The Turkish Journal of Occupational / Environmental Medicine and Safety

2017; Volume 2, Issue 1(3): 150-157 Web: http://www.turjoem.com ISSN : 2149-471

IMPORTANCE OF INTEGRATED WATERSHED MANAGEMENT ON WATER QUALITY

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ABSTRACT

The management and planning of water resources recently become important and increasingly complex. While the most of the developed countries managed their water source with sustainable plans to water production, our country has newly started the work within its watershed management principles. Due to excessive population growth the environmental problems blow out after industrialization, land degradation, wrong agricultural and forestry applications. These misapplications negatively affect water resources. Drinking water resources are divided into surface water and groundwater. The water needs of settlements are mostly covered by surface water resources. For water supply generally a dam is built into the most suitable lower part of the river. However, the basins contain not only forests and meadows, but also settlements, livestock and agricultural activities. The required quality and quantity of drinking water production have become very difficult and expensive due to this reason. Integrated watershed management aims to protect water resources and improve the quality of drinking water with a systematic and comprehensive approach to addressing all these problems. European countries enforced a water framework directive in 2000 in order to produce and protect water resources according to common standards. This provided continuous monitoring of physicochemical, chemical, biological and hydro-morphological quality of water as measured by the Water Framework Directive.
This study illustrates the sustainability of renewable water source and to plan for sustainable water production with considering climate, geology, topography, soil, vegetation cover, land use types and socio-economic elements and relations between them by the determined management principles.

Keywords: Integrated watershed, WFD, water sources, water quality

INTRODUCTION

The industrial revolution has offered comfort life and benefits but also has caused many environmental problems. It is well known, human activities such as fertilization, agricultural application, land degradation; unplanned settlements in a watershed, which is integrated with other ecosystems, negatively affect its water quality (Carpenter et al., 1998; Wilcock et al., 1999; Hunter et al., 2000 Niyogi et al., 2003). Indeed, the land misuse severely becomes the most dangerous human activity for the terrestrial ecosystem. Some researchers focused on the influence of land use changes on the ecosystem (Garcia-Ruiz et al., 1996; Dunjo et al., 2003; Patz et al 2004) and on water quality (Lenat and Crawford, 1994; Hall et al., 1994). Last two decades, the freshwater sources rapidly decrease due to unsustainable land use practices (Ngoye and Machiwa, 2004).Before, the water quality concept is generally ignored in land use plans because of the fact that the land use and water quality management agency do not work coordinately.

The water quality of a natural resource is related to climate, geology, geomorphology and land use types of the watershed. The precipitation, temperature, soil erosion status, topography, the characteristics of the watershed (shape, slope, hypsographic curve…etc.), the characteristics of soil (texture, structure, organic matter …etc.), vegetation types and covers play the critical role in the water quality of watershed (Schindler 1997). It is very difficult to manage the watersheds, which are natural water resource due to the different administrative borders and units (Moss, 1998). Especially, agricultural applications such as fertilization, pesticide, irrigation, tillage influence water quality of freshwater source (Moss 1998; Elliott and Sorrell 2002). Also, the vegetation cover significantly related with quality and quantity of water (Lougheed et al. 2001; Maberly et al. 2003). On the other hand, the settlements and industrializations, which controls by municipalities build in the river basin.

In Turkey, the "National Watershed Management Strategy" was developed by the Ministry of Forestry and Water Affairs within the years 2014-2023. In order to sustainable management of watershed basin system is divided 25 macro river basins (Figure 1) and its micro basins (GDF, 2012). The Forest Service is very concerned about the functional management planning since 2000. Turkey has 3.599.328 hectares hydrological forest area accounting for about 16 percent of the country's total forest area (Table 1).

Figure 1. Maps of Turkey Major River Basins (SHW, 2012)

Table 1. Forest distribution according to functions in Turkey (GDF, 2012).

Main Function	Sub-function	Forest Area	%
Economic Function	Forest Production	10138990.0	47.00
Ecological Function	Nature Protection	4251039.4	19.00
	Erosion Protection	2429897.7	11.00
	Climate Protection	101576.6	1.00
	Total	10381841.7	47.00
Social Function	Hydrologic	3599328.0	16.00
	Public Health	86799.0	1.00
	Esthetic	364354.0	2.00
	Ecotourism and Recreation	117521.8	1.00
	National Defense	75963.5	1.00
	Scientific	23277.0	1.00
	Total	667915.3	3.00
General Sum		21188747.00	100

All these components of the watershed should be managed with a cumulative combination under water framework directive. This paper presents a brief overview of the importance of integrated watershed management on water quality and management. Also, it illustrates major problems and challenges in watershed management. And then, the practical strategies will be suggested for the purpose of stimulating further discussion and better management.

1. Concept and Principles of Watershed Management

Watershed management is the process of managing and coordinating land-use type and water resource. The three main objectives of watershed management are producing high-quality water; protect soil from erosion and floods, and the planning of natural resource with regards to social-economic dimension. For these aims, Watershed management carries out developing appropriate policies and laws; decreasing soil erosion, reducing sediment transportation and development of water quality; preserve an adequate water supply for irrigation of agriculture areas; maintaining water quality criteria that the international standards; reducing to natural disasters such as droughts, landslides, and floods; prevent land degradation from water resources (Tuyll, 2006).

Initially, watershed management related with solving localized problems without considering the wider effects of practices on ecological, economic and social aspect. Watershed management was generally organizing with technical interventions related to water and soil conservation (Heathcote, 1998). Therefore, the following definition is still maintained by Tideman (1996), *"Watershed management, or protection, implies the wise use of soil and water resources within a given geographical area so as to enable sustainable production and to minimize floods. The objectives of watershed management programs are: to increase infiltration into the soil, to control damaging excess runoff and to manage and utilize runoff for useful purposes".*

Recently, Watershed management ensures a comprehensive framework for defining and solving complicated natural water resource management challenges (Brooks, 1994). This working combines the sustainable management of natural resource with regards it's ecological, social and economic aspects. The successful watershed management requires good coordination with multi-stakeholder at all levels (private sector, civil society, and government) management of water, land and other natural resources in an area (FAO, 2006).

2. An Overview of the Watershed Management History

Before the last century, scientists and government were working on some precautions against environmental hazards such as erosion, floods, avalanche...etc. At the last century, the concept was gradually changed to watershed management. After B.C. in 1215, the king of France IV Louis published an order about "water and forest". In 1342, the first conservation forest was established in Switzerland (Satterlund, 1972).

Early 19th century, the different and counter ideas have begun to appear in watershed management concept (Satterlund, 1972). In Europe, the watershed management concept was considered against the flood hazards from the Alps. They try to control streams and their area against to erosion, flood and land degradation (Sheng, 1994). During the periods, the forests were destroyed from the Alps and other mountains. This event caused great floods in France, Italy, and Austria. And then, European countries investigated and managed the effects of forests on climate, floods and water resources. They have legislated on the protection and development of forests. At that time, France was the most working country with afforestation and grazing about watershed management.

After the discovery of America, Europeans destroyed the forest and nature for their settlements. As a result of these destructions, floods and soil erosion have increased to serious dimensions. The first studies on watershed management started in 1890 and the study of forest watershed management started in 1910. After 1930, extensive research on soil and water protection has been carried out. Thus preventing erosion and flooding and producing high-quality water in a rainfall basin. In 1960, the versatile usage principle of the forest such as wood product, water, forage, recreation and wildlife mentioned for the first time on 5th World Forestry Congress (Balcı, 1978).

Recently, the watershed management is one of the most important branches of science when contribute to improving quality and quantity of water.

3. Challenges of Integration of Watershed Component

Today's water quality issues are more difficult and complex than before. Thus watershed boundaries include different institutional and administrative borders. Although multiple types of development work need to be done at upstream watersheds, the watershed agency cannot take responsibilities of other agencies. To integration with administratively, many activities into a watershed program will become complexity, impractical and ineffective.

Also, to integrate all units of watershed components is unique but unlikely or unaffordable for many countries. Such as forestry department, a power company, state hydraulic works, municipality and other institutional constraints want to use the natural source with their benefits. The solution of this challenge work on balance and coordination with all agencies related with water resource (Sheng, 1992).

4. Integrated Watershed Management

A watershed contains not only a hydrological function but the socio-political functions as well. The sustainable use of watershed resources related to combining nationwide social governor and institutions behavior the values of a society than on technical solutions. Watershed management should be managed a multidisciplinary and multi-stakeholder with regards both natural and socio-political aspects. This led to a new approach to *Integrated Watershed Management* (IWM). IWM is the combination of education, economic incentives, regulations and their sanction (Simonovic, 2009).

The concept of IWM is defined "*IWRM is a process that promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Integrated management has to be applied through a complete rethinking of water management institutions – putting people at the center.*" (SDC, 2005). Moreover, IWM is a reform of managing natural resources and human activities on a watershed basis. This reform provides the protection and improvement of water quality and quantity (Figure 2).

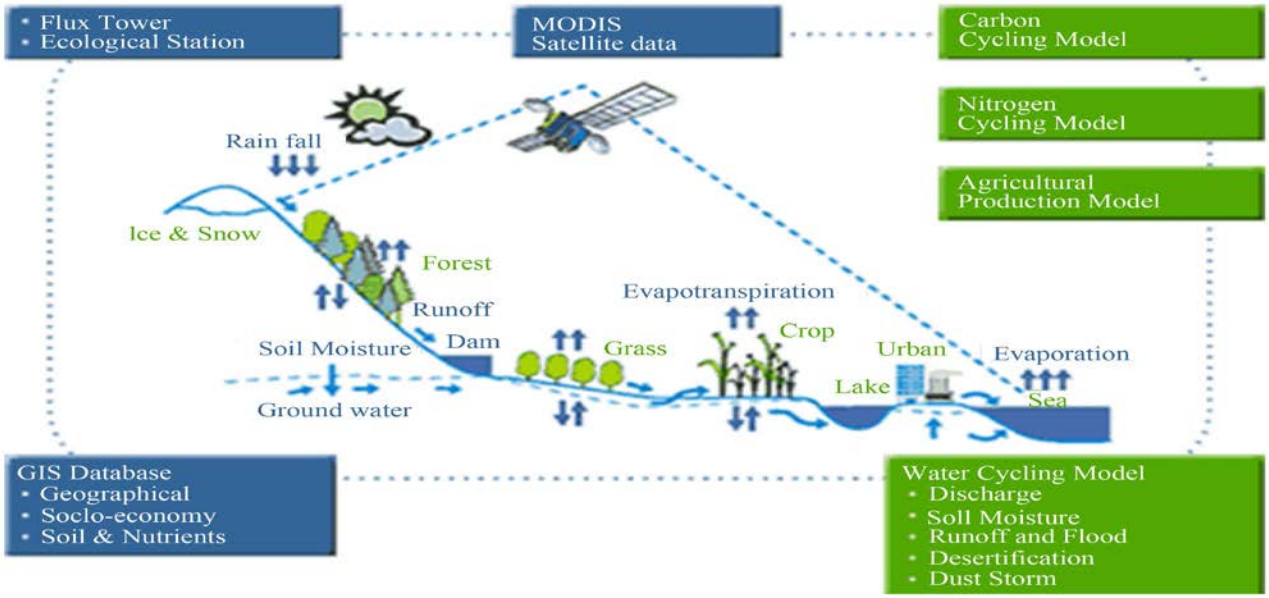

Figure 2. The structure of the integrated watershed management model (APEIS, 2003).

The methods to be applied into the watershed vary depending on its characteristics. Sustainable and successful agricultural management practices integrated with water and soil protection and improvement techniques which contribute to decreasing the effects of erosion and sedimentation. These activities can contain crop rotation, grazing, vegetation management, shifting cultivation, natural fertilizer, etc. (Verheye, 2010). On the other hand, some soil properties such as infiltration, soil organic matter, porosity...etc. directly influence with erosion and water quality. The infiltration rate and organic material of soils are really most important characteristics to prevent erosion and help to increase water quality.

This method is less costly and saves time with demands less labor. Moreover, it is decreasing raindrop impact on soil degradation process; boost up infiltration capacity, reducing runoff within the integrated way. However, it requires time to get well managed (REMA, 2010).

In this integration approach, people's essential needs such as income, health, shelter, education and food are considered. The approach of participatory integrated watershed management can be supposed through two goals. Primary, determining the process by which participants can engage in related activities (Hinchcliffe, et al., 1995; Rhoades, 2000; Turton and Farrington, 1998). A crucial question must be asked when preparing a participatory IWM is, "Can a farmer go beyond thinking like a farmer? The problem is the adjacent borders for interventions are not necessarily the ''watershed,'' however, units described by non-biophysical parameters (cultural or administrative units) or at other scales. Does problem conform to hydrological borders? Second, the process must be integrated. Integration can be understood differently by different people, a common approach is to underline the integration of objectives (income generation, conservation, food security) (Shah, 1998) or disciplines (social, institutional and technical) (Bellamy et al., 1998; FAO, 1977; Reddy, 2000) (Figure 3).

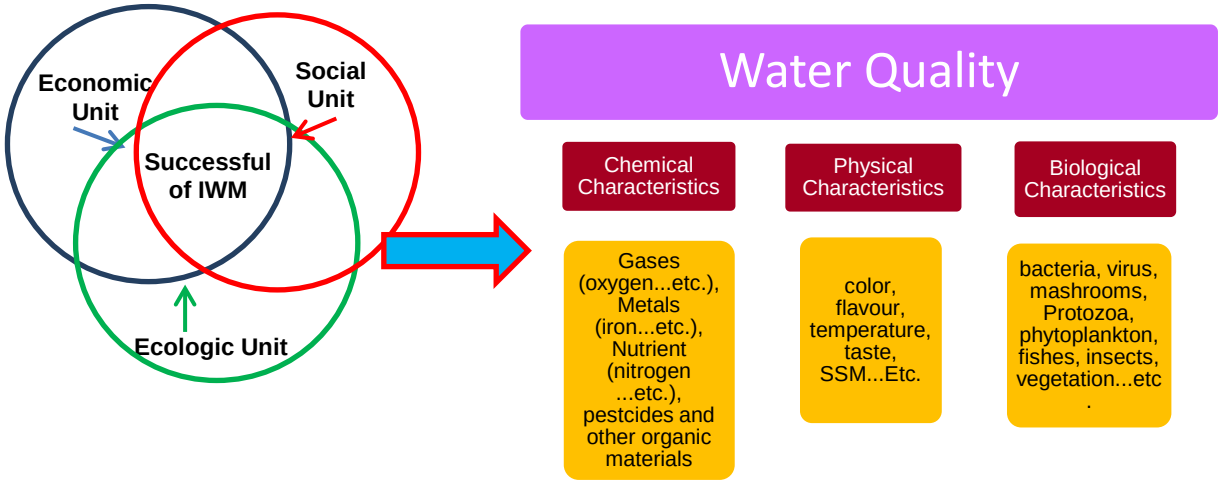

Figure 3. Linkage between Unites of Integrated Watershed Management and water quality parameters

CONCLUSION

As a result, it should be goal the sustainability of renewable natural resources and sustainable water production with regards to climate conditions, geology, topography, soil, vegetation cover, land use patterns, socio-economic elements and in line with the management principles determined in accordance with the relations between them, in a watershed basin with Integrated Watershed Management Methods. In a watershed, sedimentation and erosion are the major environmental problems that reduce the productivity of natural resources. As evolved in recent years the Integrated Watershed Management approach should be regulated by considering the increasing comprehensive objectives of agricultural demands. Therefore, the integrated watershed management practices and its conservation strategies are the very important issue to increase agricultural production, boost up quality water production and reduce the environmental degradation in the territory.

ACKNOWLEDGEMENTS

We thank the scientific and organizational secretariat of the *2nd International Water and Health Congress* had been organized in Antalya Rixos Sungate Hotel between February 13 - 17, 2017.

REFERENCES

Balcı, N., 1978. Soil Protection lesson books. Teksir Publication.
Bellamy, J.A., McDonald, G.T., Syme, G.J., 1998. Evaluating integrated resource management. Society & Natural Resources 12, 337– 353.
Brooks, K.N., Folliott, P.F., Gregersen, H.M., Easter, K.W. 1994: Policies for Sus-tainable Development: The Role of Watershed Management.
Carpenter, S.R., Caraco, N.F., Correll, D.L., Howarth, R.W., Sharpley, A.N., Smith, V.H., 1998. Nonpoint pollution of surface waters with phosphorous and nitrogen. Ecological Applications 8(3), 559-568.
Dunjo, G., Giovanni Pardini, Maria Gispert, 2003. Land use change effects on abandoned terraced soils in a Mediterranean catchment, NE Spain. Catena 52; 23 – 37.
Elliott, S., Sorrell, B., 2002. Lake Managers' handbook, land–water interactions. Ministry for the Environment, Wellington, New Zealand.

FAO, 1977. Guidelines for Watershed Management. FAO, Rome.
FAO, 2006: Forestry Paper 150 – The new generation of watershed management programmes and projects.
Garcia-Ruiz, J. M., Teodoro Lasanta , Purificacion Ruiz-Flano , Luis Ortigosa , Sue White, Constanza Gonzailez and Carlos Marti, 1996. Land-use changes and sustainable development in mountain areas: a case study in the Spanish Pyrenees. Landscape Ecology vol. 11 no. 5 pp 267-277.
General directorate of forests, Strategic plans of Turkey Ministry of Forestry and Water Management. Turkey, 2012.
General directorate of State Hydraulic Works, Strategic Plan, Turkey, 2012.
Hall, L. W., Fischer, S. A., Killen, W. D., Jr, Scott, M. C., Ziegenfuss, M. C., Anderson, R. D., 1994. Status assessment in acid-sensitive and non-acid-sensitive Maryland coastal plain streams using an integrated biological, chemical, physical, and land-use approach. *Journal of Aquatic Ecosystem Health* 3, 145–167.
Heathcote, I.W., 1998. Integrated Watershed Management – Principles and Practice. John Wiley & Sons, Inc., New York, Chichester, Weinheim, Brisbane, Singa-pore, Toronto.
Hinchcliffe, F., Guijt, I., Pretty, J.N., Shah, P., 1995. New horizons: the economic, social and environmental impacts of participatory watershed development. IIED Gatekeeper Series 50, pp. 3–20.
Hunter, C., Perkins, J., Tranter, J., Harwick, P., 2000. Faecal bacteria in the waters of an upland area in Derbyshire, England. The influence of agricultural land use. Journal of Environmental Quality 29, 1252-1261.
Lenat, D. R., Crawford, J. K., 1994. Effects of land use on water quality and aquatic biota of three North Carolina Piedmont streams. *Hydrobiologia.* 294, 185–199.
Lougheed, V.L., Crosbie, B., Chow-Fraser, P., 2001. Primary determinants of macrophyte community structure in 62 marshes across the Great Lakes basin: latitude, land use, and water quality effects. Can J Fish Aquat Sci. 58:1603–1612.
Maberly SC, King L, Gibson CE, May L, Jones RI, Dent MM, Crawford J (2003) Linking nutrient limitation and water chemistry in upland lakes to catchment characteristics. Hydrobiologia. 506–509:83–91.
Moss, B., 1998. Ecology of Fresh Waters: man and medium, past to future, 3rd ed. Blackwell Science, Oxford, UK.
Ngoye, E., Machiwa, J.F., 2004. The influence of land use patterns in the Ruvu river watershed on water quality in the river system. Physics and Chemistry of the Earth. 29, 1161–1166.
Niyogi, D.K., Simon, K.S., Townsend, C.R., 2003. Breakdown of tussock grass in streams along a gradient of agricultural development: implications for ecosystem functioning and ecosystem health. Freshwater Biology 48, 1689-1708.
Patz, J. A., Peter Daszak, Gary M. Tabor, A. Alonso Aguirre, Mary Pearl, Jon Epstein, Nathan D. Wolfe, A. Marm Kilpatrick, Johannes Foufopoulos, David Molyneux, David J. Bradley. 2004. Unhealthy Landscapes: Policy Recommendations on Land Use Change and Infectious Disease Emergence**.** Environmental Health Perspectives Vol. 112, No. 10, pp. 1092-1098.
Reddy, V.R., 2000. Sustainable watershed management institutional approach. Economic and Political Weekly (September), 3435–3444.
REMA (2010) Practical Tools on Soil and Water Conservation Measures, Republic of Rwanda, Kigali. Rwanda Environment Management Authority, Kigali.
Rhoades, R., 2000. The participatory multipurpose watershed project: Nature's salvation or Schumacher's nightmare? In: Lal, R. (Ed.), Integrated Watershed Management in the Global Ecosystem. CRC Press, London, pp. 327–343.
SDC, 2005: Water 2015. Policy Principles and Strategic Guidelines for Integrated Water Resource Management – IWRM.
Shah, A., 1998. Watershed development programmes in India: emerging issues for environment-development perspectives. Economic and Political Weekly (June), A66–A79.
Sheng, T. C. 1992. Interagency Coordination in Watershed Conservation. In Conservation Policies for Sustainable Hillslope Fanning. Soil and Water Conservation Society. Ankeny, Iowa, USA. 364 pp.
Sheng, T.C., 1994. Challenges and strategies of Integrated Watershed Management in Developing Countries. The 8th International Soil Conservation Conference, New Delhi, India.

Simonovic, S.P., 2009: Managing Water Resources: Methods and Tools for a Systems Approach, UNESCO and Earthscan.
Tideman, E.M. 1996: Watershed Management – Guidelines for Indian Conditions. Omega Scientific Publishers, New Dehli.
Turton, C., Farrington, J., 1998. Enhancing rural livelihoods through participatory watershed development in India. ODI Natural Resource Perspectives 34, 1–4.
Tuyll C. 2006: What is Watershed Management all about it? [unpublished]
Verheye, W.H. (2010) Soils, Plant Growth and Crop Production, Volume I. Encyclopedia of Life Support Systems (EOLSS).
Wilcock, R.J., Nagels, J.W., Rodda, H.J.E., O'Connor, M.B., Thorrold, B.S., Barnett, J.W., 1999. Water quality of a lowland stream in a New Zealand dairy farming catchment. New Zealand Journal of Marine and Freshwater Research 33, 683e696.