Universidad Nacional de San Martín
Fundación Innovación y Tecnología (FUNINTEC)
Director: Alberto Pochettino

Programa FUTUROS
Escuela de Posgrado: Agua + Humedales

New perspectives in the watershed approach for water management

(Conferencia)

Por José Galizia Tundisi [1]

Filiación:
[1] Instituto Internacional de Ecologia, São Carlos/Universidade Feevale, Novo Hamburgo, RGS/INCT-Acqua-MCT. Brasil. Email:

Registro del capítulo del libro digital
Título del capítulo: New perspectives in the watershed approach for water management
Autor capítulo: Tundisi, José Galizia
Páginas: 83-92
Título del libro: Agua + Humedales
Edición: 1ª edición.
Editor: UNSAM Edita.
Serie: Futuros
Fecha de publicación: junio 2018
Páginas: 485
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Idioma: Español

Identificación y acceso
ISBN: 978-987-4027-68-9
URL: https://www.funintec.org.ar/contenidos/aguahumedales-es-el-primer-libro-de-la-serie-futuros/
Cita del capítulo: Tundisi, José Galizia. (2018) New perspectives in the watershed approach for water management. En: Universidad Nacional de San Martín y Fundación Innovación Tecnológica (FUNINTEC). *Programa Futuros: Escuela de Posgrado: Agua + Humedales*. (Serie Futuros). Buenos Aires: UNSAM Edita.

Área de conocimiento
Área: Recursos naturales
Categoría: Ciencias ambientales e ingeniería
Palabras clave: POLÍTICA GUBERNAMENTAL; GESTIÓN DE LOS RECURSOS HÍDRICOS; ECOHIDROLOGÍA; CUENCA DE DRENAJE; PREVISIÓN HIDROLÓGICA

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RESUMEN

La relevancia del enfoque de la gobernanza de las cuencas hidrográficas en relación con la Gestión Integrada de los Recursos Hídricos (GIRH) ha sido señalada por varios autores, organismos estatales y en foros internacionales. Tanto en la producción de alimentos como en la generación de energía, en el abastecimiento de la población o la recreación y en la producción industrial, la disponibilidad de agua de calidad es clave para la economía de las cuencas. La gobernanza de las cuencas, incluyendo la disponibilidad y seguridad del agua, la vulnerabilidad, los actores involucrados y la participación pública, es un proceso fundamental y estratégico. El planeamiento estratégico, la legislación sobre el uso del agua y la mejora de las bases de datos y la capacidad de predicción son acciones fundamentales. La gobernanza del agua debe ser abierta y transparente, inclusiva y comunicativa, coherente e integradora, equitativa y ética. Para llevar la GIRH al nivel de las cuencas hidrográficas, debe comprenderse la interconexión entre los sistemas naturales y sociales. Además, se debe cuantificar la brecha entre los múltiples usos humanos de los recursos hídricos y el volumen adecuado para el funcionamiento del ecosistema. El monitoreo en tiempo real, las mediciones de las cargas provenientes del uso del suelo y las imágenes satelitales brindan herramientas importantes para la gobernanza del agua. La investigación ecológica continua sobre las cuencas hidrográficas es clave para este enfoque. Dado que las cuencas son sistemas complejos, la investigación ecológica a largo plazo es esencial para entender tal complejidad y traducirla en aplicaciones prácticas.

Palabras clave: *Cuencas hidrográficas; gobernanza del agua; ecohidrología; monitoreo; investigación ecológica continua.*

ABSTRACT

The watersheds approach for governance regarding the Integrated Water Resources Management (IWRM) has been stressed by several authors, international forums and government agencies. Either as a fundamental component of food production, energy, public water supply or recreation as well as industrial production, the watershed economy is strongly dependent on the availability of water of good quality. The watershed governance, considering water availability, water security, vulnerability, stakeholders and public participation, is a fundamental and strategic process. Strategic planning, watershed regulation on water uses, improving data bases and capacity of prediction are key actions. The watershed water governance should be open and transparent, inclusive and communicative, coherent and integrative, equitable and ethical. In order to advance the IWRM at a watershed level, linkages between social and natural systems must be better understood. It is also necessary to quantify the gaps in knowledge between multiple human uses of water resources and the adequate volume for ecosystem functioning. Real time monitoring, measurements of loads due to soil use and satellite images are important tools for water governance. Sustained Ecological Research at the watershed level is one key component of the advanced watershed approach. Since watersheds are complex systems, Long Term Ecological Research is a fundamental tool to understand this complexity and translate it to practical applications.

Key words: *Watersheds; water governance; ecohydrology; monitoring; Long Term Ecological Research.*

New perspectives in the watershed approach for water management[1]

José Galizia Tundisi[2]

1. Introduction

The watershed approach as a basic unit for water management has been adapted worldwide already in the last decades of XX century.

The economy of the watershed is dependent upon the water availability, the relationship availability supply to demand for multiple uses and the water quality. Management of the watershed implies in the incorporation of all components of this ecosystem population, water multiple uses, industries, food and energy production, recreation, tourism and navigation; social structures, culture are other basic components. All these components interact directly or indirectly and the scientific knowledge of these interactions is a key element of the management process [1].

Water governance of the watershed, based on water security, accessibility, water availability, water demand and vulnerability is an advanced process that involves technology, expertise, capacity building and interdisciplinary [2].

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1 Acknowledgments - The author is grateful to Fapesp (Fundação de Amparo a Pesquisa do Estado de São Paulo) Process Number: 51502-3/2012 and CNPq Process Number: 403820/2012-0. For finantial support (Projeto PELD – Pesquisas Ecológicas de Longa Duração).

2 Instituto Internacional de Ecologia, São Carlos/Universidade Feevale, Novo Hamburgo, RGS/INCT-Acqua-MCT. Brasil.

2. Evolution of the watershed unit as basic concept for water governance

In the last decades of the XX century the watershed was adopted as a management unit. This was conceptually developed already in many countries, eg. France, Germany, but the adoption of the watershed for water resources management was developed worldwide and described in official documents of international organizations and seminars [3]. The concept is consistent: the watershed is a biogeophysical unit with natural boundaries where water flows throughout the hydrographic network of rivers, creeks, natural channels, wetlands [4]. The components of the watersheds in the space of its boundaries are distributed accordingly to geomorphological features, altitude, river origins, water flux. These components all interact among themselves. Furthermore, the human activities such as soil uses for agriculture, reservoirs for irrigation and energy production, industries, urban areas, interact with the natural systems. This is a systemic and articulated view of the watershed. Its natural and artificial-human made components and interactions is essential for an integrated water resource management initiative [5].

The conceptual basis for a watershed approach was a consequence of the impossibility to manage water resources at the aquatic ecosystem level: rivers, reservoir, lakes, wetlands, estuaries. The extension of the management to the watershed has its roots, most probably, in the work of Vollenweider [6] which introduced around 1968 the concept of load from the nutrient input originated in the soil uses (diffuse load) or wastewater discharge (point load).

The advance of the concept was a key component in the water management at the end of the XX century and introduced immediately news and innovative capabilities of integrated water management towards the XXI century [7].

3. The watershed approach for management: strength of the concept

The watershed approach a biogephysical unit introduced several new perspectives for management, such as:

- It is a biogephysical unit with well-defined boundaries, extending for several spatial multi scales, from small watersheds of 50,100,200 km^2 to large watershed such as the La Plata basin (3 million km^2).

- It is a hydrologically integrated ecosystem with components and interactive subsystems-natural and artificial.
- Allows a Rational organization of a data bank on climatological, hydrological, limnological, water quality, soil uses, population growth, and economy.
- Promotes alternatives for conservation activities, and adequate conciliation between economic development and protection of natural resources.
- Promotes the necessary institutional integration: municipalities, private initiatives such as farms, industries, universities and research centers. This institution aggregation in fundamental for the strategic planning of the watershed towards the future. [8]
- Stimulates the participation of communities in a well known region – The watershed-where they live in and share the resources – water, soil, food, recreation.
- Promotes a systemic overview of a natural area and stimulates the capacity building of managers, decision makers, the general public in order to participate in legislation, fiscalization, regulations, technical applications.
- Stimulates the population in participative and collective actions for environmental education, and conservation.

4. Main challenges of the watershed approach and concept

The watershed as a unit of integrated water resource management is a fundamental concept for strategic planning of the future use of the water resource-surface and underground. As such the watershed management has to incorporate three levels of integrated management: The *organization level, the constitutional level, the operation level* [9].

- The *organizational level*, coordinates and reduces conflicts between competitive uses and the various stable holders: this is the watershed committee, the watershed agency. It is this level that is responsible also for the strategic planning of the future use of water resources. It is important that the watershed committee transcends governants changes.
- The constitutional level reports to the existing legislation, to the water quality classification of the water bodies accordingly to the multiple uses, and the territorial planning.

◗ The operational level has the focus on the diversity of the existing systems: natural forests, wetlands, urban areas, agricultural and industrial areas, rivers, artificial reservoirs. The maintenance of infrastructure, wastewater treatment, protection of natural areas, control of contamination is the responsibility at this operational level public on private [10].

◗ The ideal integrated water resources management at watershed level, has a conceptual basis a society of the watershed, with common interests including planning, management actions in the same systemic view, structural, functional, operational [11]. Related to this. The directives for the Water Management of the Europe, Union 2000 [12] are:

◗ All member states will identify their watersheds and must assure that these units will have a Management Plan.

◗ On the environmental question: All member states will protect and restore their aquatic ecosystems, the underground waters and assure that good water quality will be achieved in 15 years.

◗ All member states should include in their costs of water management the environmental costs, the principle of pollutant-pay, and promote incentives for efficient use of water resources.

◗ All member states are stimulated to include effective participation of stakeholders; plans, programs and projects should be efficiently informed to the community and open to receive comments, proposals, discussion.

◗ The integration between protection and sustainable management should consider all multiple uses: energy, navigation, tourism, fisheries, as well as regional policies.

◗ On dangerous substances: The European Parliament should secure specific actions and legal measures to contain pollutants or groups of pollutants that present risk of toxic substances, with the progressive reduction of and cessation of all discharges and emissions.

◗ Further challenges in the Watershed management include [13]:

◗ Integrate the three components of water availability: surface, underground and atmospheric.

◗ Indentify and quantify the demand and establish criteria for multiple uses of water and license for water uses.

◗ Determine the main indicators of watershed: water quality of surface waters; aquatic and terrestrial biodiversity; contamination of surface and underground waters; pollutants load; nutrients load; eutrophication status of rivers, lakes, reservoirs.

◗ Promote the information system on water resources.
◗ Classification of water bodies related to main uses.

Integrated urban water management. The difficulty in the management of water resources in urban areas is the lack of coordination of the different municipalities agencies (Tundisi *et al.* 2015).

5. Technological advances

During the last three decades of the XX century, several new sub-disciplines of ecology aimed to solve environmental problems were developed. These sub disciplines built a bridge from the ecological knowledge towards environmental management [14].

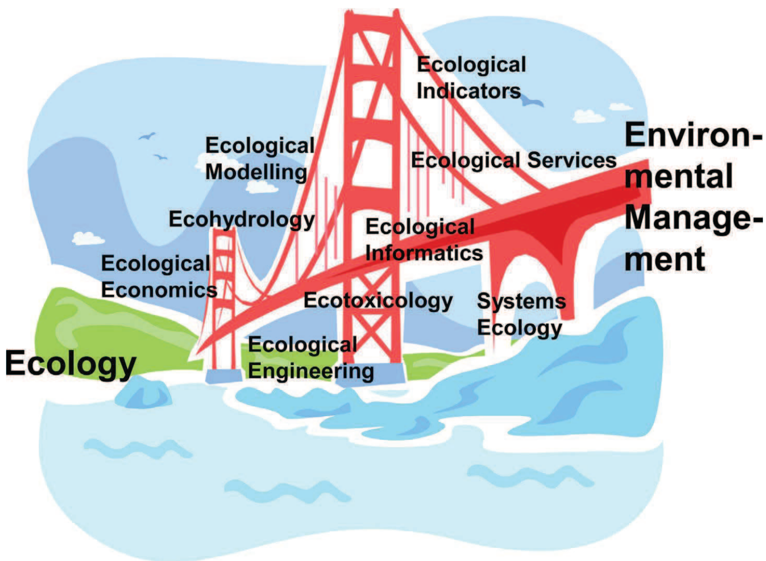

Figure 1. During the last three decades of the 20th century, several ecological sub-disciplines were developed to facilitate the application of ecological considerations in environmental management. They formed literally a bridge between the scientific discipline, ecology and the environmental management that was urgently needed to abate the pollution and environmental problems. Source: Jorgensen, 2016.

The present management of the watersheds should use all these new tools for environmental management.

In particular ecohydrology is a powerful tool and concept: it will help in solving several environmental problems by integrating the "nature software" concepts into the watershed, management; it will be also fundamental in the effort to solve climatic problems that impact watersheds: increasing temperature, extremely weather conditions such as hydrological extremes, and dry periods.

Ecohydrology can be applied to improve the balance, hydrology-biological components – bio technologies (natural wetlands, artificial wetlands, nutrient control).

Ecohydrology will be a useful tool in maintaining ecosystem diversity: aquatic ecosystems, wetlands, natural forests that will act as a buffer against climate change, pollution and contamination.

Ecohydrology will be an important tool in the assessment and evaluation of ecosystem sustainability, ecosystem services, and will be a key concept to the knowledge of interaction between the hydrological cycle and sustainability of ecosystems.

Therefore altogether with the *institutional, participative, information, finance, environmental policy*, applied to the watershed management, the vast technological tools, existing –ecological indicator, ecological economics, ecotechnologies, ecosystems services, ecological modeling, systems ecology– should be extensively used to promote the bridge between the ecological knowledge and the environmental management.

As pointed out by Zalewski [15] the management of a watershed has to be based on a multidimensional goal integrated in the following areas: water resources, biodiversity, ecosystem services, resilience and cultural heritage. Thus the integration of environmental, engineering and social sciences is vital to this watershed concept.

The concept of rivers capes introduced by Wantzen *et al.* [16] "can be regarded as an interface of aquatic and terrestrial conditions controlled by complex interactions of many factors: hydrology, sediment transfer, soil – vegetation dynamics, biogeochemical processes and other biotic interactions and finally by land use and pollution" (sic).

These authors propose the integration of Culture, Technologies, Economy, Governance, centered on rivers as cultural vectors, reducing thus political conflicts and sustain resources on a more equitable basis.

6. The role of monitoring and sustainable ecological research on the watershed management

Monitoring and sustainable research have an important role in the watershed management. Long term ecological research on a watershed and a well-designed and advanced technological monitoring system will provide stakeholders, decision makers and the community with the necessary information of the structure and function of the watershed. Monitoring will help in the detection of impact source; if adequately distributed in spatial/time scales will help in the detection of extremes and disasters of natural on artificial origins (contamination, pollution such as oil spills, industrial discharges).

Integrated monitoring with the use of satellite images, drones real time evaluation of water, quality, climatological and hydrological cycles will be essential to describe the watershed status and its evolutions. Toxicological analysis, bioindicatores are also important tools. Long term ecological research will promote the knowledge on biodiversity status, ecosystem services, structure and functions of aquatic and terrestrial system and will sets up the basic science concept of the watershed as a complex, dynamic and interactive. Long term ecological research should be the responsibility of Universities and research institutes.

7. Conclusions

The integrated water resources management based on the watershed concept and approach as a unit is an advanced tool for the future of water management. Surface and underground waters are used for human consumptions, industrial application and processes and generation of hydropower as well as tourism and recreation, food supply or irrigation. Plants, animals and ecosystems consume water. Applied to surface and underground sources of water, the basic demands for quality of life include: i) protection from floods and droughts; ii) protection from water based and water borne diseases; iii) water of good quality; iv) production of food from lakes, rivers and reservoirs.

Public perception on water quality and of water for multiple uses is based on visual factors as primary determinants of water quality. Also the perceptions of multiple use of water are related to the proximity of the residence near a water body. This is why a culture and concept of watershed are so important for water management. People are living in a watershed with specific boundaries and frontiers. The management of the watershed should include, technical, political, institutional and people's participation to be effective. Watershed management in the future has to stress and support strongly these components, the systemic vision and the planning strategy based on the water availability, water demand, watershed economy, society participation.

New and advanced technologies should include a bridge between ecology and environmental management incorporating several disciplines and tools. Long term ecological research strong science basis advanced monitoring will complete the basic data necessary for an advanced and integrated water resources management at watershed level [18, 19].

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