# Rangeland Ecohydrology, New Paradigm in Water Management of Arid and Semi-arid Lands

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**Abstract.** At the beginning of twenty-first century, the water crisis in the priority policy and management is inside and outside of the country as principle thoroughly human, social, economic and political rulers of the country is considered abundant. The World Bank has announced that during 1960 and 2025, water resources in Middle East, from 3430 $m^3$ for the each person in year reach to 667 $m^3$ because of population growth, degradation of natural resources, extent and spread of deserts. Study of ecohydrology in arid and semi arid rangelands of the world is one of the newest methods for available water resource management. In this science, all of effective ecology elements on water balance equation were reviewed. In these areas, a strong relation had been seen between ecology and hydrology processes. In these areas, not only lack of precipitation, but also irregular and unpredictable distribution of precipitation was problematic. Ecohydrology pays particular attention to these areas of vegetation and its impact on groundwater and surface water.

**Key words:** Ecohydrology, Qualitative and quantitative deficiency of water resources, Arid and semi arid rangeland.

## Introduction

Qualitative and quantitative development of water resources and protection of resources are the most basic strategies to achieve sustainable development. Sustainable development along with social policy at the correct levels of international, national, local and even family benefits for the equitable distribution of goods and services are obtained and the development and efficient use of water resources are the tools to achieve it. New interdisciplinary sciences like ecohydrology given above are required.

For approximately 10 years, the various models regarding the relationship between vegetation and climate are provided and there is the assumption that the interaction is seen between vegetation and climate zones so that there is a change in the position equation leading to direct and indirect changes on the other side of equation. Currently, watershed hydrology models on the physical processes and rarely the actual dynamics of vegetation and their influence on the behavior of the basin are discussed. In these models, some components of the vegetation and land use factors such as rippling field coefficients of hydrology and hydraulic conductivity are combined.

To show real relationships, complex ecosystem components, effectiveness of water balance, models and other words associated with ecohydrology water cycle, ecosystem dynamics, composition of vegetation and hydrology concepts are used.

## Introductory Knowledge on Ecohydrology

First time in 1997, the term ecohydrology was considered in the world fifth program of UNESCO as a scientific interdisciplinary to describe and quantify relations between Hydrology and ecology, assess overall water cycle, influence, effectiveness and defunct components on cycle of water.

UNESCO ecohydrology program expressed goals as follows:

1- Raising the awareness of ecological, hydrological and other residents in watershed areas.
2- Increasing the use of water resources and capabilities towards sustainable utilization of water resources.
3- Considering the impact on the water cycle components including environmental factors, climatic, economic, social, political, cultural and historical conditions (Zalewski *et al.*, 1997).

## Definitions of Ecohydrology Science

This Science affects the hydrology cycle distribution concerning the structure, function and ecosystem dynamics and feedback live on the water cycle components and semi-arid and arid areas for predicting the effects of natural and human factors on the cycles of nutrient elements and soil moisture used (Newman *et al.*, 2002).

Ecohydrology expressing functional relationship between ecology, hydrology and climatology is leading to environmental problems (Pauly, 2007).

In scientific ecohydrology, the sustainable management of water resources is based on sustainability goals such as establishing the water cycle, energy flow, nutrient elements and increasing the carrying capacity of natural ecosystems. Proper management of natural resources is the sustainable utilization of water resources (Janauer, 2000).

Ecohydrology includes public program to improve rangelands. In these methods, unlike the technical procedures (Dam, Bankt, Terrace), climate data, geology, soil science and expression of all components of the ecosystem are considered in combining economic and social issues in watershed leading to the upgrading of the status are pastures (Zalewski *et al.*, 1997; Zalewski, 2000).

**Main Ecohydrology Equations**

The most important ecohydrology equation is the equation of balance or equilibrium of water. This equation expresses the principle that a time delay and the total water are inputs to terrestrial ecosystems while changes in its water equivalent are the output of these ecosystems.

*Nzr (ds (t) (dt)) = R (t) -1 (t)-Qe (s (t))-L (s (t))*

Left side of the equation expresses the total depth of water in plant roots week (average 30 cm from soil surface), the amount of space available in the soil (n), depth of plant roots or week active soil depth (zr) and soil moisture change saturation over time ds/(t)/(dt).

Right side of the equation includes rainfall R (t), interception I (t), evapotranspiration, runoff Q, the soil moisture content s (t) and the amount ($0 \leq s(t) \leq 1$), rate of water loss from the surface and subsurface layers (root access) L (s (t)).

The above equation shows factors affecting ecohydrology conditions covering different areas of plant diversity, the main frame and the variables in the study clarify ecohydrology.

Vegetation itself is a function of environmental factors on the production of water basins (interception, evapotranspiration, runoff and soil moisture content) directly affecting the groundwater table. Obviously, the downstream water supply of lands is affected by these factors.

**Ecohydrology in Arid and Semi arid Regions**

Ecohydrology survey of arid and semi arid areas are very important because ecology and hydrology conditions are very fragile and the strong relationship between ecological processes and hydrology is seen in these areas. Not only lack of precipitation, but also irregular and non pre-distribution Precipitation Forecast is problematic. Ecohydrology studies in arid and semi arid regions on the following components are based on:

1- Viewing the existing water resources,
2- Boundaries between evaporation and transpiration,
3- Reviewing the food cycles and their confrontation,
4- Role of vegetation and its influence on the water cycle,
5- Climate of confrontation with the elements and relationships of living ecosystems and water cycles,
6- Impact of vegetation on surface and Underground water,
7- Reaction of plants against changes in hydrology,
8- Role of plants in the dynamics of soil moisture, surface and subsurface runoff (Pipe Yu I *et al.*, 2002).

**Ecohydrology Literature on Rangeland Ecosystems of World**

Since many studies regarding the world situation have been performed on ecohydrology of rangelands and of course, in any study of a limited number of components listed above, has been dealt with yet in all these articles, effectiveness and influence of factors and natural ecosystems on the water balance.

Studies conducted in America in origin rangeland by Jones *et al.* (2002) surveys the effect of vegetation type on penetration, sediment and runoff. In this study, rainfall simulator system was used in small plots. Measurements in four dominant regions and two ecologically distinct sites were performed. Percentage of vegetation in the plot was 22%, 15% and 3%, respectively. Rain drops with the ratio of 10.2cm/ha and high and low intensity in different plots being 60 minutes and the amount of runoff with a frequency of 5 minutes were recorded. Influence of its duration, stability in plots with high and controlled cover, 68% larger than the control plots, and 34% more than plots with vegetation was moderate. In the northern slopes, the difference in penetration was observed at different levels of precipitation. Increasing the amount of litter in two sites, penetration

increased. Penetration depth in plots with juniper cover was more, and less runoff and sediment levels in the plot were from other plots.

Contreras *et al.* (2008) studied semi-arid rangelands in southeastern Spain through the water output rate of regression models estimating the basin. These models were used to access data from precipitation, evapotranspiration and leaf area index. Results from the calibrated model with natural conditions prevailing rangelands showed high correlation.

Snyman (2009) studied grass root characteristics and its influence on soil moisture conditions, characteristics of plants in a little amount of water production in southern Africa and meadows. The results showed that air biomass, dead plants and underground roots have high correlation with soil moisture. The right management models based on the principles ecohydrology and the most appropriate management practices are applied to achieve sustainable development in rangelands.

Studies conducted by Hultin *et al.* (2007) in the forests of northwest America river areas showed that the vegetation structure and function affected water cycle and found that the important factors such as changes and land degradation, increasing the volume of runoff, sediment and melting snow led to early ecohydrology frequency changes in the basin.

Studies conducted by Poporato *et al.* (2001) in South Texas Savants showed the relationship between rainfall, depth of plant roots and dynamics of soil moisture. The results showed that the physiological characteristics of plants affected soil moisture levels and leaves. Among all factors investigated, the highest correlation was seen between soil texture and available water.

## Ecohydrology Literature in Iran

Iran with an area of more than 1.6 million kilometers is located in northern temperate zone. Caspian sea coast with a height of approximately 28 meters below sea level and Mount Damavand with the height of 5,610 m above sea level are the lowest and highest points of Iran (Iran Statistical Yearbook, 2000).

Ninety percents of total area of Iran are arid and semi arid areas. Annual rainfall average in Iran is only 37% of total precipitation in the world. Areas with more than 2000 mm of precipitation (Astara) and areas with less than 0.5 mm precipitation within 50 years (Lot Desert) indicate severe vulnerability of water resources in Iran.

The highest and lowest rainfall has been recorded in the northern slopes of Alborz and dry desert areas (Mahdavi, 1995).

Iran like many countries located in arid and semi arid zones of world with shortage, irregular distribution of atmospheric precipitation, degradation, natural ecosystems and increasing demand for residents, need the planning, and management based on the principles of ecohydrology. In the other words, ecohydrology is the management and promotion based on the current situation.

## Conclusion

Management of existing water resources should be sustainable and long term so that study of rangeland ecohydrological conditions as the widest and most important land ecosystems, especially in arid and semi arid areas with few restrictions on the frequency and quality of available water resources is very important.

So for the process of ecohydrological studies, the following principles should be considered:

1- Analysis of effects of the rangeland ecosystem elements on water cycle.
2- How live ecosystem components influence the use of rangeland.
3- Importance of spatial and temporal elements affecting evapotranspiration.
4- Water resources and related changes of Carbon.

5- Impact of vegetation and land management on runoff and soil erosion.
6- Influences of the development of woody plants on rangeland streams.
7- Topographic characteristics impact on hydrology, ecology and pedology.
8- Effects of coverage plant on surface water and underground streams.
9- Review of basin conditions of ecohydrology and desertification processes (Wilcox *et al.*, 2006).

However, considering the broad concepts of science ecohydrology, the great variety of data collected from rangeland, the time and costs, ecohydrology studies in arid and semi arid regions of Iran include the following items:

1- Determination and correlation of independent variables influencing vegetation, soil, and topography and landforms on the dependent variables of runoff, infiltration, abduction and evapotranspiration.
2- Evaluation of factors including vegetation biomass, cover percentage, density, frequency composition and litter, soil factors including porosity, bulk density and soil texture, percent of rocks and pebbles, percentage of bare soil, organic matter, total nitrogen, phosphorus, potash, climatic factors including rainfall, temperature, amount of received light and the topographical factors including percentage of land slope, slope direction, elevation above sea level and some factors including those on human and animal changes in water balance ranges.
3- Production of surface water runoff resulting from different types of rangeland plants.
4- Study of subsurface and deep penetration with plant germination and root depth geological characteristics.
5- Evaluation of balance or imbalance in rangeland ecohydrology.
6- Providing proper watershed management strategies according to the equation of appropriate ecohydrological spatial and temporal access to water resources.

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