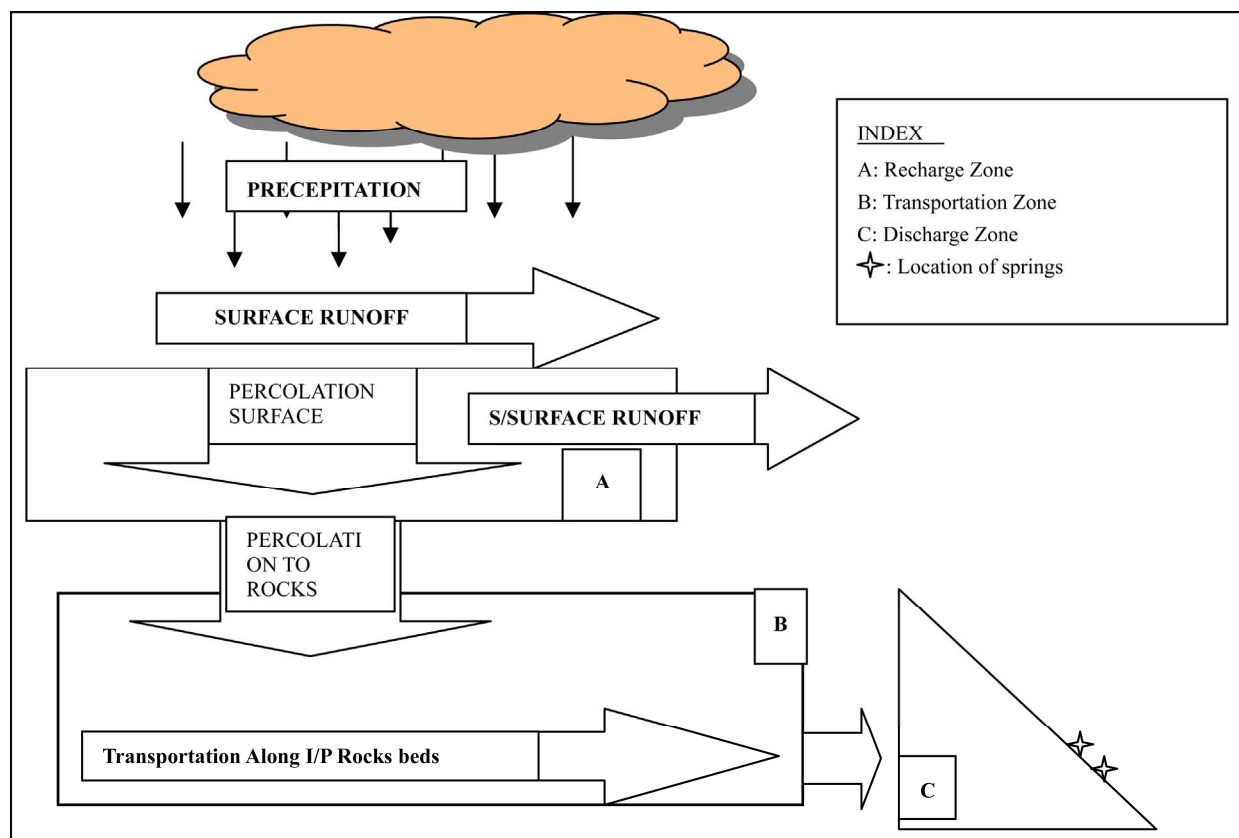


Figure 4. The general mechanism of ground water system.

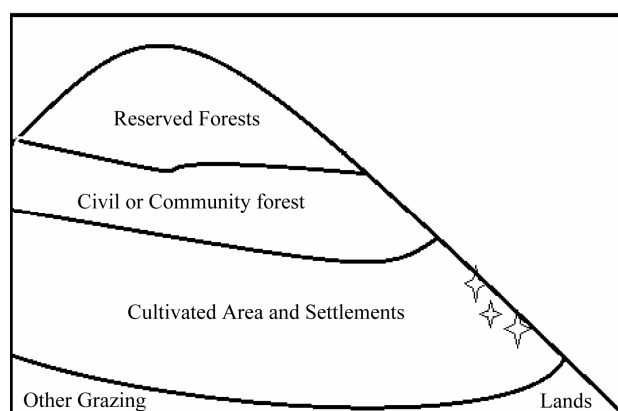


Figure 5. A generalized model of land use management of Himalayan villages.

water sanctuary. It could also be said as the watershed of ground water. The geological map of the area is used to understand the complexity of underlying rock strata and movement of ground water in a particular area or water sanctuary. This will be especially useful for giving treatment to recharge area and feeding a number of Minches.

3) Conservation Strategies

The recharge areas can be protected from exploitation by human encroachment and by afforestation and forest conservation, S&W conservation measures and checking

over grazing.

5.4.2. Transportation Zone

The water seepage channels are checked or diverted due to unplanned construction and this causes drying of springs. There should be practices to be followed based on geological and geomorphology experts to overcome this problem. Seismic activities in the Himalayan area plays a significant role in disturbing the transportation seams in rock strata, specially the earthquakes having intensity more than 4 in rector scale, but experts have a opinion that it may not be a significant cause for the disturbance of the water seams in Gondar-Gojjam areas.

5.4.3. Discharge Zone

This is the zone attached to ground water discharge. The human settlements are historically attached to this and the region should be managed well by human beings for proper utilization of the resources.

The Himalayan villages and their practice in these areas can be used as guidance for Ethiopian highlands.

1) Give an Architect to Springs

As described in **Slide 1** and **2** the discharge zone is given the architect of temple which makes people to worship the place. A similar approach can be made for Ethiopian Minches that otherwise are open water pits.

2) Imparting Spirituality

In India the discharge sites are associated with Gods or Saints. The same can be implemented in Ethiopia. As it is observed in Giesh Abey near Injibara where the sacred minches are given the shape of an orthodox church.

3) Socio Cultural Management

The rituals of communities are performed in these places as they are considered auspicious. In Himalaya the rituals are part of life associated with God and they are performed in holy places. Since the Naule and Dhare are given the sanctity of a temple the people are getting together and performing rituals with cultural values. The similar practices can be followed in Ethiopia also that makes the place important for the cultural aspects.

4) Develop a Positive Attitude

As the advancement of technology and human migration for various reasons, the traditional methods of practice are being ignored. This leads to the lack of maintenance of water bodies due to siltation and finally extinction. The data of Kumaon hill, the study area shows that for 14.19% of the villages, the main source of water are the conventional sources (Naule and Dhare). It is interesting that only 28.4% of conventional sources are in full use, 31.16% are in partial use, 25.16% of conventional sources are ignored and 15.28% are extinct (Dube, 2003) [9].

The common factor that is observed in both areas are that the traditional practices are being abandoned, indigenous knowledge is considered as a sign of backwardness. The increasing network of tap water is considered as the modern suitable solution by government, funding organizations and local people which may be due to the perceptive change... so what if it is for a shorter period and will lead for bigger problems. Short sightedness in the people perceptions is reflected as the ignorance of Naulas in Kumaon Himalaya and ignorance of Minches in Gonder zone of Ethiopia (Singh and Pandey, 1987 [10]; Dube, 2003; Yilama and Yusuf, 2005 [11]).

6. Recommendation from the Study

On the basis of observations and comparisons made during the study the following recommendations may be practiced for:

- The recharge areas of ground water should be identified and monitored without any external disturbances and managed by local community;
 - The geology of the area should be well understood to find the possibility of Minches and to utilize them in sustainable way;
 - The Minches should be preserved with architectural outlook and sanctity that provides cultural values; *i.e.* they should be given an outlook of a small orthodox church, dedicated to some god or deity;
 - The deforestation and forest fires should be avoided and afforestation programmes should be practiced.
- There should be societal involvement for conservation and management practices as in case of Naule in Himalaya for Minches of Ethiopia.

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