SUSTAINABLE WATERSHED MANAGEMENT

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CRC Press
Taylor & Francis Group
A BALKEMA BOOK

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PROCEEDINGS OF THE SECOND INTERNATIONAL CONFERENCE ON SUSTAINABLE WATERSHED MANAGEMENT (SUWAMA 14), SARIGERME, TURKEY, 13–15 OCTOBER 2014

Sustainable Watershed Management

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CRC Press
Taylor & Francis Group
Boca Raton London New York Leiden

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business
A BALKEMA BOOK

Cover photo: Dalyan Lagoon, Turkey, courtesy of Nil Koray YILMAZ

CRC Press/Balkema is an imprint of the Taylor & Francis Group, an informa business

Typeset by MPS Limited, Chennai, India
Printed and bound in Great Britain by CPI Group (UK) Ltd, Croydon, CR0 4YY.

Published by: CRC Press/Balkema
P.O. Box 11320, 2301 EH Leiden, The Netherlands
e-mail: Pub.NL@taylorandfrancis.com
www.crcpress.com – www.taylorandfrancis.com

ISBN: 978-1-138-00018-6 (Hardback)
ISBN: 978-0-203-76470-1 (eBook)

Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
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Preface

The Sustainable Watershed Management Conference 2014 (SuWaMa 14), Sarigerme, Turkey was the second in a series of Sustainable Watershed Management Conferences. The objective of the Conference Series is to present and discuss advanced environmental models and contemporary decision support tools for the sustainable use and development of watersheds. This objective was accomplished with a view to evaluate, improve, and share developments from around the world.

In addition to the overarching objective, SuWaMa 14 focused on a number of specific points identified by participants. Scientists from all over the world shared knowledge on tools for assessment, prediction, and decision making. Transboundary environmental issues (e.g., air pollution, climate change) were considered. Model applications that identify how to minimize and mitigate anthropogenic effects on the natural capital of watersheds and sustain socioeconomic systems by balancing economic and environmental issues were presented. The use of decision support tools and integrated ecosystem approaches that benefit both humankind and the environment were discussed. Further, group sessions built on the Principles and Terms of Good Watershed Management developed at the first conference, which are in the SuWaMa 11 Declaration. The Terms and Conditions were used to establish criteria for global recognition of individual sustainable use and development of watershed management programs.

The SuWaMa 14 Conference outcomes:

- Scientific knowledge shared by internationally acclaimed scientists.
- Integration and free exchange of information and data fostered from around the world.
- Networking of experts and stakeholders across and throughout the participating countries.
- Expanded use of advanced environmental models and contemporary decision support tools for sustainable use and development of watersheds.
- Promotion of a global perspective on transboundary issues including air pollution and climate change.
- Understanding of the economies of scale for higher levels of environmental protection at a lower cost by evaluating global, continental, and regional models.

In conclusion, there is a growing feeling of urgency, a sense that we are at a tipping point, a critical moment for addressing the range of environmental issues that come to be reflected in our watersheds, and in the quality and quantity of our water. It is increasingly clear that the issues that we face are serious ones, requiring innovative ideas and committed attention, and that there is a limited window of opportunity to focus concerns into meaningful actions. SuWaMa 14 sharpened the international effort to take constructive steps directed at sustainability in watershed management.

The editors

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Acknowledgements

The Sustainable Watershed Management Conference Series was founded based on three principles:

- Independence from influence – there were no political affiliations or organizational funding.
- Science-based decision-making – sound science-based management directed at sustainability of natural resources.
- Education – commitment to professional development particularly of young scientists as well as all involved with watershed management.

The SuWaMa 14 Conference Proceedings is a product of the hard work of many individuals from around the world who participated in the conference. This includes those who made presentations and those who worked diligently prior to the conference and behind the scenes at the event.

The conference and this book would not have been possible without the dedication of the SuWaMa Scientific Committee: Prof. Dr. Amir Sadoddin (Iran), Prof. Dr. Angheluta Vadineanu (Romania), Prof. Dr. Antonio Marcomini (Italy), Prof. Dr. Björn Klöve (Finland), Prof. Dr. Bojan Srdjevic (Serbia), Prof. Dr. Jose Paulo de Azevedo (Brazil), Dr. Lewis Linker (USA), Prof. Dr. Ramiro Neves (Portugal), Dr. Raymond Walton (USA), Prof. Dr. Selmin Burak (Turkey), and Prof. Dr. Yvonilde Dantas Pinto Medeiros (Brazil).

Critical to the conference was the work accomplished prior to the event by the Organizing Committee: General secretary Zeynep Akgün (Turkey) and members Assoc. Prof. Ali Ertürk (Turkey), Dr. Alpaslan Ekdal (Turkey), Defne Gönenç (Switzerland), Gökhan Cüceloğlu (Turkey), Assoc. Prof. Melike Gürel (Turkey), Assoc. Prof. Nusret Karakaya (Turkey), Chair Prof. Dr. I. Ethem Gonenç (Turkey), and co-Chair: John P. Wolflin (USA).

Supporting organizations were important in notifying professional scientists around the world. We are indebted to:

- Environmental & Water Resources Institute (EWRI), ASCE, USA
- IGEM Research & Consulting, Turkey

Special thanks goes to publisher CRC Press/Balkema, specifically Alistair Bright, Acquisitions Editor and Ms. José van der Veer, Production Editor.

We dedicate the conference and this book to those responsible for watershed management worldwide. We hope that this initiative will continue to sharpen efforts to take constructive steps directed at sustainability in watershed management on a global basis. We also are grateful for the summer offshore breezes, called "*imbat*" in the Aegean countries, which sustained us during our work.

I. Ethem Gönenç, John P. Wolflin & Rosemarie C. Russo

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Section 1: Keynotes

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An emerging multi-level SPSI for sustainable management of the Romanian watersheds

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EXTENDED ABSTRACT

Over the last 23 years a wide range of science – policy interfaces have been established across space and political levels, as key elements of environmental governance. Within this context the need for comparative research of the existing SPI[s] aiming for their classification and mapping, and identification the strengths and shortcomings of their structure and functions, as well as major challenges for further conceptual and operational improvements has been widely accepted. The comparative assessment of a representative sample for the full spectrum of SPI[s], supporting the environmental governance, has shown that they have a formal and institutionalized statute or they are informal and more flexible. They can operate at different political levels and at different stages of the policy cycle or they can be closer to policy or scientific processes (Young et al. 2013). Moreover the comparative analysis clearly showed that defining and designing the interfaces aiming for environmental governance, evolved from the initial conceptual framework which looked at science and policy as more or less independent domains of human activity to the model of unidirectional link between science and policy or one way flow of scientific knowledge to policy and decision makers, neglecting traditional knowledge and technical expertise owned by many stakeholders, and to the most recent conceptual framework of two ways flow and dynamic interfaces which can be established at the intersection between science, policy and society (Cash et al. 2003, van den Hove 2007, Perrings et al. 2011, Young et al. 2013). In parallel to the growing interest around SPI[s] in terms of practices and discourses, an increasing attention was given, in particular in the recent years, to theoretical aspects regarding: i) the environmental governance and multi-level integration (Paavola 2007); ii) social learning and responsibility as primary governance mechanism (Reed et al. 2010); iii) the domains of intersection between science and policy as well as the critical attributes of scientific knowledge reflecting its complexity, uncertainty and indeterminacy, and the balance between issue – driven vs. curiosity – driven science (van den Hove 2007) and iv) the interpretative approaches in the analysis of science – policy interactions (Wesselink et al. 2013).

The "Science – Policy Interfaces for Biodiversity: Research, Action, Learning (SPIRAL)" is one of the EU – FP Collaborative research project, which brought significant theoretical and methodological contribution to the complex process of designing, implementation, assessing and adapting effective SPSI[s] in the field of biodiversity and environmental governance. One of the SPIRAL objectives addressed the need to experiment and test the basic theoretical and methodological achievements, and to ensure continuous feed-back, in different real-life test cases. To address these aims, the implementation of the EU-Water Framework Directive in Romania has been selected as one of the test cases. In that regard intensive and extensive contacts and discussions have been carried out between members of the UB research team and policy and decision makers at national (6), regional (8) and local (15) levels (policy side) and open-minded leaders of the academic and research organization around the country (25) (science side) as well as with representatives of key

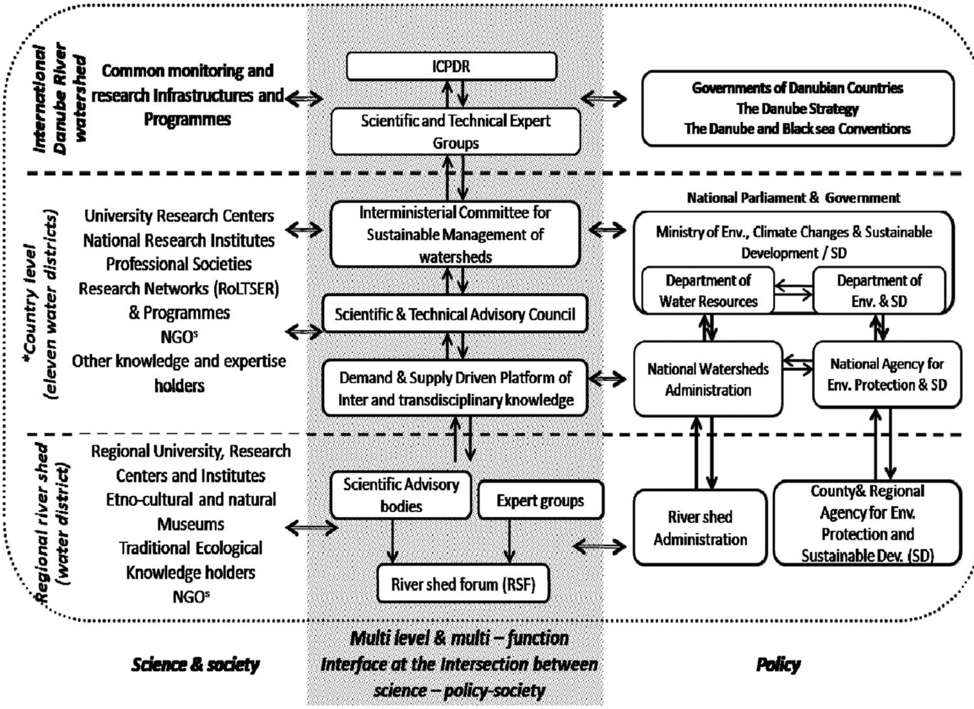

Figure 1. Multi space scales and policy levels of the Institutional arrangement at the Science – policy – Society intersection for sustainable Watershed Management (case test of WFD implementation in Romania).
*Romanian watersheds belong to mid and lower Danube River Watershed.
ICPDR – International Commission for the Protection of Danube River.

stakeholder groups (30) (society side).The presentation highlights the basic scientific principles and assumptions underpinning the applied conceptual and operational frameworks, and the key results of three years investigation on the changing landscape of water SPI^{s} driven by very dynamic policy and institutional context. According with recent theoretical achievements in the global science of Systems Ecology and Sustainability the quality and quantity of surface and ground waters and the structural and functional integrity of the inland and coastal water ecosystems has been defined in terms of the trade-offs of long term integration of the cumulated stress of both human and natural drivers acting at/and across watersheds (Nienhuis et al. 1998, Vadineanu 2009, Gonenc et al. 2008).

Such holistic conceptual framework enables better identification and understanding the complex and dynamic relationships within and among social-ecological systems established in the nested watersheds as well as better interpretation of the overall goal and provisions of the EU – WFD. This allowed to wider the interpretation of the stated WFD's goal and to briefly describe it in terms of sustainable watersheds management which certainly goes beyond the prevailing narrow interpretation of the former. Complementary, has been assumed that: designing, implementation and continuous improvement of the connectivity and interaction at the intersection between science – policy – society can influence the behavior and decisions of the policy makers, scientists and other society actors leading to more policy relevant research and to better informed policies, that in turn is expected to facilitate effective sustainable management of watersheds and; a multi level and multi space scale SPSI can provide the operational support (e.g. co-production of transdisciplinary knowledge; policy instruments, wide participation, social learning) which allow to achieve effective synergy and/or integration among sector oriented environmental policies. Under such circumstances, special attention has been paid to the new designed and tested SPSI (Fig. 1) which is expected to facilitate:

i) integration of most important environmental policies at watershed scale; ii) to establish effective alliance between scientists, policy and decision makers, many other stakeholders and public; iii) communication, learning, co-production and jointly use of inter and transdisciplinary knowledge and; iv) to create conditions for sustainable management and development across nested watersheds.

The analysis clearly showed that the efficiency of former water SPI components, established during the preparatory phase for EU accession (2001–2006) and soon after becoming full member (January 2007) of the EU, to implement the basic WFD's standards and targets has been constrained by key limitations related to: i) understanding and implementing innovative concepts, approaches and tools such as biodiversity, ecosystem services, Good Ecological Status (GES) and Potential (GEP), ecological indicators, integrated or holistic approach, extended economic valuation by including critical ecosystem services; ii) the capacity to deliver reliable and relevant inter and transdisciplinary knowledge; iii) the capacity to involve a wide range of stakeholders, both from science and non-science sectors; iv) weak connectivity and coordination among former and newly established SPI components; v) the absence of well defined and effective process to bridge between science and people on one hand, and between science and key policy bodies on the other hand. The designed and tested SPSI proved to allow overcoming most of the limits of former SPI components. Thus, has been already noticed that such architecture better facilitates: balancing membership and power relations; multi-disciplinary and transdisciplinary integration of most relevant scientific and traditional knowledge and expertise and; flexible combinations among science, society and policy driven functions. The composition and multi-level structure of the SPSI enables continuous and iterative policy support, maintenance of high networking potential and dynamic membership which assure adaptation to the changing policy and economic context. Moreover open scientific and policy debates among science and policy experts, and diverse stakeholders are the main mechanism used to manage cross sectoral conflicts or to buffer power relations. By 2007 most of the policy makers and scientists who were involved in WFD implementation shared sectoral and short term vision, reductionist approach and conventional tools. Thus building and improving specific capacity for WFD implementation at and across watersheds, has been viewed as a long term objective. In that regard, two initiatives were launched: one dealing with the development of the cyber infrastructure and information system which is aimed for integration and flow of the reliable data and knowledge in the policy cycle, and second, dealing with development and implementation of transdisciplinary curricula (in particular master and PhD) and short training courses aiming at education and training a new generation of policy and decision makers, and scientists better skilled to understand complexity and to address water and related policies issues at large space and time scales.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Chehalis river basin management studies

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ABSTRACT: The Chehalis River basin in southwest Washington State, USA, has a long history of flooding. These floods have caused severe hardship for the residents of the basin, and have included the closure of the major north-south transportation route from Washington to California. For years, various agencies have considered a range of flood reduction and flood warning measures. Recently, a number of studies have been done to look at early flood warning, hydrologic and hydraulic modeling for flood reduction and habitat restoration studies, and the potential impacts on fish habitat and fish passage from alternative flood reduction projects. Alternatives considered have included an upstream retention dam, levees around the Twin Cities and regional airport, and levees along Interstate 5. This paper discusses the various basin-wide studies undertaken to reduce flood impacts, increase flood warning, and environmental assessments that are designed to maintain the rivers fisheries and environmental restoration activities. This work is ongoing as studies continue to examine flood control alternatives, and the effects of a potential upstream impoundment on fish habitat and populations.

1 INTRODUCTION

The Chehalis River Basin is Washington State's second largest basin at 6,890 square km (Figure 1). Elevations range from over 3,000 feet in the headwaters, to 170 feet near the Twin Cities of Centralia and Chehalis, to sea level at Grays Harbor. Floods typically occur from November-February, and are often driven by atmospheric river (or "Pineapple Express") weather systems that tap moisture from the tropics and funnel it to western Washington, resulting in heavy precipitation (Figure 2). Major floods in 1990, 1996, 2007 and again in 2009 impacted the basin's citizens. The closure of Interstate-5 (Figure 3), the major highway between Washington State and California, can result in detours for large commercial vehicles of up to seven hours over the Cascade Mountains. Of these recent floods, the 2007 flood was an estimated 500-year flood that inflicted more than $166 million in damage, killed an estimated 1,600 livestock, and shut down Interstate-5 for four days.

In response to the 2007 flood, stakeholders formed the Chehalis River Basin Flood Authority in 2008 to address the basin-wide flooding impacts. Currently, the Flood Authority consists of three counties, seven cities, and the Chehalis Tribe of Indians. The purpose of the Flood Authority is to improve flood preparedness and to develop flood reduction alternatives. However, flood reduction alternatives have also to consider the treaty rights of the Chehalis and Quinault Tribes, which provide for fishing allocations and the preservation of fish habitat in the Chehalis River. With State and Federal funding, the Flood Authority, and more recently, the Chehalis Basin Work

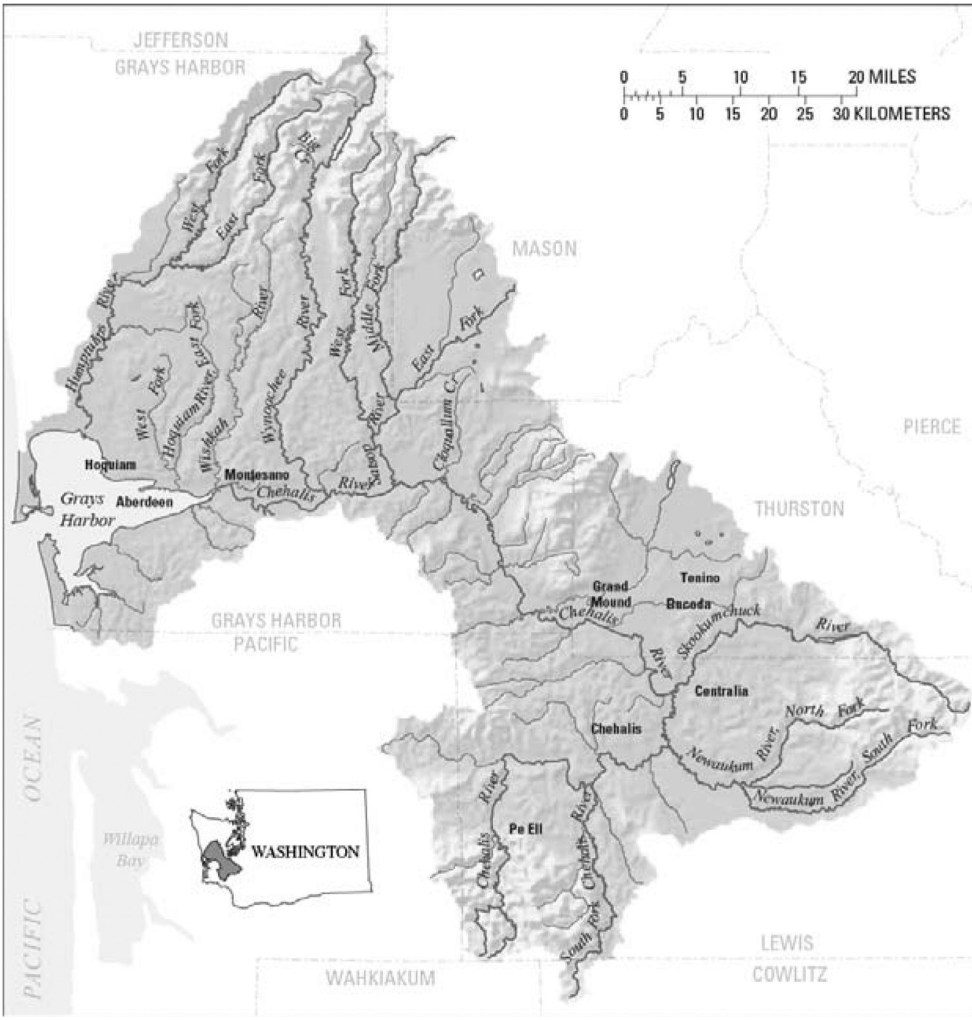

Figure 1. Basin location in Washington State, USA.

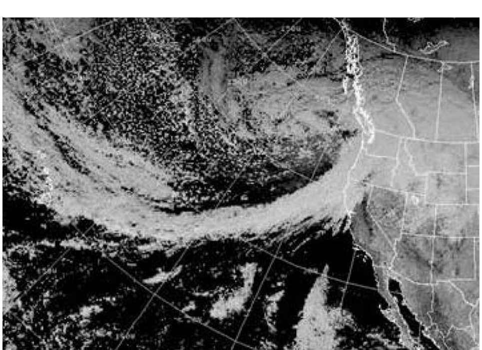

Figure 2. Atmospheric river that caused December 2007 flood.

Figure 3. Interstate-5 during December 2007 flood.

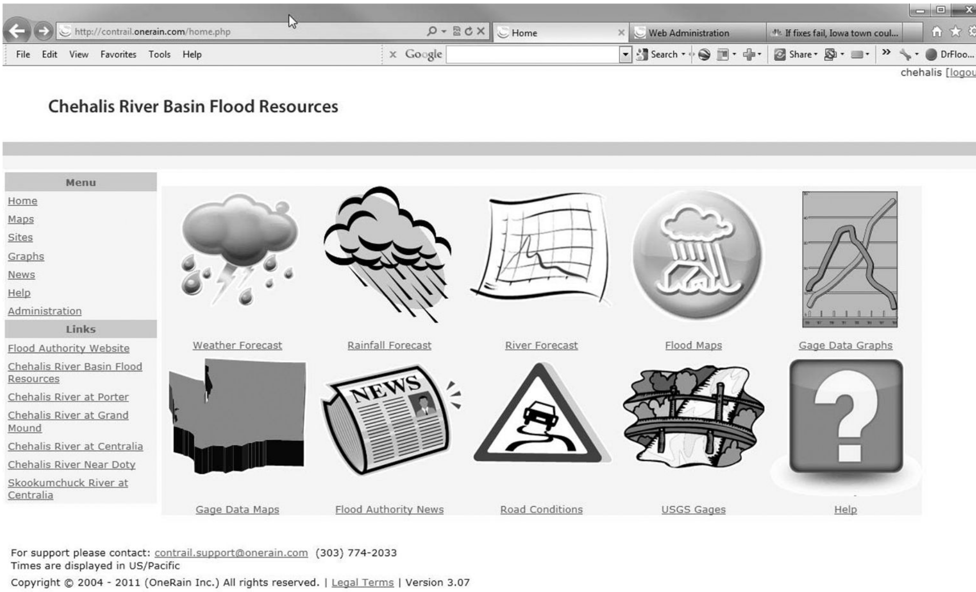

Figure 4. Chehalis River Basin Flood Warning System homepage.

Group, have conducted a number of studies, include early flood warning system improvements, the identification and analysis of flood reduction alternatives, and the impact of fish populations and fish habitat if an upstream flood retention facility were built.

2 EARLY FLOOD WARNING SYSTEM UPDATES

The Flood Authority identified the need to improve early warning to help avoid some of the catastrophic impacts of previous floods. The region required a more reliable information network than what had become a "word of mouth" warning process. Flood Authority consultants, WEST Consultants, worked with community groups, Indian tribes, and local governments within the basin to assess their current flood preparedness practices and needs. In addition, flood forecasting and related programs of the National Weather Service (NWS), the U.S. Geological Survey (USGS), the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), and the Washington State Departments of Ecology and Transportation were reviewed.

The findings led to a plan for improving the identification of flood threats, agency coordination, and communication with the public. The plan included a web-based data collection, visualization, and dissemination tool, plus the installation of additional rainfall, temperature and river monitoring gauges to fill gaps in the existing observation network in the Chehalis River Basin.

The new flood warning system collects existing hydrometeorological sensor data from a variety of sources in and near the basin. The addition of 10 new rain gages, 10 new temperature sensors, and two additional stream gages helped fill identified gaps in the data network. All of the hydrometerorological stations in the Chehalis River Flood Warning System report via the GOES network. The new rain, temperature, and stream gages report 15-minute data each hour and are programmed to report more rapidly if conditions warrant.

Flood inundation maps help the public, as well as government officials, better understand where flooding is to be expected at each forecasted river stage. Flood maps were prepared from existing hydraulic models along the Chehalis River and major tributaries. Areas of inundation were prepared for river reaches associated with NWS forecast points. Maps were developed at 1–2 foot intervals

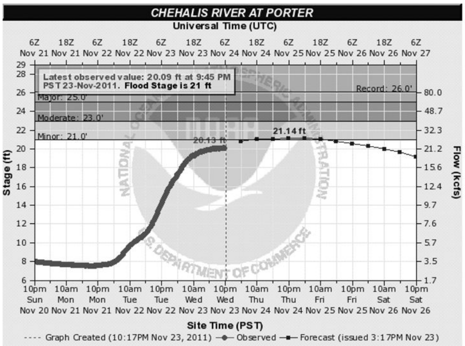

Figure 5. National Weather Service forecast for the Chehalis river at Porter, WA.

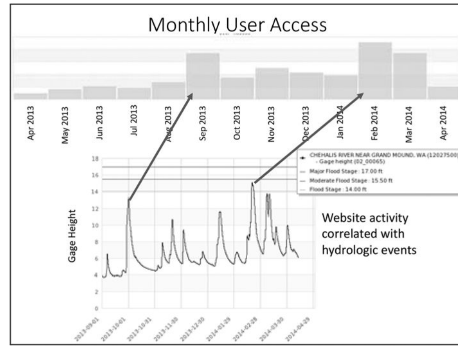

Figure 6. Monthly user access to Chehalis river Flood Warning System.

that spanned the range of action, minor, moderate, and major flood stages as defined by the NWS. The website provides real time access to flooding mapping data, putting the information in local context, allowing residents to be better prepared.

The Chehalis River Basin Flood Warning System received its first test during a period of significant rain just prior to Thanksgiving 2011 that resulted in localized minor flooding. From November 20–26, 2011, up to ten inches of rain fell in the basin resulting in significant rises along the main stem Chehalis and tributaries. Fig. 5 shows an NWS river forecast for minor for the Chehalis River at Porter, WA. Higher stages were forecast early in the event but the expected rainfall moved north of the Chehalis; saving the basin from further damage.

The November 2011 event occurred just one week after the public rollout of the Chehalis River Basin Flood Warning System through a series of news releases, public meetings and trainings. Basin residents and government officials both reported using the system during the flood and provided important feedback for further improvement.

Since the flood warning system rollout in 2011, more and more users are accessing the system for the latest flood information. Figure 6 shows monthly user access from April 1, 2013 through April 16, 2014. As expected user interest and website access peaks during high water events. User accesses in February 2014 were about 400% higher than accesses during a similar high water event in 2011.

3 FLOOD REDUCTION ALTERNATIVES

In 2011, as part of the capital budget, the Washington State Legislature directed the Office of Financial Management to prepare a report on alternative flood damage reduction projects and — in coordination with tribal governments, local governments, state and federal agencies — to recommend priority flood hazard mitigation projects in the Chehalis River Basin for continued feasibility and design work. The purpose of the report was to provide the Washington State Legislature and other decision makers with information to set the course for effective solutions to reduce the adverse impacts of flooding in the Basin and, at the same time, support the economic prosperity of communities in the Basin and the protection/restoration of fish and other natural resources.

To enable the quantitative assessment of flood reduction alternatives (and for other purposes, such as restoration analyses), the Flood Authority (through Watershed Science and Engineering and WEST Consultants, 2012) and the U.S. Army Corps of Engineers (through WEST Consultants, 2012) funded the development of a detailed hydrologic and hydraulic analysis of the Chehalis Basin. Using HEC-RAS, an unsteady flow model was developed for 108 miles of the Chehalis River and some of the major tributaries, including 50 miles of the Wynoochee River, the Newaukum River, the Skookumchuck River, and a number of small streams (Figure 7).

Figure 7. HEC-RAS model sections for Chehalis river hydraulic model.

To provide hydrologic input for the hydraulic model, data from 15 USGS streamflow gauges were analyzed to estimate the inflow hydrographs from gauged and ungauged subbasins. The analysis consisted of flood frequency analyses at gaged sites, comparing gauges with long-term and short-term records, and the use of similar basin methods. These procedures were used to develop inflow hydrology for the major floods of 1996, 2007, and 2009, and to estimate inflows from subbasins that would result in the 1%-annual-chance event in the Twin Cities area; a focus of flood reduction studies. The model was calibrated and validated to these historic events along the length of the Chehalis River and major tributaries, and then used to simulate the hydraulic changes from a number of potential flood reduction alternatives. Potential large-scale, construction-intensive projects include:

- Upstream retention on mainstem Chehalis (with and without airport levee improvements)
- Corps Twin Cities Levee and Dam Modification Project
- WSDOT I-5 flood protection project
- Mellen Street and Scheuber Road (high-flow) Bypasses
- Channel Dredging (Mellen Street to Lincoln Creek Confluence)
- Complete Bridge Replacement Option
- Specific Bridge Replacements

Following initial simulations of individual flood damage reduction projects, projects were grouped into combinations and simulated to evaluate their cumulative impact on flood levels. The following alternatives were selected for final modeling and analysis:

A. Mainstem Dam on the Chehalis River, Airport levee improvements, small floodwall along I-5 near Dillenbaugh Creek, Skookumchuck Levees, Sickman Ford Bridge modification, and Wakefield Road (South Elma) Bridge Modification.
B. Same as Alternative "A" with the addition of WSDOT's proposed I-5 berms and floodwall protection project.
C. WSDOT's I-5 berms and floodwalls, Airport levee improvements, Mellen Street and Scheuber Road Bypasses, Skookumchuck Levees, Sickman Ford Bridge modification, and Wakefield Road (South Elma) Bridge Modification.

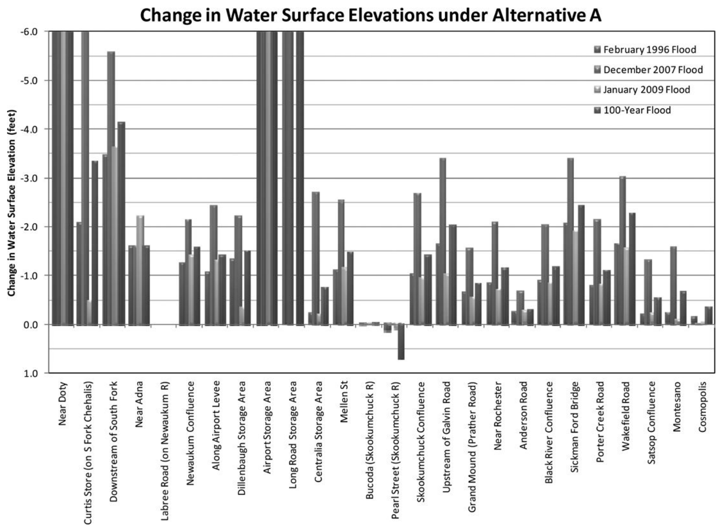

Figure 8. Change in water surface elevation under Alternative A.

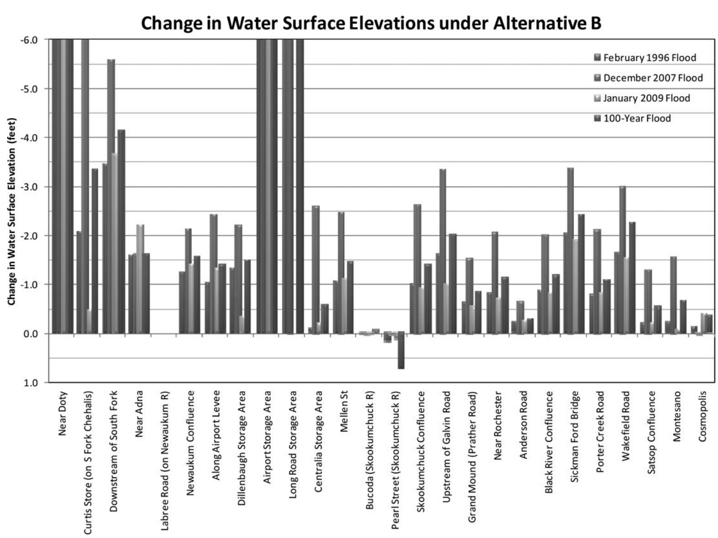

Figure 9. Change in water surface elevation under Alternative B.

3.1 *Basin-wide effect on flooding*

Figures 8 through 10 show the effects on water surface elevations of the combination alternatives at locations throughout the watershed. This graphical presentation of results for the four simulated floods facilitates quick comparisons between the alternatives. As can be seen in the bar charts, Alternatives A and B, which include the mainstem dam, result in lower flood water levels throughout the basin for all of the floods. Other proposed elements of these flood relief alternatives have more localized effects. Alternative C, which does not include the main stem dam, would have no effect on water levels upstream of Highway 603 and would have less overall benefit on reaches within

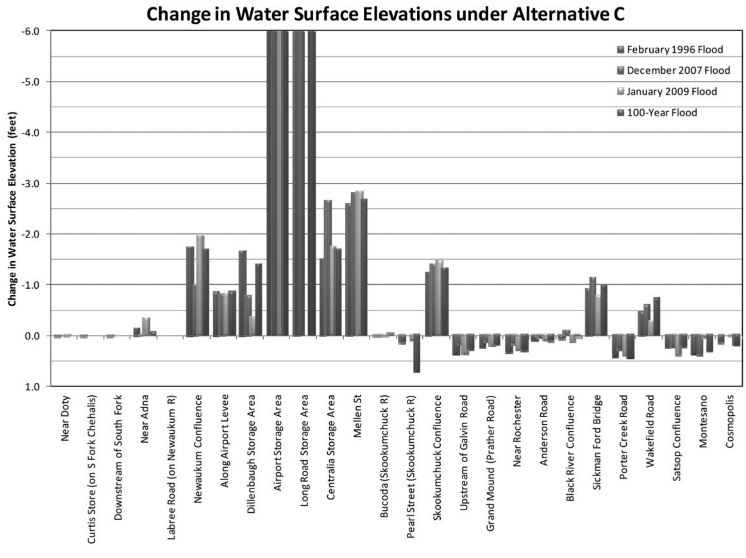

Figure 10. Change in water surface elevation under Alternative C.

the Twin Cities. Downstream water levels would also be generally increased under this alternative with the exception of near the downstream bridge replacement projects.

3.2 *Twin cities inundation mapping*

Figures 11 through 13 show inundation maps for the three basin wide flood relief alternatives (A, B, and C) for the December 2007 flood event. As shown in these figures, the inundated area would be reduced significantly under Alternatives A and B (with the main stem dam). Alternative C, without the dam, tends to increase water levels in some locations while lowering water levels at other locations within the Twin Cities.

4 DISCUSSION OF RESULTS

The results presented above show the level of flood water level reduction that can be achieved through individual flood relief projects and combinations of those projects. Data are presented for four flood events to show how each project or alternative performs in each different types of storm events. The data show benefits and potential water surface elevation impact of each project. Given this information, projects can be refined and alternatives can be configured to address specific flood damage problem areas. The data presented herein is limited to water surface elevation comparisons. Information on depths of flooding can be generated using the model output but this level of analysis was beyond the scope of this study. Ultimately, conclusions regarding flood impacts would need to consider changes in water surface elevation in conjunction with actual depths of flooding. In some cases, a small decrease in flood depth could have significant benefits while in other cases even large reductions might not have much effect. The same is true for water level increases – some locations may not be particularly sensitive to increases (for example areas where flooding is already very deep) while other areas might be particularly problematic. That level of analysis and evaluation of the results will need to be undertaken in combination with information on project costs to define a preferred package of flood relief projects for the basin. The model developed for this study will be helpful to generate the hydraulic data needed to inform that effort.

Figure 11. Twin cities inundation map and flood WSEL changes.

Figure 12. Twin cities inundation map and flood WSEL changes.

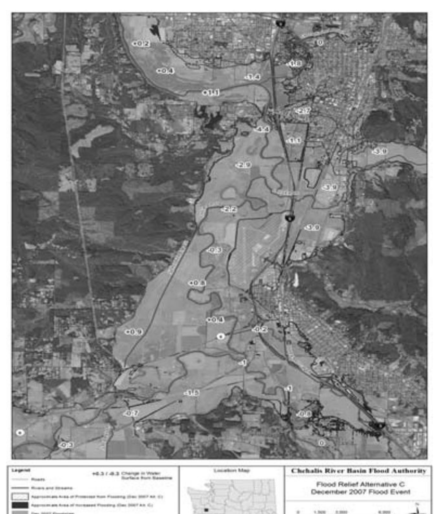

Figure 13. Twin cities inundation map and flood WSEL changes for Alternative C.

5 FISH HABITAT AND POPULATION STUDIES

The Flood Authority evaluated the feasibility of reducing the frequency and severity of flooding on the Chehalis River by means of a flood retention structure on the upper mainstem Chehalis River. The evaluation considers two types of structure: (1) a flood storage-only dam that would

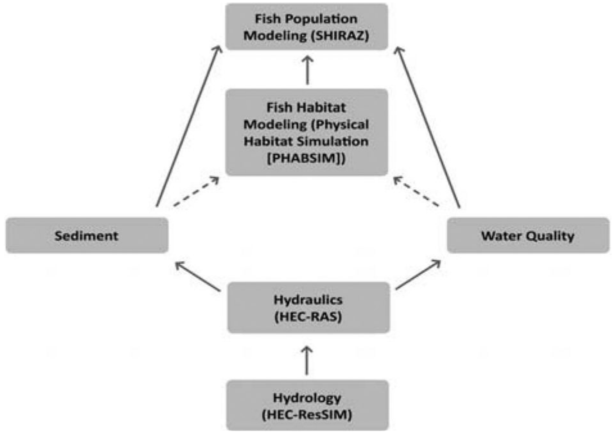

Figure 14. Schematic of fish population studies.

temporarily impound water in a reservoir during a high-flow event for a more gradual release into the lower watershed, and (2) a multi-purpose dam that would provide the same flood capacity as the flood storage-only dam, but would continuously maintain a reservoir behind the dam in order to release flows at rates beneficial to fish and to generate hydropower as a secondary purpose.

The Flood Authority hired Anchor QEA to conduct a study to evaluate the potential effects of the flood retention structure on fish populations in the mainstem Chehalis River between its headwaters near RM 126 and the town of Porter, Washington, at RM 33. The fish study focused on three salmonid species—spring Chinook salmon, winter steelhead, and coho salmon. These species are commercially, recreationally, and culturally important. These species also use spatially diverse areas in the mainstem river and represent a diversity of anadromous life history strategies and habitat requirements. In order to assess the potential impacts on salmonid populations, the fish study included evaluations of hydrology and hydraulics, water quality, sediment transport, large woody debris (LWD), and fish habitat (Figure 14). The information provided by each of these evaluations was used in a salmonid population simulation model named SHIRAZ to interpret potential impacts to fish populations. SHIRAZ is a spatially explicit life-cycle modeling platform that simulates the effects of environmental change on salmon populations (Battin et al. 2007). SHIRAZ uses a set of user-defined functional relationships among habitat characteristics, fish survival, and carrying capacity to evaluate population performance across space and time (Scheuerell et al. 2006). The model is used to translate the effects of changes to habitat quantity and quality resulting from a dam into consequences for salmonid population abundance and productivity in the basin.

Table 1 shows the estimated changes in habitat areas upstream of the proposed flood retention structure. The possible loss of habitat is the main reason that a multi-purpose reservoir was also considered to determine if this loss could be mitigated to prevent substantial fish population loss.

This analysis of the potential impacts of either a flood storage-only dam or a multi-purpose dam on the upper mainstem of the Chehalis River predicted substantial declines for two of the three mainstem salmonid populations studied. The only exception to this finding was the predicted increase in the number of spring Chinook salmon if a multi-purpose dam was installed and operated to maximize suitable fish habitat downstream of the dam through water releases from the reservoir. For spring Chinook salmon in such an optimized multi-purpose dam scenario, the SHIRAZ model estimated increases in numbers of more than 100 percent. For winter steelhead and coho salmon, two species that depend heavily on high quality habitat in the upper watershed, reductions in population numbers of 32 and 28 percent, respectively, were predicted for dam operation at the target fish passage survival rate. Greater population reductions, more than 50 percent, would occur for winter steelhead and coho salmon with poor fish passage survival rates.

Table 1. Fish habitat remaining in the upper watershed with upstream dam.

	Percent of Existing Habitat Area Remaining	
Species and Life Stage	Flood Storage Only Dam	Multi-Purpose Dam
Spring Chinook spawning	4	0
Spring Chinook rearing	51	48
Winter Steelhead spawning	45	42
Winter Steelhead rearing	59	54
Coho spawning	52	46
Coho rearing	50	45

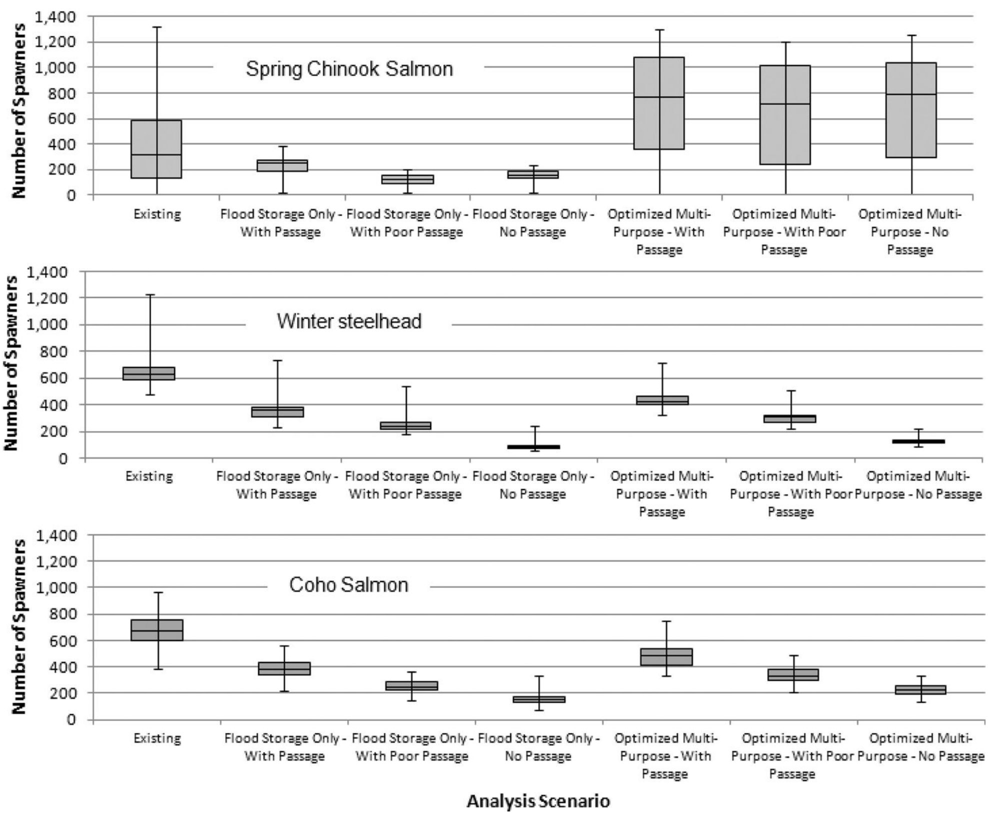

Figure 15. Results of fish population studies.

For the flood storage-only dam, reductions of 22 percent for spring Chinook salmon populations and 43 percent for winter steelhead and coho salmon populations were predicted for operations with the target fish passage survival rate. Reductions of more than 60 percent are predicted for poor fish passage survival conditions. Larger reductions in numbers of spawners were predicted for all three salmonid species in the flood storage only dam compared to the multi-purpose dam.

A water release schedule from a multi-purpose dam that is not optimized to maximize fish habitat for the species and life stages present during different months of the year would be expected to cause larger reductions than those predicted in the optimized multi-purpose dam scenario analyzed in this study. Because the multi-purpose dam scenario that was analyzed optimized flow releases

Table 2. Fish habitat remaining in the upper watershed with upstream dam.

Dam Type	Fish Passage Analysis Scenario	Spring Chinook Salmon	Winter Steelhead	Coho Salmon
No Dam – Continuation of Existing		0%	0%	0%
Flood Storage Only Dam	Target Survival	−22%	−43%	−43%
	Poor Survival	−62%	−62%	−63%
	No Survival	−52%	−87%	−77%
Optimized Multi-Purpose Dam	Target Survival	140%	−32%	−28%
	Poor Survival	122%	−52%	−52%
	No Survival	146%	−81%	−67%

for fish habitat, the analysis would be applicable whether a turbine for hydropower is included at the dam or not. The hydrology and hydraulics analysis estimated that the optimized flow release schedule could support hydropower generation for approximately 200 days per year. A water release schedule with more of an emphasis on hydropower generation would be expected to result in fewer salmonid spawners than reported in the scenarios analyzed in this study

The likelihood of fish passage operations successfully passing salmonids is uncertain, particularly for downstream migrating juvenile salmonids, but has a major impact on the magnitude of population impacts. The results of this analysis suggest that fish passage operations achieving target survival rates (in this study, 80 percent survival of juveniles and 95 percent survival of adults) would be necessary in order to not reduce salmonid populations by more than 50 percent, with the exception of spring Chinook salmon in the optimized multi-purpose dam scenario.

This analysis focused on the mainstem populations of three salmonid species. Either type of dam would also be expected to impact other fish in the mainstem and upper watershed study area, as well as fish populations in the tributaries off the mainstem Chehalis River that may use the mainstem habitats for migration or rearing. For those fish species in the upper watershed, habitat quantity and quality may be detrimentally impacted. For those fish species in tributaries off the mainstem Chehalis River and migrating through the lower mainstem, the augmented low flows provided in the optimized multi-purpose dam scenario may improve habitat quantity and quality. These potential detrimental and beneficial impacts to other fish, as well as other aquatic organisms and wildlife species, should be evaluated in a comprehensive assessment of the environmental impacts of a dam on the upper mainstem of the Chehalis River.

6 DISCUSSION

The Ruckelshaus Center was asked by the Washington State Governor's Office to help the Office of Financial Management–in collaboration with the Department of Transportation, Department of Ecology, and affected and interested federal agencies, tribal governments and local governments–produce a report to the Governor and Legislature that identified recommended priority flood hazard mitigation projects in the Chehalis River Basin in southwest Washington. The Center's tasks are to coordinate the report, using technical information provided by other agencies and organizations, and to conduct a situation assessment of flood alternatives and relationships between the responsible parties and stakeholders.

The studies reported here, and others performed for other State of Washington agencies, including the Department of Transportation, formed the basis for the identification and analysis of flood reduction alternatives presented in the Ruckelshaus report (2012). No conclusions are reported here because the State of Washington legislature is just beginning to evaluate these alternatives. And that is before presenting recommendation to interested parties and beginning negotiations with them, especially with the Tribes who will want to ensure that their individual treaty rights are maintained.

This work is ongoing as studies continue to examine flood control alternatives, and the effects of a potential upstream impoundment on fish habitat and populations.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Managing interfaces in catchment modelling

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ABSTRACT: This paper describes the main reasons why catchment modelling is most efficient if carried by integrated models, putting into evidence uncertainty control, learning efficiency and maintenance costs. The integrated approach followed in the model MOHID Land is described and some applications are presented to illustrate the concepts. Operational models running at regional scale, encompassing several catchments are shown to be a valuable application of integrated models.

1 INTRODUCTION

Roughly a catchment is a ground surface catching rain water and transporting it through the drainage network up to a delivering point located at the sea or at an inland lake, at the mouth of the catchment main river. This definition is based on sensorial perception, being simplistic since some water is discharged in the receiving water body (sea or lake) as ground water.

Meteorology, hydrology, agronomy, hydrogeology and ecology are disciplines assessing water and the transported products since the evaporation phase up to the return to the sea. Each of these disciplines studies specific processes in specific water bodies. The link between these compartment studies is done through boundary conditions imposed at interfaces between water bodies. Integrated approaches avoid the need for those boundary conditions simplifying the study and improving the results.

Evapotranspiration is an interface process merging meteorology, ecology, soil water dynamics and soil biogeochemistry. Evapotranspiration is a result of plant activity determined by energy and nutrients availability (including water) having feedback on atmospheric and soil temperature, on water availability in the soil and river network and on soil organic matter content and nutrient's export.

The quantification of interface fluxes requires the dynamic knowledge of water content and properties inside each compartment, which can be provided only by integrated models coupling compartments dynamically. In absence of integrated models fluxes must be parameterized using empirical formulations requiring data local specific, i.e. fluxes calculation requires calibration.

Models based on static, parameterized, interfaces cannot forecast consequences of heavy managing actions (e.g. modification of land use) or of climate change consequences because there is no guarantee that parameters still remain valid. Another consequence of the use of simplified models was the development of a large range of specific process models, e.g. models for floods, soil biogeochemistry, irrigation, erosion very often based on very different conceptual approaches.

2 THE MOHID MODELLING SYSTEM

MOHID is an environmental modelling system dealing with transport and with biogeochemical transformation processes in complex geometries. It was developed to be used by researchers and by professionals and to be applicable to a large range of scales and physical conditions. Researchers require tools able to test hypotheses and compare options. Professionals require efficiency for quick results production. A wide range of scales requires the consideration of the corresponding transport processes and of interactions between scales.

MOHID Water, MOHID Land and MOHID Studio are the main products composing MOHID family. MOHID Water was designed to o simulate 3D free surface flows considering hydrostatic or non-hydrostatic pressure and barotropic or baroclinic flows, MOHID Land was designed to simulate the flows in catchments, coupling surface runoff, porous media and the river network and MOHID Studio is modelling environment designed to support the implementation of MOHID and to explore the results.

A spatial description based on finite-volumes and a temporal description based on a fractional time step are basic MOHID concept pillars (Neves 2013). Finite-volumes compute rates of accumulation inside the volumes as the integral of the fluxes across the volume surface. They simplify coupling of domains with different processes and guarantees mass conservation on the resolution of the transport process. The fraction time step allows the separation of processes inside each finite volume simplifying the development based on independent modules.

MOHID Water development was initiated as a 2D depth integrated model (Neves 1985) and evolved up to the present format described in Leitão (2003). The modular structure is described in Braunschweig (2003). MOHID Land shares with MOHID Water all the input/output modules, the interface with the atmosphere and the geometry module.

3 MOHID LAND MODEL

MOHID Land follows an integrated catchment approach. The main hydrological modules are (1) *Porous_media*, (2) *Runoff* and (3) *Drainage_network* dynamically coupled by interface modules. Downstream of the hydrological modules are modules to compute the transport and transformation of properties, vegetation growth and microbiological processes in the ground. Evapotranspiration is computed as a result of plants activity determined by their development stage, meteorology, soil water content and nutrients availability. The module *Basin* is the top module and manages the communication between modules. The model uses a 3D grid and permits different types of vertical coordinates.

Figure 1 describes MOHID Land concept and structure. Rain is provided by the module *Atmosphere* to the module *Porous_media*. This module uses the infiltration method chosen by the user from a list of possibilities and manages percolation. The non-infiltrated water is provided to the module *Runoff* that drives the water along the slope using the full *shallow water equations* shown on the Figure 1 or the kinematic wave equation according to the user specification. A river network can be considered if the *Runoff* resolution is too coarse to simulate rivers (as shown on the Fig. 1). The river network exchanges water with the Runoff and the ground and solves the St. Venant equations to simulate the flow.

The porous media solves the Richards equation in the vadose zone (Neves et al. 2000). The rate of accumulation of water inside a control volume being the integral of the surface fluxes. Fluxes are computed as the product of the hydraulic conductivity times the effective pressure gradient component in each direction. The pressure is computed as a function of the soil moisture using the retention curve (*pF* curve). Hydraulic conductivity and the pF curve are computed using the classical van Genuchten (1980) or Mualem (1976) models. In the saturated zone water accumulation is impossible and any water accumulation computed by the model is transformed into a pressure increase that inhibits water from entering into the finite volume. When the water moves into a saturated zone, pressure decreases according to the head loss generated by friction. The model

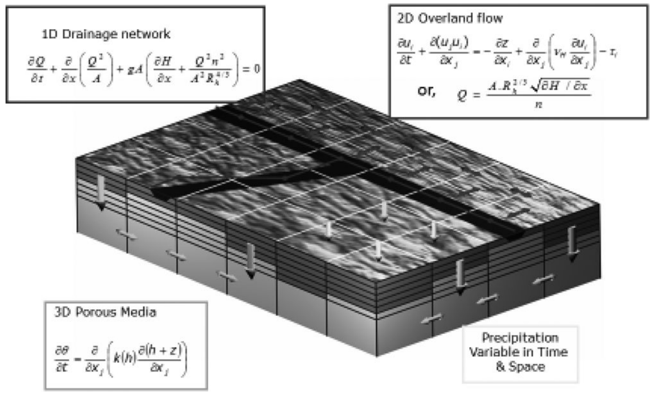

Figure 1. Schematic representation of the compartments considered by MOHID Land (river network, vadose zone, saturated zone and ground surface). Arrows represent precipitation.

can consider different horizontal and vertical conductivities to account for media anisotropy. The interface between the porous media and rivers is computed dynamically considering the hydrostatic pressure in the river and the effective pressure in the soil.

The surface runoff can be computed using the shallow water equations, including inertia terms, or the kinematic wave equation, assuming equilibrium between pressure and friction. Inertia terms are important when velocity is high, e.g. in case of floods, influencing the maximum water level and the flood propagation time. The management of the impermeable areas is a critical issue in this module. Those areas create preferential flow paths up to the river, influencing the time for flood concentration, water infiltration and erosion in the catchment.

The river network can be computed by a 1D drainage system or directly by the surface runoff module when the spatial step is small enough to describe the rivers otherwise the river network is simulated by the full 1D St. Venant equations. Doing so the river network can compute flow reversing in the river. This type of flow is important in tidal systems when marine water can flow into coastal channels, but also during flood situations when the flood propagated by the main river can enter into small tributaries.

Vegetation growth in MOHID Land is adapted from the SWAT model and modified using more recent information from bibliography. The biogeochemical processes in the soil follows a concept very close to the RZWQM (Root Zone Water Quality model), also modified using recent formulations found in the literature.

4 COUPLING TO OTHER MODELS

Coupling different models is a requirement of integrated catchment modelling for (1) physical reasons e.g. coupling estuarine model to the drainage model or this one to a reservoir model, but also for (2) historical reasons, e.g. when part of a catchment has been modelled by a team and another part by another one and they want to combine their models without being obliged to modify their own work. In this situation the use of openMI (open Model Interface) is a possibility. This standard was developed in the framework of the project HarmonIT, is managed by http://www.openmi.org/ and can be downloaded from http://sourceforge.net/projects/openmi/.

MOHID Land uses the interface openMI to connect to MOHID Water and to connect to SWMM model (Rossman, 2010) http://www.epa.gov/nrmrl/wswrd/wq/models/swmm. These connections allow the dynamic coupling to tidal systems simulating estuaries and adjacent catchments interactively (MOHID Land + MOHID Water) and the interaction between surface runoff and the sewer system in urban environments during urban floods. This interaction allows the water overflowing from the sewer system to escape to the surface and to re-enter into the underground sewer network later.

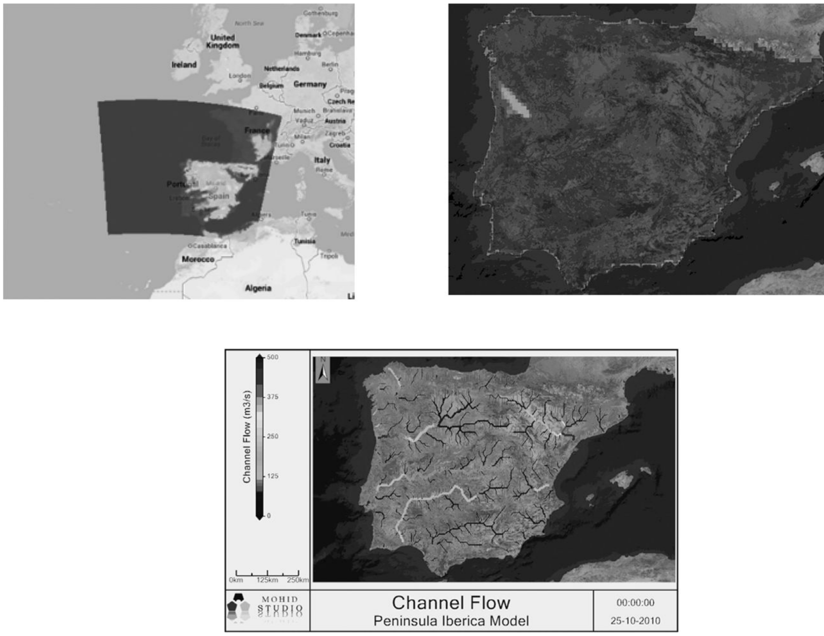

Figure 2. Domain (upper-left) and a rain event forecast (upper – right) by MeteoGalicia, in Spain (www.meteogalicia.es) using WRF model and MOHID Land forecast of river discharge in the Iberian river network.

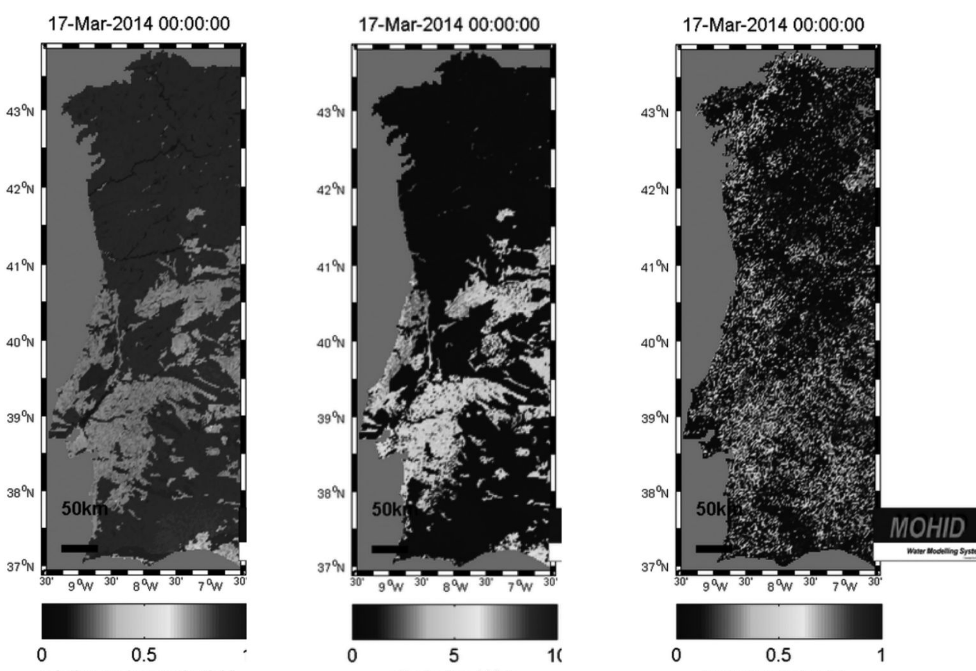

Figure 3. Soil surface properties computed by MOHID Land: Relative soil water content (left), nitrate and leaf area index.

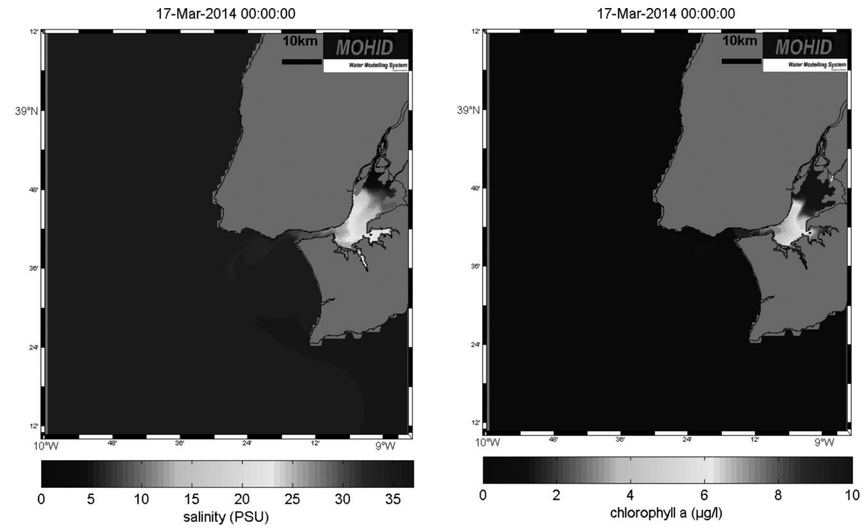

Figure 4. Salinity and chlorophyll_a computed in the Tagus Estuary based on the river Tagus discharge computed by MOHID Land (Fig. 3) and on the Regional Ocean Model shown in Figure 5.

5 APPLICATIONS

MOHID Land has been applied at very different scales. Figure 2 shows results of an application to whole Iberia running in forecast mode with a 10 km grid. The model is forced by meteorological forecasts from the Galician regional meteorolocical centre (Meteogalicia), topography is based on the NASA digital terrain map from, land use is based on CORINE land cover and soil data uses the European Soil Map from the JRC. A major output of the model is the river discharge shown in the lower part of the Figure 2.

Figure 3 shows results of an application to a more restricted area (the Portuguese territory) using a 2 km grid. This application also considers the biogeochemical processes in the soil. The left image shows the soil surface moisture, the central image shows the nitrate concentration at the surface and the right side image shows the leaf area index computed using the results of the vegetation model.

Figure 4 shows results of MOHID Water running operationally in the Tagus estuary using the catchment model to specify river discharge and water properties at the land boundary and the regional application shown in Figure 5 to specify the marine boundary condition. The coastal model is running using results of a meteorological model (http://meteo.ist.utl.pt) to specify momentum and energy fluxes and www.myocean.eu results to specify temperature, salinity and the low frequency sea level variation. Tide is specified using FES2014 results. Land discharges are specified using the Tagus model results along an inner cross section.

The network of models described allows the simulation of the full water cycle, from the evaporation at the sea or inland evapotranspiration up to water return to the sea after crossing catchments and the estuaries.

6 CONCLUSIONS

This paper puts into evidence the importance of using integrated models to simulate catchment's hydrology and biogeochemical processes. The paper describes the MOHID Land model as an example of an integrated model and describes how this model is coupled to free surface models for estuaries and coastal seas and to a model for the flow in urban areas. The paper illustrates the

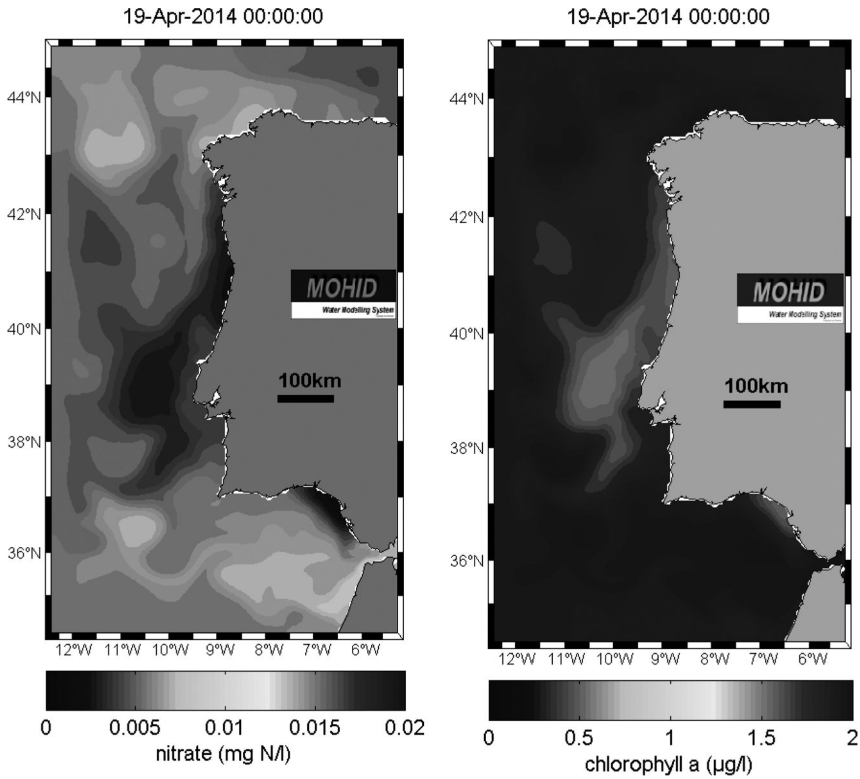

Figure 5. Surface concentration of nitrate and chlorophyll_a computed by MOHID Water applied in the regional ocean surrounding Portugal.

idea with some large scale applications, showing some results for Iberia, refined for Portugal puts into evidence the advantage of these models to simulate biogeochemical processes in coastal areas illustrating the idea with the case of the Tagus Estuary and the regional ocean off Portugal.

This type of application is very important for the implementation of the Water Framework Directive inland and of the Marine Strategy Framework Directive that are very much related in coastal areas.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Regional risk assessment for climate change impacts on marine coastal water

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EXTENDED ABSTRACT

Climate change is generating several impacts on coastal ecosystems such as sea level rise, storm surge floodings, coastal erosion and decrease of water quality. In order to analyse the potential consequences of climate change on marine water quality and evaluate the related impacts on marine biological systems, a Regional Risk Assessment (RRA) methodology was developed and applied to the marine water bodies of the Northern Adriatic coast (Veneto and Friuli Venezia regions, Italy). The RRA outputs are GIS-based hazard, vulnerability, risk and damage maps providing useful information to stakeholders and decision makers about the potential consequences of water quality variations. Provided outputs allow establishing priorities for interventions supporting adaptation and management strategies.

1 INTRODUCTION

Marine coastal waters are particularly important for their role: they allow the transformation, detoxification and sequestration of pollutants, are a place used for recreational and touristic activities (Peterson and Lubchenco 1997), represent the habitat for many species and are rich of natural resources. In addition, they contribute to the regulation of the climate, but are also very sensitive to climate changes (Hoegh-Guldberg and Bruno 2010). Recent climate changes are generating several impacts mainly caused by the sea surface temperature increment and the consequent ice melting in the arctic regions (Wang and Overland 2009) and by changes in the marine currents. As a consequence, water biogeochemical and physical parameters (e.g. primary production, pH, salinity) are exceeding the thresholds of ecosystem tolerance, and thus lead to aquatic ecosystem degradation (Hoegh-Guldberg and Bruno 2010).

2 THE METHODOLOGY FOR MARINE COASTAL WATERS QUALITY IMPACTS RELATED TO CLIMATE CHANGE

According to the Regional Risk Assessment (RRA) approach (Landis 2005; Pasini et al. 2012), the developed methodology is aimed at analysing the potential consequences of climate change on marine coastal water quality. The RRA approach has been implemented within a Decision support

System for Coastal climate change impact assessment (DESYCO), using Geographic Information Systems to manage, process, analyse, and visualize data and employing Multi-Criteria Decision Analysis (MCDA) to integrate stakeholders preferences and experts judgments into the assessment process. Specifically, the RRA model integrate regional marine biogeochemical and physical data with site-specific environmental and socio-economic information according to five steps (i.e., hazard, exposure, susceptibility, risk and damage assessment). The RRA methodology was applied to the coastal marine waters of the Northern Adriatic sea (along the Veneto and Friuli-Venezia regions, Italy).

The evaluation of the hazard is based on the comparison between future and present hazard metrics' values derived from a chain of models that included regional models providing information about the main marine water biogeochemical and physical parameters (i.e., concentration of C or Clh-a, nutrients (N and P) concentrations, dissolved oxygen, pH, temperature and salinity). If hazard metrics' values in the considered future scenario are out of defined tolerance ranges, many impacts can appear in the ecosystem (e.g. time of reproduction and growth variations, changes in the distribution and abundance of the organisms) and, thus, represent a potential hazard.

The next step is represented by the exposure assessment, aimed at identifying areas potentially exposed to the water quality variations: only the marine water system was considered within this application.

Then, the susceptibility assessment was performed based on the identification and integration of a set of biophysical and environmental susceptibility indicators and indexes, using specific MCDA functions. Susceptibility factors represent the sensitivity of the considered receptors to the potential effects of marine water quality variation and determine the degree to which a receptor is affected by climate-related stimuli.

Furthermore, the risk assessment phase, aimed at identify and prioritize areas and targets at risk in the case study area, was performed through the integration of the results obtained in the exposure and susceptibility assessments for each considered receptor.

Finally, in the damage assessment step, areas and targets, where higher socio-economic losses are expected, are identified and prioritized aggregating the results derived from the risk assessment and from the value assessment for the considered receptors. The value assessment is based on the aggregation of value factors, representing relevant environmental and socio-economic values of the receptors that need to be preserved for the interest of the community.

3 CONCLUSIONS

The proposed approach allowed to study climate change impact on marine coastal water quality supporting the definition of adaptation measures according to the Integrated Coastal Zone Management principles, coherently with European directives and documents related, directly or indirectly, to climate changes, such as the Marine Strategy Framework Directive.

ACKNOWLEDGEMENT

The research work presented here has been partly funded by the PEGASO project (People for Ecosystem-based Governance in Assessing Sustainable development of Ocean and coast) within the European Commission 7th Framework Program (Grant agreement no: 244170). Additional funding came from the Italian Ministry of Education, University and Research and the Italian Ministry of Environment, Land and Sea under the GEMINA project.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
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Groundwater and dependent ecosystems: A review on process and measurement methods

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EXTENDED ABSTRACT

1 INTRODUCTION

Groundwater provides an important source of water for ecosystems and humans, especially during droughts (Kløve et al. 2014 a). Increasing use of groundwater has led to groundwater level declines in many part of the world. Reduced groundwater levels have resulted in changes river flow affecting riverine ecology, lakes and wetlands. Besides the changes in quantity, increased pollution from cultivation, households and industry has occurred (Balderacchi et al. 2013). In future management, a complete knowledge of groundwater systems and the influence of land use on the services groundwater provides must be understood. For future planning purposes the impacts of groundwater abstraction and irrigation must be better understood.

Integrated management of groundwater has not received much attention compared to the integrated management of surface water systems. For groundwater resources, integrated management would mean that considering groundwater system should include also hydraulic links to surface waters (lake, river, ocean) and groundwater dependent ecosystems. The management should include socio-economic and political issues that evidently relates to future land use and food production (self-sufficiency, farmer income, ecological agriculture etc.). For groundwater systems the key issues to consider is assessment of future groundwater consumption and recharge, pollution and environmental impacts. Besides assessment of direct effect of abstraction for human water use also impacts of climate change on groundwater renewal rates must be assessed. For future management, also new methods to assess and reduce impacts of land use are essential.

On a long term planning horizon, the land use impacts must be understood to assess if land management plans complies with given environmental policy and the set restrictions on e.g. groundwater quality standards. Groundwater and ecosystems are controlled by many regulations working in tandem (Kløve et al. 2014 b). For effective management decision, the understanding of key natural and socio-economic processes are required and essential. The intention of this paper is to highlight key hydrological processes and methods for measurements.

2 GDE

2.1 *What are GDEs?*

GDEs include many different type of aquatic and terrestrial ecosystems. The role of groundwater in these systems is variable from being completely dominant to minor. The role of groundwater in GDEs can be to provide flow, waterlogged conditions, high moisture, pressure and quality. Besides having high biodiversity GDEs can also be important for recreation, tourism etc.

2.2 *Policy context and GDEs*

The role of groundwater in ecosystems is well recognized in EC Water Framework Directive. From groundwater directive point of view, GDEs could be understood to be the GDEs connected to groundwater bodies. If the groundwater in such systems influence the GDEs in a significantly negative way then the groundwater body should be classified as poor. A key point is the significant influence which is in many cases difficult to assess due to unclear casual relationships between impacts and pressures and poor conceptual models for GDEs. Monitoring and research is seen as the only way forward to better understand these systems (Kløve et al. 2014 b).

3 TOWARDS INTEGRATED GROUNDWATER MANAGEMENT

In the future, groundwater and GDEs should be managed based on an integrated approach that considers all current and potential ecosystem services. One way to improve scientific understanding of GDEs is to develop integrated conceptual models of GDEs, including hydrology, ecology and main pressures and risks, with the focus on nationally important sites. As groundwater systems are poorly known and heterogeneous, local studies are needed on GDE and groundwater body scale. The role of groundwater on the socio-economic systems should also be understood locally to asses all ecosystem services. Management and policy still needs to be developed hand in hand with scientific progress. Modelling provide a good method to analyze groundwater and GDEs. The methods used should be further developed to include relevant ecosystem processes. Recent developments made on this topic within the EC 7FP project GENESIS (226536) can be found on www.thegenesisproject.eu

4 CONCLUSION

The recent increasing awareness of the importance of groundwater dependent ecosystems (GDE) has put focus on a better understanding of how groundwater interacts with ecosystems. As GDEs are vulnerable to changes by climate and land use these pressures should be better understood and considered in groundwater management.

The vulnerability of GDEs to changes in land use or climate change depends on local conditions such as hydrogeology, climate, additional water sources (e.g. surface water contact) and the type of GDE. Water loss to GDEs can result in anything from drastic to minor impacts. When new impacts or e.g. abstraction are assessed, also past impacts and future pressures must be evaluated.

Several scientifically sound methods can be used to measure impacts in GDEs. Impacts of restoration or abstraction controls are not well studied yet but methods are emerging for e.g. conjunctive use or adaptive management. National monitoring is recommended to provide the basic data for characterization of GDEs and their assessment.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Innovative group decision making framework for managing regional hydro-systems

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EXTENDED ABSTRACT

Decision making in modern times assumes participation of a number of individuals or parties (in further text 'agents'), i.e. participants in a group. Agents are people coming from public sector, water users, delegates from local municipalities and else. They usually have different background in education and knowledge, attitudes and interests.

Long term planning of water resources development within multipurpose regional hydro-systems in developing countries (e.g. Serbia) is faced with problems such as a lack of financial funds for investment and annual operation and maintenance of facilities, conflicting interests of upstream-downstream water users, and transition scenarios related to national economy and possible frequent changes in political system. Given available information about one of such systems, existing and perspective water users and other parties, all with exposed interest in development and maintenance of the system, we propose the two conceptually different models of participative decision making. The first one directly aggregates individual judgments of participating agents at all levels of the problem hierarchy, without any further influence of agents on the decision process, once they have completed their judgments. The other model is based on building consensus. Reaching an agreement of involved decision makers is achieved in iterative manner. Consensual approach is in many case realistic because it does not imply discussion or other 'means' of direct communication between agents which is typical, e.g., for political scenarios of decision making in developing countries.

In developing participatory model we adopted a realistic approach and propose several options on how to associate weights to agents, e.g. according to their demonstrated consistency in assessing and evaluating purposes of the hydro-system. Consensus is preserved indirectly because agents reach an agreement objectively and mathematically rigorously. The process is fair because each agent has a 'vote' which counts in the final decision, dominance is at least reduced (if not fully excluded), and finally, the final decision is expectably acceptable for all agents at the end of the process. The final outcome is a decision with legitimacy for real-life implementation.

In introductory part of this presentation (paper) we discuss different concepts and aggregation schemes in group decision making, and comment applicability of several most popular mathematical models and related computerized tools in improving management of regional hydro-systems.A typical regional hydro-system in Serbia is selected to demonstrate how different aggregation shames influence resulting group decision(s). Emphasis is put on how to treat different interests and priorities of involved stakeholders, how to model decision making process itself, and how to provide instruments (mainly institutional) for monitoring the decision implementation and the effects of the decision(s) made.The paper provides short description of the hydro-system, detail statement of related decision-making problem and proposed solving methodology based on the Analytic hierarchy process (AHP) which is applicable in both with/without consensus scenarios.For the consensus case we demonstrate how to apply developed algorithm when a group of qualified decision makers participate in assessing importance of different system's purposes.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Participatory decision-making methodology for water quality management in the Brazilian water basin

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ABSTRACT: The Brazilian Water Resources Policy establishes, among its management tools, the Classification of Water Bodies. This instrument aims to maintain the quality of the water body, in order to meet the preponderant water uses. To ensure a water quality that fits with such uses, strategic actions of remediation must be implemented at the river basin. These actions, in turn, are selected considering also economic, technical, social and environmental aspects. Appropriated actions must be identified, analysed and prioritized in accordance with the approval of the river basin committee. Some obstacles hamper the efficiency of this instrument, such as: lack of information about such an instrument, by the members of river basin committee, and lack of support for their participation in decision making. The present study aims to develop a methodological for the identification, analysis and prioritization of strategic management actions to the abatement of pollution load in the Brazilian rivers.

1 INTRODUCTION

The concern about the progressive degradation of water bodies is increasing considerably, and is necessary and urgent to promote prevention and control of pollution. This concern is even greater in semiarid regions, where rivers are predominantly intermittent with insufficient conditions for consumption, transport, and natural dilution of effluents.

Arid and semi-arid regions in the world comprise a significant portion of Earth's surface. These regions are characterized by the presence of temporary rivers, usually defined as those in which the water flow ceases and surface water may disappear in some periods of the year (Medeiros 2009).

In such a context of scarcity and degradation of water quality, typical of many Brazilian basins, the water resource management has made great advances thanks to the Law No. 9433/1997 that establishes the National Water Resources Policy (PNRH). One of the objectives of this law has been "to ensure the necessary water availability to current and future generations, with quality standards appropriate for the respective uses." In order to achieve this purpose, this law establishes five instruments: 1) the Water Resources Plan; 2) the Classification of Water bodies, according to their predominant uses; 3) the permitting of water use rights 4) the water pricing and 5) the water resources information system.

The Water Resources Plan aims to support and guide the implementation of the National Water Resources Policy and management. The Classification of Water Bodies aims to ensure water quality to attend the uses desired by the population. The permitting is the right to use water resources in a controlled manner, considering quantitative and qualitative aspects. The pricing is the attribution of an economic value for water use. The information system is the collection, processing, storage and recovery of information on water resources and factors involved in its management.

The Water bodies' Classification articulates with the other four instruments. In fact, for its implementation is necessary to observe the guidelines established in the Water Resources Plan, using detailed information related to water and its users and, thus, involving an Information Water System. In order to grant the catchment or release right, it is necessary to check the quality water classification of the river, and, once that Pricing system has been implemented, the grant starts do be an economical cost (Damasceno 2013).

According to the Resolution of the National Council on Water Resources (CNRH) no 91/2008, the classification of water will be effected by the establishment of uses classes associated to water quality standards, as it is established in the CONAMA Resolution no 357/2005, which classifies rivers into freshwater conditions, brackish and saline.

With regard to the procedures for implementation of the Classification of Water Bodies, the CNRH Resolution No. 91/2008 indicates four phases: i) diagnostic; ii) prognosis; iii) propose of goals and iv) execution program. The diagnosis refers to "*the river that we have today*," this is a survey to collect the most amount of information, in order to contextualize the general and current situation of the basin, including the identification of strengths, limitations and risks related to water resources of the region. The Prognosis refers to "*the river that we want*", this consists in the constructions of projections and development scenarios of the basin, including the estimation of uses, population growth and economic activity (industrial and agricultural) (Brites, 2010). In the Prognosis phase are defined future projections, the choice of priority parameters for water classification, the modelling of quality and quantity of water bodies, what should be the abatement of pollution load in order to achieve the desired water quality; alternative plans for preventive, remedial and corrective programs and also the investment necessary to carry out the identified actions. The third phase discusses "*the river that we can have*", given the socioeconomic conditions of the basin. The proposed targets refer to progressive, intermediate and final goals of water quality, built according to the needs of users. Last, the execution program, according to CNRH 91/08, should contain proposals of management actions and their deadlines, investment plans and commitment instruments that incorporate also recommendations to public and private stakeholders for reaching the goals and recommendations for educational, preventive and corrective actions, and for social mobilization and management.

Considering this framework for setting the Water Body Classification, it is important to underline that this instrument not only considers the current state of water quality, but ponders also the quality targets that they should attend to meet local needs and ensure the existing and potential water uses.

The PNRH gives a central role to River Basin Committees in the water policy process, recognizing them as a prosperous context to put participation into practice. The River Basin Committees (CBH) must accompany all the stages of the Water Bodies Classification and approve its execution program. A CBH is a deliberative institution and the lowest territorial unit for the integrated management of water resources, where choices are oriented with the effective participation of the stakeholders, represented by government (federal, state, and municipal organizations), civil society and direct users of water resources (irrigation, human consumption, animal consumption, etc.).

The proposal of Water Bodies Classification and its execution program, once approved by the CBH, should be directed to the respective Water Resources Council, being at State, District or National level, according with the domain of the water bodies. The National Water Agency (ANA 2007)) states that, upon approval, the Council has to emanate a resolution or a norm, setting the class of that water body. For supervising the process and the accomplishment of the proposed targets, it is necessary a water quality monitoring network that periodically communicate to society the water quality conditions and the evolution of those parameters not attending the water quality classes.

All the political and technical actions must be identified, analysed and prioritized in accordance with the approval of CBH. In this process, the involvement of social actors would allow the community to know the problems associated with water quality, and also would stimulate the commitment for effecting strategic actions to mitigate or resolve these problems, which, in turn, contributes to the progress of water policy implementation.

According to the National Water Agency (ANA 2012), within the Brazilian State river basins, few of them have made progress in implementing the Water Body Classification. The main advances have been achieved only in the basins of Federal domain. Some of the factors that triggered this situation are related to lack of information, lack of methodology and lack of management (ANA 2012).

The State of Bahia has installed fourteen River Basin Committees. Of these, six are currently involved in the process of River Basin Water Resources Plan creation, simultaneously with the Water Body Classification. According to Porto (2002) and Medeiros (2004), the Water Body Classification is considered one of the most complex instruments of water policy, due to its difficult implementation. Gonçalves (2001), Good (2006), Brites (2010) and Daniels (2013) affirm that the realization and implementation of Water Body Classification, as indicated by the Law, is still restricted due several factors, among others: the lack of information and knowledge of the instrument, methodological difficulties and lack of technical and legislative improvements for its application and consequently the lack of support to River Basin Committees.

The need to support to the River Basin Committees comes from the complexity of a group decision-making process, which naturally involves several conflicts for the water management. Indeed, the decision is made by a group of heterogeneous people, in an environment where exists lack of trust and commitment between the Committee segments, lack of time in order to build consensus and, in some cases, lack the financial support to make the Plenary meetings. In this context, the decision-making process, related to any issue, including the selection of management actions carry out the Water Bodies Classification, is compromised and unstructured.

Bearing in mind the difficulties encountered in effecting the classification of water bodies, can be recognized the need to develop a methodological procedure of decision support, directed at River Basin Committees, seeking to create a clearer, structured and consistent decision-making process, fostered by knowledge and information, minimizing the scepticism between Committee segments and strengthening the commitment on water quality management.

Therefore, this study aims to develop a methodological procedure for the identification, analysis and prioritization of strategic management actions aimed at pollution prevention and abatement in water bodies. It considers the cost and the achievement of water quality targets, according to preponderant water uses in river basins of semiarid regions, with the effective participation of stakeholders in the decision process.

2 THE STUDY AREA

The methodological approach was developed using, as a case study, the Salitre River Basin and its River Basin Committee. This basin was chosen because it concentrates many of the typical problems of semi-arid regions of north-eastern Brazil, such as the water scarcity and the occurrence of several conflicts arising from the indiscriminate water uses. Also, this basin has already been the object of study in other research projects of the Water Resources Research Group of the Federal University of Bahia (GRH/UFBA), and, therefore, offer an abundant database and a knowledge that have been a indispensable information source for the development of this study.

The basin of the Salitre River is geographically located in an area of tropical semi-arid climate, with very irregular distribution of rain and influenced by cold fronts associated with low atmospheric pressures. It is fully inserted in the drought polygon of the State of Bahia, and is one of the São Francisco River sub-basin. Salitre basin is located in one of the conflict regions with regard to water resources, mainly because it is an intermittent river. The sever problem of water scarcity is not only related to low rainfall, high evaporation and high level of salinity content, but also with water pollution, indiscriminate use of water and soil. Figure 1 illustrates the basin under study.

3 THE METHODOLOGY AND RESULTS

The methodology procedure developed in this study includes four specific objectives, defined in accordance with the phases for Water Bodies Classification, as mentioned in the CNRH Resolution 91/2008.

1. Identify and evaluate strategies and limits of River Basin Committee participation, within the instrument of water bodies classification.

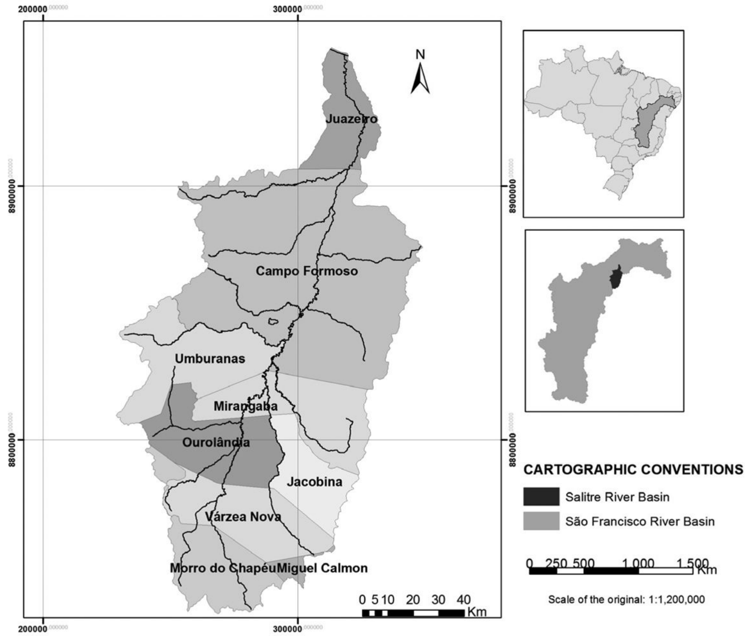

Figure 1. The Salitre river basin, a sub-basin of São Francisco river, in the north-east of Brazil.

2. Set progressive intermediate and final water quality targets, respecting the predominant water uses of the river basin.
3. Identify and analyse the strategic management actions necessary to achieve the progressive goals of water quality and propose future scenarios of pollution abatement in the river.
4. Select strategic management actions, regarding social, environmental, technical and economic aspects, through a participatory decision-making process.

Figure 2 illustrates the relationship between the required procedures for the implementation of water bodies Classification (CNRH Resolution 91/2008) and the specific objectives set for the methodological development of this study.

Objective 1, the analysis of the river basin committee participation embraces the preparation of all stages of application of this methodological procedure, from diagnosis to the execution of management actions. In the phase of the water quality goals definition, the participation of the local community is extremely important for gathering information of current and future water uses in the basin. It also contributes to detect the environmental problems around the basin, and consequently, to indicate what are the management actions required to reduce pollution and attend water needs of local population.

The proposition scenarios refer to the study of pollution abatement in the river, more specifically, to the study of the dispersion, transport and dilution of pollutants in the river. This step is achieved through the application of water quality and hydrological simulation models. The diagnosis stage is the starting point of the study; indeed all information collected in this phase subsidizes the development of the other activities proposed in this methodology. This phase in intrinsically related to the objectives 2 and 3.

3.1 *Limitations of river basin committee in the water resources management participatory processes*

The Water Law attempts to enhance social participation in the management system, trough the creation of collective bodies such as river basin committees (Damasceno 2013). Also, according to

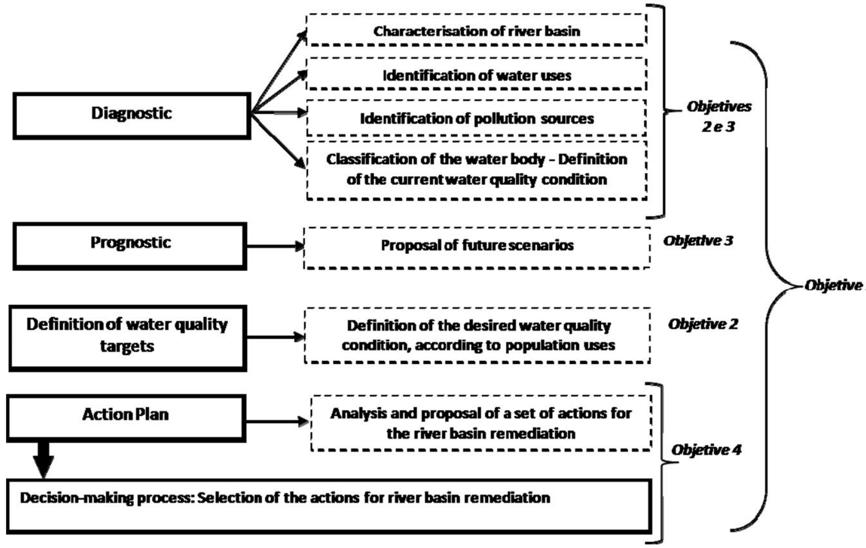

Figure 2. Phases of the methodological framework.

the author, social participation in the process of creating the Water Bodies Classification should go beyond the moments of public consultation or the collection of historical information on the basin. However, in order to effectively participate in the decision-making with positioning skills, several aspects are need, like for example, the circulation of knowledge and the existence of environments where knowledge is acquirable.

The Salitre River Basin Committee (CBHS) was used as a case study to understand the limits of committee's participation in the process of Water Bodies Classification. The CBHS legally exists since 2006, and is an active Committee of great importance for the region. However, it has not implemented yet the management tools established by the L. 9433/1997, and the discussion on water quality has been fostered only by the Federal University of Bahia (Damasceno 2013). To better understand the characteristics of the Committee, its knowledge and attitudes, these activities were carried out:

- Application of questionnaires and interviews with members of CBHS, in order to understand the profile of participants such as gender, level of education, knowledge about the Water Bodies Classification, and professional qualification in water quality management.
- Monitoring of the plenary meetings of the CBHS, in order to investigate the conflicts, the duration of the meetings and the segments participation in discussions and the final decision on related topics.

As recommended in the state and federal Brazilian legislation, the Institute for the Environment and Water Resources (INEMA) in responsible to foster the creation of committees, evaluate the implementation process, pay their maintenance through technical and financial administrative support, assuming the function of Executive Secretary of the Committee. So, INEMA helps to promote the participation of society in decisions related to water resources management in the State, until that a Basin Agency is formally created.

In the State of Bahia, the existing Basin Committees don't have the Basin Agency yet, thus, the charge of Executive Secretary is given to INEMA. Damasceno (2013), after analysing the plenary meetings of CBHS, pointed out some obstacles that inhibit the good realization of the meetings as: the notices of convocation do not mention all the content that will be discussed in the plenary; notices are sent via email and not all members have daily access to the internet; financial resources to cover travel expenses are not available before the trip, thus many committee members of small organizations, associations and farmers, representing civil society and small users, not always have funds to cover the displacement, accommodation and food expenses.

Beside what has already been presented, the study of the Committee showed that the CBHS consists of 18 full members, 14 of them are male. The level of education oscillates between primary education and master degree. The majority of those present at plenary meetings are representatives of civil society and the public authorities. N the other side, the segment of users is the one that less participates in the discussions, and in decision making regarding water quality management. Most members do not know the instrument water bodies classification, and do not hold any qualification courses related to water quality management (Damasceno 2013).

Regarding the duration of the plenary meetings, we can infer that committee members do not have sufficient time for the presentation and discussion of the topics described in the agenda. Consequently, the decision-making process becomes unstructured and inconsistent.

Given these considerations, it is crucial to development and implementation of a decision support system to River Basin Committees, so that they can perform their duties as stipulated in PNRH. For this, members have to receive specific and continuous trainings, through workshops, lectures and roundtables on the procedures for the implementation of Water Body Classification and on the methods that can make effective their participation among the entire process.

3.2 *Definition of progressive and final water quality targets*

The second objective of this study relates to the definition of progressive and final water quality targets, according to the predominant water uses in the basin. This phase can be developed only after the realization of a diagnosis of the basin, including the characterization of the basin, a survey on current uses and sources of pollution.

To identify the current quality status of water bodies, water quality parameters defined by CONAMA Resolution 357/2005 were adopted. These parameters were chosen based on the sources of pollution identified in the Salitre River Basin and according to the availability of water quality data (Medeiros 2003, Medeiros 2004). For the analysis, the observed values of water quality parameters collected in the field were compared with the reference values of the respective parameters in CONAMA Resolution 357/2005.

The parameters used for this analysis, according to the characteristics of the Salitre River Basin were: Biochemical Oxygen Demand (BOD); Dissolved Oxygen (DO); Nitrogen and its fractions (Nitrite, Nitrate, Ammonia and Organic); Phosphorus and its fractions (organic and inorganic) and Faecal Coliform (FC).

The definition of reference classes was obtained from field surveys, through interviews and questionnaires applied to local communities, seeking information on current and future uses desired by this population (Silva 2011, Damasceno 2013; Torres 2014).

To reach this goal, the following activities were carried out:

- Identification of sites on the river to collect and analyse water quality samples.
- Inspection of the river basin with the aim of evaluating its features, such as dams, drainage areas, contribution of tributaries, location of pollution sources, the condition of the river channel and identification of the main uses of each segment of the river.
- Assessment of availability and demand of water, to define the ultimate goals of water quality.
- Interview and questionnaire with the local population in order to investigate the uses of the basin (current and future).

The main water uses raised in the basin were: human supply, animal consumption, recreation, livestock and irrigation, mining. The main identified sources of pollution were: open air urban waste discharges, release of domestic sewage into the nature, use of detergents for utensils washing, animal waste and uses of pesticides in agriculture; waste from mineral exploration.

The major problems identified were related to water scarcity and poor water quality, which usually is brackish, turbid and untreated. Regarding supply, we registered lack of water, deficiency in supply, high cost and lack of plumbing to villages. The sewage services follow the same pattern in most municipalities of semiarid regions, where a system of tanks is usually adopted, but built and operated intermittently. The collection network operated by municipalities, where it exists, does not perform any processing of waste, throwing them directly into the nature.

3.3 *Identification of strategic management actions for pollution reduction of water bodies*

The objective of this study refers to identification of strategic management actions for pollution reduction, needed to achieve the established water quality goals. After defining the current and the desired water quality, water management actions were then proposed.

These actions were determined according to the diagnosis survey of the basin, especially considering the sources of pollution (Pessôa 2013, Torres 2014).

According to the survey of pollution sources, also some remediation actions were identified in the basin, namely: garbage collection and construction of landfills; collective solutions for sewage treatment; individual solutions for sewage treatment; environmental education targeted to users; alteration of irrigation methods, containment of diffuse pollution and attempts for a more efficient water use in agriculture. Among the identified actions, what was considered a priority for the basin, were actions related to sanitation (sewage treatment processes) and agriculture.

The indication of processes for sewage treatment considered the specifics reality of the semiarid region, such as low skilled labour. In order to verify the association between sewage treatment and its effectiveness in reducing the pollutant load, the mathematical model of water quality "QUA-UFMG," based on QUAL2E (Sperling 2007) was used. The use of water quality models permits to evaluate the effects of anthropogenic intervention in environmental systems (Chagas 2009, Salla et al. 2013), enabling a better understanding of the dynamics resulting from the processes of dispersion and dilution of pollutants, and testing, through simulations, future conditions and possible interventions in the water body.

The analysis of the efficiency of the sewage treatment systems was done in a reference situation of minimal flow. This flow is associated with the critical conditions of the water body, which occurs during drought periods, where the dilution capacity of the river is reduced. To do this, associations of different sewage treatment systems were defined, like individual systems, septic-tanks followed by Anaerobic Filters, and collective systems like stabilization ponds. Subsequently, these systems were tested in the water quality simulation model (release of effluent treatment system in the river) in critical flow condition and checking which one reached the best results in terms of treatment effectiveness.

3.4 *Participatory decision-making process to select management actions*

The fourth objective refers to the participatory decision-making process for the selection of strategic management actions to be implemented in the basin. The decision-making involves a choice, within a range of options, of the preferred alternative for the decision maker or for a group of decision makers. To achieve this, these elements of a decision-making process are required, as Table 1 shows.

According to the National Water Resources Policy (Law No. 9433/1997) the River Basin Committee has within its duties the approval of the Action Plan of the Water Bodies Classification. Thus, the actions that will compose the Action Plan of the Water Bodies Classification of the Salitre River should be evaluated and approved within a decision-making by members of CBHS.

The decision process that involves the selection of management actions, in a group of deciders with heterogeneous characteristics, is often characterized by conflicts and little initial knowledge about the situation being faced. These difficulties can be improved with the use of methods of multicriteria analysis. These are methods able to organize the decision-making problem, identify the players involved, the alternatives and select the criteria that evaluate the best option to choose, and present more clearly all the elements covered in the decision making process.

To achieve this goal, this study proposed to undertake the following activities: Developing a strategic plan for water quality management of water bodies in semiarid region; Analysis of the

Table 1. Elements of a decision-making process.

Elements of a decision-making process	
Objective of Decision	It is a goal or a purpose that we wish to achieve. The establishment and judgment of criteria and alternatives aimed at reaching the goal set out in the decision-making process and hence, this element represents the highest level of a hierarchy.
Facilitator	Contributes to the process, helping to clarify doubts, negotiation and communication between actors.
Decision-makers	Are the actors more involved in the decision making process, responsible for the final decision.
Alternatives	Are the select option. For this study the alternatives are the strategic management actions
Criteria	The criteria have to be able to permit evaluation of each of the proposed alternatives

identified actions related the efficiency of pollutant abatement and their relative costs of implementation and operation; Discussion with social actors on the criteria for judging the alternatives; Structuring the decision-making process, which includes defining the elements of the decision process (Table 1) for the study area; Construction of an evaluation matrix and application of a multi-criteria analysis method; Prioritization of strategic actions by applying multicriteria analysis, and discussion of results within a decision-making process with participation of social actors of the basin.

This study adopted the Analytic Hierarchy Process (AHP) as a method evaluate and choosing the set of actions. This is a multicriterial method developed by Thomas L. Saaty in the mid-1970s. For its application questionnaires with members of the committee were realized. The utilization of a multicriteria analysis to aid decision making on the selection of management actions contributed to a more reliable and consistent decision based on knowledge, considering both qualitative and quantitative aspects.

4 FINAL CONSIDERATIONS

The Classification of water Bodies is an efficient instrument of the National Water Resources Policy (PNRH) for planning and managing of the quality of water bodies. According to the PNRH, the decision on the desired objectives or goals of quality and the action plan for achieving these goals should include the participation of the River Basin Committee.

Social actors of the basin define the water quality goals, according to current and future uses in each stretch of river. An action plan is aimed at progressively achieving these goals, through intermediate steps, until the final goal of water quality is reached, and has do be submitted and approved by the River Basin Committee. Therefore, an effective participation of social actors is a great challenge for the management of water bodies. Moreover, in the case of intermittent rivers, the choice of efficient solutions for reducing pollution is an even bigger challenge, since these rivers have little or no ability to dilute effluent. Effluent discharges into water bodies from inefficient sewage treatment systems can cause negative impacts to the aquatic ecosystem and to coastal communities.

The choice of the best alternative or a set of strategic actions to be implemented in the watershed should be performed through a decision making process, with the involvement of members of the Watershed Committee. However, failures are common in decision-making processes that involve multiple social actors. Some of these failures relate to the lack of information and transparency in decision-making and lack of trust between their members necessary for assuming long-term commitments. Therefore, it is necessary to involve the Watershed Committee in training processes, and more, to enhance the development of skills of its members for making collective decisions.

The utilization of the multicriteria analysis method *Analytic Hierarchy Process* - AHP, was tested for the improvement of participatory decision-making process in selecting the best alternative to reach the Water Bodies Classification of the Salitre River, located in the semiarid region of Bahia. The participation of River Basin Committee of Salitre contributed to reduce asymmetries in understanding the instrument, whose goal is the environment preservation and the control of pollution of water bodies. In this context, the methodology proposed in this study produced relevant results to the dissemination and transfer of knowledge in the area of water resources management. From these results, it is possible to conclude that:

- There were methodological advances in the participation of members of committees of the basin, in the water resources management, and in particular, in the Water Bodies Classification process;
- There were a methodological advance directed to support the selection of strategic actions to control, minimize and correct pollution in intermittent rivers, in semiarid regions, considering environmental, social and economic criteria;
- There was an improvement in the perception and understanding of social actors (role of watershed committees) in the decision-making process.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)

Agricultural water demand management in the south-eastern Anatolia region (Turkey)

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EXTENDED ABSTRACT

Satisfying all types of water demand for humans whilst preserving the required amount and quality of water for ecosystems is becoming increasingly challenging for water managers. Human-induced pressure, such as overexploitation and pollution of water resources, is exacerbated by climatic disturbances resulting in increased frequency of hazards such as prolonged droughts, episodes of heavy rainfall and flooding.

Water demand management calls for mainly i)conserving resources; ii) limiting disputes over use; iii) minimizing the cost and effort of providing water; iv) making the best use of water. The first two concepts relate to the use of the resource itself from the point of view of users, whereas the last two relate to the production of water encompassing both quantity and quality from the view point of management. Water demands, water imports and non-conventional water production such as desalinization and re-use doubled in the second half of the 20th century. Furthermore, there is a tendency towards an overestimate of the future demands. Undoubtedly this is due to an expected increase in water demand related to natural population growth, which is likely to generate additional water needs for domestic use and irrigated agriculture, in particular.

In arid and semi-arid regions the highest water consuming sector is the irrigated agriculture. Existing incentives and economic deterrent have not yet slowed down investments geared towards supply-sided management in this field, especially in developing countries where all water resources have not yet been fully exploited.

The controversies encountered in recent years relate to "energy optimization" versus water production. Actual water resources planning must incorporate energy optimization within the water resources systems as one of its objectives to achieve. The solutions proposed for the future must not only meet the water needs of the territories in an environmentally sound way, but they must do so at the lowest possible energy consumption and maximum recovery.

In the Mediterranean Region where Turkey is located, this consideration achieves great relevance for several reasons: First, the scarcity and irregularity of the flow regimes often requires the mobilization and transport of resources, leading to significant energy costs. In addition, the intensive use of groundwater requires energy for pumping in significant quantities. Besides, the transfer of water from one sub-basin/basin to another requires significant amounts of energy for the transmission main. These considerations about water and energy relationships operate at the planning level, but are also of main concern at the level of local facilities, in which the links between water and energy are also very important. (IME 2012)

The irrigation water efficiency index is the indicator representing the most important impact on water demand management in the Mediterranean Region where irrigation consumes approximately more than 75% of the total demand on the average.

This paper presents a study carried out in the South-eastern Region of Turkey in order to make an overview of the agricultural water management based on the existing data and to assess the evolution of the water use efficiency index after the adoption and utilization of modern techniques related to the water distribution systems for the irrigated agriculture (e.g. drip irrigation, sprinkler). The

evolution has been computed based on the irrigation water index Eirr taking into account different irrigation methods.

The study area exhibits diverse environmental particularities and challenging social and management issues. The region has a high potential of natural resources. The annual mean flow of Euphrates and Tigris is 53 billion m^3. Out of this amount, 30 billion m^3/year and 16,7 billion m^3/year is the annual average flow of the main streams of Euphrates and Tigris respectively (GAP 2012). This amount corresponds to the 28.5% of the total river flow potential, the groundwater potential is estimated at 1.5 million m^3. The region has approximately 2.1 million ha of gross irrigation potential which corresponds to 20% of Turkey's overall economically irrigable potential. The South-eastern Region has a very high solar energy production capacity and the energy cost is the main expense for cash crop production in the region. Already more than 400,000 hectares are being irrigated with deep well pumps and use the electricity as the main energy source. Water is pumped from 150–200 meters and the energy consumption is very high (DSI 2009).

As a conclusion of this regional study, pilot projects have been identified with the main following objectives: 1-policy analyses for better water use efficiency; 2-capacity building/training; 3-economic analysis of on-farm development; 4-increased yield/water used (water use efficiency analysis with indicators); 5-water and energy in irrigation management.

A SWOT analysis has been carried out with regard to the feasibility of pilot projects to be proposed in the region and also their sustainability after the implementation phase. This analysis has been carried out in close exchanges with stakeholders and experts having sound field experience from the region based mainly on their judgments (e.g. GAP-RDA, DSI, World Bank experts, land-owners, WUAs' members, farmers).

ACKNOWLEDGMENT

This study carried out between December 2012 and May 2013 was sponsored by UNESCO IHP-Germany in collaboration with Istanbul University.

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Section 2: Good watershed management

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Towards water sustainability by 2030 in the Rio Bravo/Grande Region, Mexico

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ABSTRACT: The hydrological region Rio Bravo/Grande is the largest in Mexico, and mainly arid and semiarid, its basin is shared with USA. The growing water demand of various uses has caused severe shortages, which has been solved through aquifers' over exploitation and over allocation of surface water. In addition, the region is subject to severe and recurrent extreme weather phenomena, including droughts and flooding. The region submits an important annual water volume to the USA, because of the International Water Treaty, signed in 1944. There is strong evidence that present water gap is large and will be greater, if specific measures are not implemented to control and revert this situation. The risk of system collapse is high with potentially severe consequences. This paper addresses this condition, and some possible solutions are proposed in a planning horizon by 2030 in order to achieve water sustainability and equilibrium, considering the objectives of the 2030 Water Agenda for Mexico.

1 INTRODUCTION

The water shortage problem in the Hydrological-Administrative Region 6 (HAR6) is identified by overexploitation of watersheds and aquifers, with high urban and industrial growth of nine metropolitan areas, where about 80% of total population is located. Drinking water, sewerage and sanitation coverage index are high, significant investment are required to keep and increase them. Because of its geographical location, the region is subject to recurrent floods and droughts events. These factors make the region specially vulnerable to variations in the availability of surface water. To control and reverse these effects has been designed a water planning model, that defines the regional policy on a horizon by year 2030. It is based on a multidisciplinary analysis process with the participation of the society in general and the basin councils.

Specific goals and strategies of medium and long time lines have been established for a sustainable use and safe water supply and, to achieve the vision of the Water Agenda 2030 (WA2030), an initiative of the National Water Commission, which seeks to consolidate long-term water policy for country's water sustainability, with four main sectors: clean rivers, basins and aquifers in equilibrium, safe drinking water, sewerage and sanitation universal coverage, and cities and productive areas protected from catastrophic floods and droughts. This paper presents a synthesis of the results of the regional water planning model, in which the region is divided into 24 planning cells (units).

2 REGIONAL CHARACTERIZATION

The HAR6 Rio Bravo (Rio Grande, as it is known in the USA) is located in the North of Mexico, on the border with the United States of America (Fig. 1); it is a big watershed shared between both countries, so it acquires international features, and its management deals with an International Water Treaty, signed in 1944 (IWT).

Figure 1. Hydrologic-administrative region 6, Rio Bravo/Grande, in Mexico.

The surface basin has a territorial extension of 388,810 km^2, equivalent to 19.9% of Mexico's land area; administratively consists of 144 municipalities and four states. To coordinate the process of integrated water management, the Rio Bravo Basin Organization (RBBO), is the government agency in charge, and has the support of a Watershed Council, composed of several representatives of major interest groups in the area.

2.1 *Environmental aspects*

The HAR6 includes 77 hydrological sub-basins. The annual average rainfall in the region is about 480 mm (38% less than the national average), and is characterized by high variability of precipitation from one year to another, and with long drought periods occur on recurrent basis. In general terms, irrigation is essential to obtain commercially competitive yields in the region.

Within the RHA6 are located 102 aquifers; of these, 34 have non-availability, of which 18 are over-exploited (Fig. 2). Average annual runoff of surface water is about 9,970 hm^3/year; most of watersheds have surface water deficit (Fig. 3).

2.2 *Hydraulic infrastructure and water uses*

There are 381 main water dams or reservoirs operated by the official and unofficial sectors; the total volume capacityis about 16,061 hm^3; the five major dams represent more than 80% of the storage capacity, and are mainly dedicated to irrigation (Fig. 4).

The total allocated water in the region for consumptive uses is about 9,248 hm^3 per year, 52% from surface water and 48% underground water, which is used as shown in Figure 5.

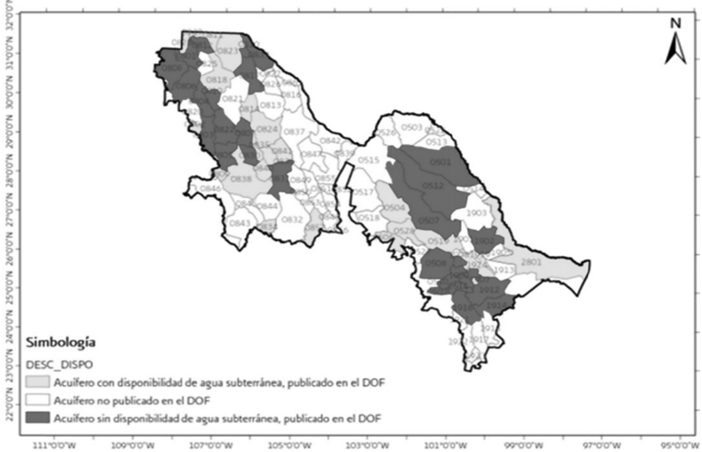

Figure 2. Aquifers in HAR6, those with available water are colored in light grey and those with non water availability in dark grey.

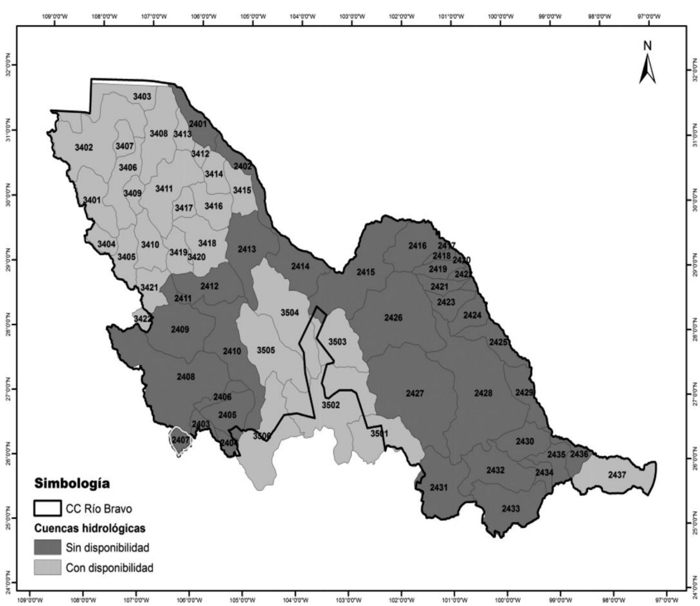

Figure 3. Basins in HAR6, with- (light grey) and without- (dark grey) surface water deficit.

2.3 *Social aspects*

Total population to 2012 is estimated around 11 million inhabitants, representing 10% of the total country population, and is predominantly urban: 92.9% is concentrated in cities. Eventhough 99.2% of towns are less than 2,500 inhabitants, the population is concentrated mostly in nine metropolitan areas, which account for 78.8% of the total HAR6 population.

Figure 4. Francisco I. Madero Dam, one of the most important reservoirs in HAR6.

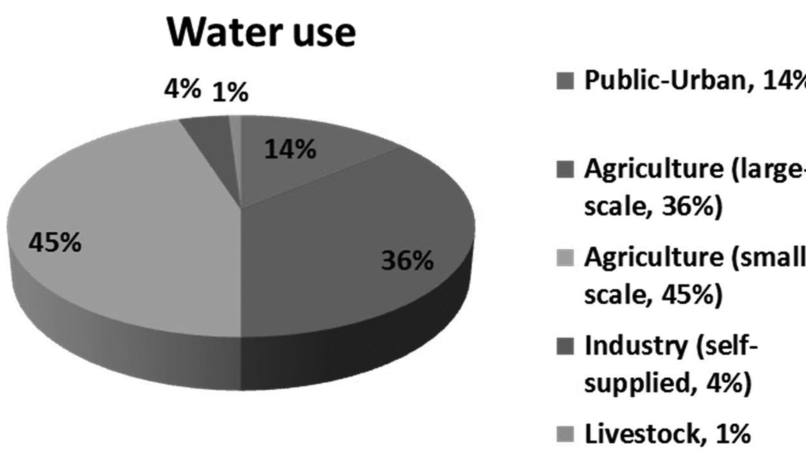

Figure 5. Water use proportion in HAR6.

2.4 *Economic aspects*

The regional gross domestic product (GDP) is 14.5% of the national's, which makes it the third largest in the country (aprox. MX$13.25 = $1USD). Sectorial water participation and productivity are shown in Table 1.

The agricultural sector is important because of its expansion, with a total crop area (rainfed and irrigated) of 1,646,133 ha, of which 942,000 hectares are watering, these 470,000 are registered in the public register of water rights, in 12 irrigation districts (ID). Irrigation area outside the ID is estimated in 472,000 ha distributed in 4,892 irrigation units.

Because of its particular location, the Rio Bravo/Grande basin is shared with the USA, therefore HAR6 management is in compliance with the International Water Treaty, which implies a commitment between the two countries concerning the distribution of surface water, in which Mexico, for the case of the Rio Bravo/Grande, is committed to submit 431.7 hm^3/year, in five-year periods.

Table 1. Some details about water use in HAR6.

	GDP sectorial participation	Water productivity (MX$/m^3)
Primary sector	2%	3.86
Secondary sector	38%	1,156.02
Tertiary sector	60%	5,733.70
Total of the region	100%	148.94
Hydroelectricity	(non-compsuntive use)	13.88

In general terms this compromise has been fulfilled, despite the wide hydrological variations in recent years. Relevant to the implementation of the program of sustainable water use in the Rio Bravo/Grande basin, has led to significant savings in the use of water for irrigation. The water supply for both municipal and industrial uses, despite the natural conditions of low availability, has not been a limiting factor for regional development.

However satisfactory current achievements in the HAR6, high population and industrial growth in the region, is fueled by the poles of economic development and border cities, presents very important challenges to overcome, and is required to intensify efforts and actions, particularly to maintain and increase the standards on drinking water supply and sewerage index coverage, especially in urban areas.

3 RELEVANT PROBLEMS AND WATER AGENDA 2030

The regional irrigation sector demands around 82% of the available water, for watering about 14% of the national irrigation area. HAR6 stands out by having an important population dynamics, that coupled with the intensity of economic activity in all the productive sectors have taken it to a growing water demand. The main related problems are:

- Water scarcity and limited water availability
- Low efficiency in water use and low profitability of some economic activities
- Degradation and pollution of ecosystems
- Rivers and aquifers water pollution
- Social marginalization
- Deficiencies in supply of environmental services
- High concentration of population
- Recurrent flooding and droughts events
- Low water governance
- Insufficient development in water management
- Low water culture
- Insufficient water sector financial system

Taking in account the relevant problems and the significance of the resource in the country's well-being and development, a policy instrument called Water Agenda 2030 (WA 2030) has been established, which promotes a clear vision (Conagua 2011): "to achieve by 2030, a country with clean rivers, basins and aquifers in equilibrium, drinking water and sewerage coverage, and safe human settlements to face extreme catastrophic hydrometeorological phenomena".

These four national priorities, the most important in relation to the water, will allow to reach water sustainability, if addressed with opportunity and efficiency, through actions, measures and strategies, which ensure the quantity, quality and timeliness of water for all uses and users, considering governance, equity, social justice and economic efficiency, as well as environmental use, indispensable for a healthy harmony of man with Nature (Fig. 6).

Figure 6. Main planning sectors and components of Water Agenda 2030.

The current government is promoting some actions and strategies in the region, in order to improve water management (Conagua 2014), keeping in mind that environment is changing because of the climate change, and this region is one of the most vulnerable to water variations (IMTA, 2012). Social participation through local committes, academia and non-government organizations have been convoked to contribute actively, and the response has been very enthusiast, sore there is a big expectation about success (Conagua 2014a).

4 PROSPECTIVE TECHNICAL ANALYSIS

To achieve in compliance with the principles of the WA2030 regional water policy, the implications were determined, recommendations were generated and defined, strategies, actions and projects were prioritized and scheduled, using a Prospective Technical Analysis model (PTA; Conagua 2010) in order to support the initiative in the medium and long terms.

In oder to reach this aim, HAR6 has been divided into 24 planning cells (Fig. 7), which are defined as a set of whole municipalities which belong to an unique political state (province) within the limits of the same hydrological subregion. Notable for its size is the Conchos Chihuahua planning cell, which has largest area with 25.8% of HAR6 (and the largest in Mexico) and the smallest one is Acuña Coahuila with just 0.6%. In each of these cells was applied a methodology that uses a specific planning terminology.

5 OBJECTIVES OF THE REGIONAL WATER POLICY

Basin and aquifers in balance planning sector, the main objectives are:

1) to maintain the availability of national waters for all applications and
2) to raise the economic and social profitability of water through sustainable production of food, energy, goods and services.

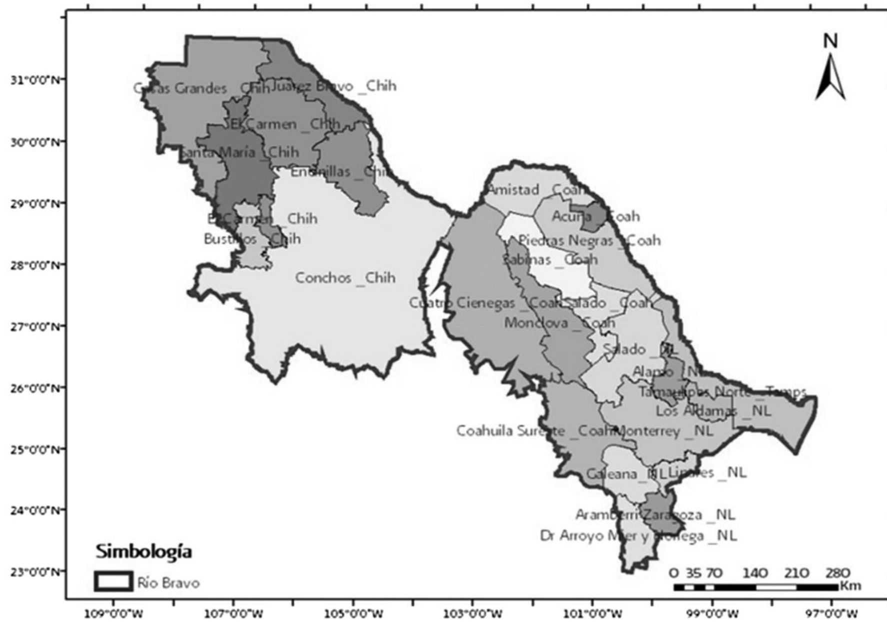

Figure 7. Division of HAR6 in planning cells.

Clean rivers planning sector also splits the problems in two major themes:

3) to rehabilitate the quality of water in streams, aquifers and beaches.
4) to rehabilitate ecosystems in watersheds.

Universal coverage of drinking water and sewer services planning sector includes:

5) to ensure access to drinking water and sewerage services appropriate for the whole population
6) to improve quality of drinking water and sewerage services.

Safe settlements to face catastrophic hydrometeorological phenomena planning sector includes a main objective

7) to reduce risks and mitigate the effects of extreme natural events and climate change.

Water Reforms: Non structural measures necessary to give cohesion to the former ones, the basic objectives are:

8) to achieve effective governance of water and natural resources associate.
9) to strengthen the education and culture of the water in all sectors and
10) to strengthen the financial system of the water.

For the different planning sectors of the WA2030, with the PTA were defined and measured several alternatives, applied in the horizon by 2030, under the premise that are the most efficient and least costly, and therefore which are more effective for closing the water gap or at least reduce it to more manageable levels.

Thus, since the agricultural sector is the most demanding in volume (82% of the total; Fig. 8), then the most appropriate alternatives are those that tend to make more efficient irrigation, both by using better irrigation methods as by the use of treated wastewater. In other sectors, alternatives such as waste water treatment, and improvement in the use of water in industry and domestic consumption are essential (Conagua 2012).

Partially the demand is supplied in a non sustainable way, about 1,700 hm^3/year, causing over-exploitation levels with a volumen around 1,200 hm^3 in aquifers and causing damage to aquatic ecosystems by not drain 500 hm^3/year as ecological volume for environmental preservation. As mentioned, an important part of the water management in HAR6, is to take into consideration the

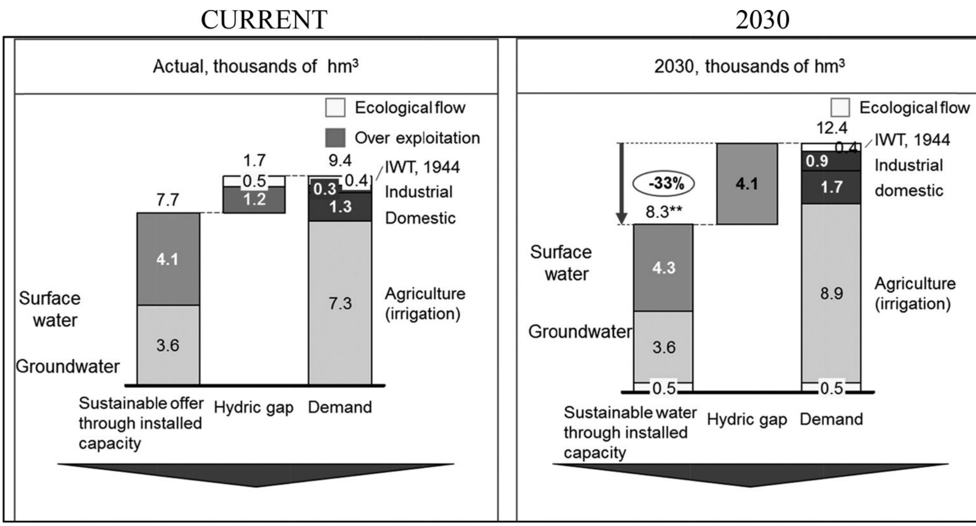

Figure 8. Sustainable offer, demand and hydric gap, current and by 2030, in absense of recovery measures, thousands of hm^3/year.

1944 Treaty, whereby 431.7 hm^3 per year are considered part of the current and future demand. Thus, in absense of corrective measures, by 2030 the hydric (water) gap would be about 4.1 thousands of hm^3/year, which could be catastrophic.

6 ALTERNATIVE SOLUTIONS

In order to decrease the water gaps in all planning cells, a technical solution has been raised that achieves a balance between building additional infrastructure measures, which are intended to improve efficiencies in water use in all sectors. In this way 38 measures have been identified, with 3,612 hm^3/year recovered volumes (Fig. 9). This solution fails to close the gap in 6 of the 24 cells, but significantly decreases aquifer's over exploitation, and tends to sustainability.

With this PTA, is possible to verify if closing the gap in each water sector can be achieved with measures of the same sector, or if it needs the recovery of volumes from other sectors.

In all planning cells, but especially in those where the gap is not closed, some measures and additional actions are needed (Conagua 2010):

- To import water from other basins or aquifers in a sustainable way.
- To reuse water in irrigation.
- To maintain current and new infrastructure in proper operating condition.
- To improve efficiencies in public-urban and agricultural water uses.
- To implement measures for efficient use of water at home, commerce and industries
- To promote water transference between sectors.
- To increase water tariffs to reduce consumption.

The HAR6 is one of with the highest drinking water and sanitation coverage indexes in Mexico (Fig. 10), to maintain and increase this condition will required heavy investment in infrastructure and actions, both in the urban and in the rural areas, where population projections by 2030, estimates nearly 14 million inhabitants, 94% of it, will be located in urban areas.

Carry out this program will require huge investments, which will have different origins: Government, contributions from users of water funds, private investment, loans of international financial

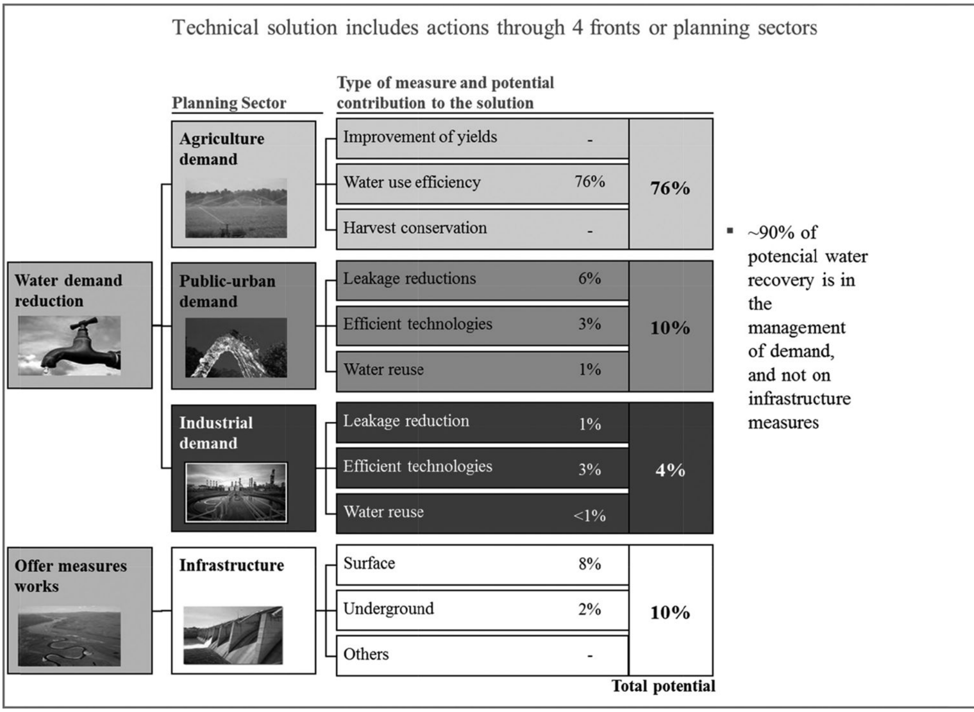

Figure 9. Technical solution results in water recovery, for each planning sector.

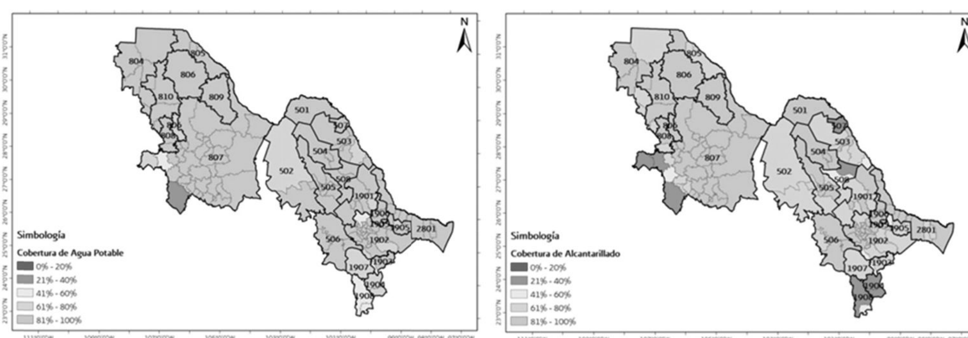

Figure 10. Current drinking water and sanitation coverage index in HAR6.

agencies, etc., all which is estimated will be required to succeed the initiative, to be applied in six-year periods, until 2030.

7 CONCLUSIONS

The HAR6, with overexploited aquifers and a high surface water deficit, structural and management measures may not be sufficient to overcome the problem, but it is necessary to achieve the consolidation of the same, and this is only possible through governance and continuous participation, determined and committed by all water user sectors. The WA2030 is not a static instrument, but a tool that should be updated and improved according to the evolution of times and situations, and its success will depend on goodwill, broadmindedness and common goal to inherit future generations a more sustainable, equitable and harmonious world, with vision and strategy.

It has been observed in the last three decades, those hydrometeorological extreme phenomena (droughts and floods), has become more intense and severe in the region, so the effects of variation and climate change are most striking, and are too additional factors that must be considered in the planning and formulation of scenarios of water use. Urbanization, increasing in energy demand and food, coupled with the natural changes, will have negative effects on the availability and quality of water, so improvement in its management will be the most viable option for ensuring the sustainability and development that the region requires.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Integrated and participatory approach based on river basin management in Turkey

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ABSTRACT: This study describes recent developments in the integrated and participatory approach applied to river basin management in Turkey. This document reviews what has been done so far, the current situation, and what remains to be done in Turkey. The concept of "River Basin Protection Action Plans" which will be converted to "River Basin Management Plans" has been examined and the efforts for participation of all stakeholders to decision and implementation phases have been defined. The projects, studies and improvements in the area of basin management have explained.

1 INTRODUCTION

It's now a more emphasized fact how socially important and vital resource water is. Turkey is not a rich country in terms of water resources and is situated in a semi-arid region of the world. Turkey's precipitation trend shows a large variety depending on seasons and regions.

In some river basins, it is seen that water demand is high above the potential resources. Throughout the country it is observed that water quality shows a large variety as well as the quantitative distribution. As a result of that, unhealthy and unsafe water consumption becomes inevitable. Turkey is aware of the fact that effective management of water resources, especially water quality, is very important. Water quality is affected by increasing population, agricultural activities, rapid urbanization and industrialization through the global and regional developments.

In order to increase the welfare and happiness of the country, developments towards evaluation of our existing resources and potentials properly are in progress. Parallel to this situation, to provide sustainable development with the socio-economic development, significant developments achieved in terms of the actions to prevent water pollution. As a candidate country for EU membership, Turkey started harmonization studies of Turkish legislation with EU legislation and several achievements accomplished especially in pollution prevention topic. The increase in the quantity and variety of elements of impacts on water resources has made it essential to manage river basins with an integrated approach.

In the past an answer was searched to the question for the quantity of water and location. Today water quality factor is also taken into account. So the obligations to consider all the factors which affect these two factors arise. In other words, water resources term is taken into account within the "environment" case. Since environment constitute a whole in terms of water, air, soil and an intervention to one of those resources can affect the others, water resources management should be evaluated within the whole environment.

To carry water resources to the future generation in a clean and healthy way, it is necessary to use water with protection and to consider water within a framework of soil-living being-climate relation. Development in technology has been a tool to provide maximum benefit from water resources. Parallel to this development, with the increase in urbanization and industrialization, especially during 1980s problems related with environmental pollution had arisen and the most affected natural resource was water re-sources.

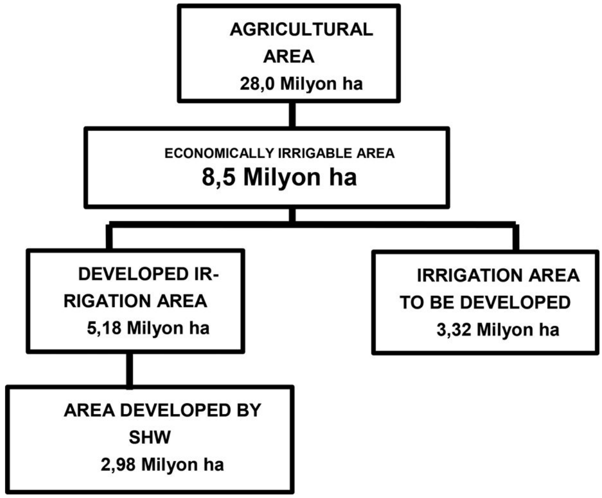


Figure 1. Irrigable agricultural areas of Turkey.

In order to protect and enhance the existing water quality of our water resources, it is necessary at first to know the qualification of the water and then to define the protection principles within the framework of consumption-protection equilibrium. Ministry of Forestry and Water Affairs has constituted its pathway by defining short, medium and long term goals. Especially with the effect of European Union period; harmonization of legislation, planning for implementation, enhancing the institutional capacity, defining the management models intended for treatment and disposal, setting economic instruments such as incentives and sanctions, water policies have brought into action. After many years, Water Regulation is arranged as a response to the increasing and changing demands.Climate change, which is a significant issue for river basin management process, taken into account through preparations of these plans and studies.

This paper reviews the implementation of river basin management in Turkey. The focus is primarily on the policy, legal, and institutional frameworks for water resources management in a basin based level. The paper has four sections. After this introductory section which briefly discusses the aim of the project and current situation of potential water resources in Turkey, the second section review the role of institutional structures and legal frameworks for river basin management. Water Framework Directive and basin studies are discussed in third section and section four contains concluding marks.

1.1 *Potential of water resources*

The distribution of annual precipitation capacity comes up to an average of 501 billion m^3. Of this amount 112 billion m^3 is usable water and in the present 40 billion m^3 is being used. It is planning to use the entire amount by 2023.

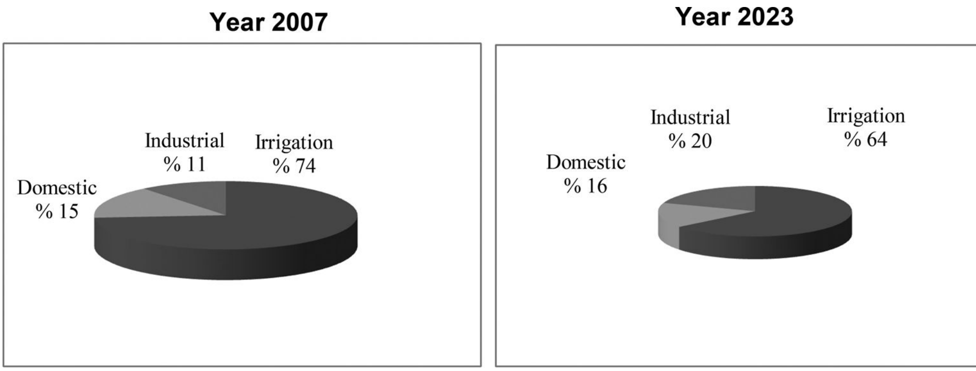
In the present, there is 28 million hectare agricultural land in Turkey and 8.5 million hectare of this area is economically irrigable land. 5.18 million hectare of this land is being irrigated and studies are conduction for the 3.32 hectare of the land (Fig. 1).

The sectoral distribution of the available water amount in Turkey is shown on Figure 2.

2 LEGAL AND INSTITUTIONAL STRUCTURES

2.1 *Institutional structure*

Water Management is defined as the aim and responsibilities of the Ministry of Forestry and Water Affairs which is established by the decree law dated on 29/6/2011 and numbered as 645. The



Irrigation : 34 billion m^3 (%74)
Drinking Water: 7 billion m^3 (%15)
Industry: 5 billion m^3 (%11)

Irrigation: 72 billion m^3 (%64)
Drinking Water: 18 billion m^3 (%16)
Industry: 22 billion m^3 (%20)

Figure 2. Sector based water consumption.

Ministry of Forestry and Water Affairs (MoFWA) which is competent authority on subjects related with water, has a general coordination task in terms of development and implementation of Turkey's water policy including coordination of adaptation of Turkish Water Legislation with the EU acquis as well as subjects such as water management and protection of water, The Ministry is in cooperation with other Ministries, public bodies and other stakeholders.The aims and responsibilities of MoFWA related with water are given as below;

General Directorate of Water Management (GDWM) responsibilities are:

1. To define policies in order to preserve, enhance and consumption of water resources.
2. To provide coordination of water management on national and international basis.
3. In order to protect and improve the ecological and chemical quality of water resources considering the protection-consumption balance, including coastal waters, to prepare basin management plans on river basins basis, to conduct complementary river basin management legislation process.
4. To define precautions with related institutions in addition to evaluate, update and supervise the implementations about pollution prevention on basin basis.
5. To define the aim, principles and receiving environment standards together with the related institutions to monitor water quality or make it monitored
6. To define strategy policies about floods and to prepare flood management plans.
7. To conduct necessary coordination related with sectoral basis appropriation of water in compliance with the river basin management plans.
8. To follow processes originated from international convents and other legislation related with protection and management of water resources, to steer the aims related with trans boundary and verge boundary waters interoperate with other public bodies
9. To build up international water database information system.

General Directorate of State Hydraulic Works (DSİ):

DSI was established by Law 6200 in December 18, 1953 as legal entity and brought under the aegis of the Ministry of Energy and Natural Resources. It is charged with "single and multiple utilization of surface and ground waters and prevention of soil erosion and flood damages". For that reason, DSI is empowered to plan, design, construct and operate dams, hydroelectric power plants, and domestic water and irrigation schemes.

The DSI's purpose "to develop water and land resources in Turkey" covers a wide range of interrelated functions. These include irrigation, hydroelectric power generation; domestic and industrial water supplies for large cities; recreation and research on water-related planning, design and construction materials.

DSİ IT Department is responsible for the establishment of Geographical Information System Infrastructure and collecting of data in one hand.

General Directorate of Nature Conservation and National Parks is responsible from the management of Wetlands, biodiversity and application of Habitat and Biodiversity Directives.

The Ministry of Environment and Urbanization is responsible from the control, inspection and sanction of discharges, providing of effective public cooperation and preparation of Environmental Impact Assessment and Environment Plans.Public bodies such as The Ministry of Health about water intended for human consumption and The Ministry of Food, Agriculture and Livestock about Nitrate bylaw are shared the responsibilities in Turkey.

2.2 *Legal arrangements*

The works related with the most important legal arrangements for protection and effective usage of water sources in our country are given below;

1. The law numbered as 5491 was published to make changes in Environmental Law (No:2872) and it satisfies requirements for EU harmonization period and efficiently protects water sources by means of national requirement.
2. Water Law is prepared as draft version and it will plan to be published in 2014.
3. "Water Pollution Control Regulations" which was published on 13 February 2008 is compared with EU Water Framework Directive by EU experts and is found fit to this Directive and needs to be developed. The procedures and principles about wastewater discharge principles, discharge standards for sectors, permissions to the receiving environment and to the sewer system, monitoring and inspection are decided in this regulation. Water Pollution Control Regulations put extensively in order to the water quality management. In this regulation, it is aimed to protect the quality of water sources within the frame of ecosystem principle and to develop the water quality in order to the requirements of country. Within this scope, in this regulation, arrangements was put in or-der about the protection areas which was needed to be formed around the drinking and service water reservoirs, domestic and industrial wastewater discharges and to protect agricultural areas. Within the frame of surface water, for quality type of water is defined such as high quality, slightly polluted, polluted and highly polluted. All purposes for each type of water is also defined. For the groundwater 3 quality type is also defined in this Regulation.
   a. Type water can be used for drinking purpose.
   b. Type water can be used for industrial and agricultural purpose directly but for drinking purpose after treatment.
   c. Type groundwater can be used after treatment according to the requirements of usage purpose.

   After the reorganization of the Ministries in Turkey, Water Pollution Control Regulations is developed by The Ministry of Environment and Urbanization according to its aims and duties.
4. Water Pollution Control Regulation, Communique on Procedures and Principles for Determination of Special Provisions in Basins was published dated on 30 June 2009 and numbered as 27274 for the arrangement of the studies on determination of special pro-visions in drinking and service water basins. The Communique will be converted to Regulation by GDWM.
5. The regulation about the quality of surface water which is used or planned to be used as drinking water is under revision. The revision about the regulation on the control the pollution which is caused by dangerous substances in water and its environment is continued to reach the aims of the Water Framework Directive
6. Communique on Sensitive and Slightly Sensitive Water Areas to aim the implementation of Treatment of Municipal Wastewater Regulation is published on 27 June 2009 and no. 27271 Official Gazette.

And also the Communique on technical methods for the wastewater treatment plants is published according to the requirements and the developments about the treatment of domestic wastewater for selection of technology for wastewater treatment plants, design criteria, disinfection and reuse of treated wastewater, deep sea discharges and disposal of sludge comes after treatment.

It is needed to use the role of economical devices to support the Environmental Policies in the application of policies about the Environment. Getting in return of services for water, wastewater and solid waste and the use of income comes from these services for the same services and subjects about strengthening the encouragement and penal sanction take part in the Environmental. The studies about this subject is continued and the Regulation about the Rates for Wastewater Sewage Systems and Solid Waste Disposal Systems is published about determination of the contributions to strengthen the municipalities financial structure and to provide the sustainability of investments 50 % discount is applied to the prices of the electricity that was used in the treatment plant by the firms which establish, and operate a treatment plant and fulfill the obligations in the Regulations.

The Legislation which is already prepared by GDWM given below;

1. “By Law on Protection of Water Basins and Preparation of River Basin Management Plans” has been published on 17 October 2012 dated and 28444 no. Official Gazette
2. “Paper on Institution, Mission, Working Principle and Basis of Basin Management Committees” has been published on 17 July 2013 dated and 28 no. Official Gazette
3. “By Law of Surface Water Quality Management” has been published on 30 November 2012 dated and 28483 no. Official Gazette
4. “By-law On the Protection of Groundwater against Pollution and Deterioration” has been published on 7 April 2012 dated and 28257 no. Official Gazette. To en-sure this by law’s efficiency, “Groundwater Action Plan” has been prepared, which targets to program actions between 2013–2024.
5. “By Law of Special Provision on Drinking Water Protection” has been prepared and ready to send to Prime Ministry.
6. “By Law on Monitoring of Surface Water and Groundwater” has been prepared and ready to send to Prime Ministry.
7. “By Law on Protection and Rehabilitation of Environment of Salmon and Carp Species” has been published on 12 January 2014 dated and 28880 no. Official Gazette
8. “Paper on Protection of Stagnant Inland Waters against Eutrophication” has been prepared and ready to send to Prime Ministry.
9. “By Law on Disposal of Membrane Concentrates in the sense of Receiving Environment” has been prepared and ready to send to Prime Ministry.
10. “Bylaw of Quality Required of Surface Water Intended for to be Obtained or Planned to be Obtained of Drinking Water” revisions has been made and has been published on 29 June 2012 dated and 28338 no. Official Gazette
11. “Paper on Identification of Irrigation Water Quality and Protection of Receiving Environment against Return Water of Agricultural Irrıgation” preparations are ongoing.
12. “By Law for Prevention of Water Loss and Leakage” preparations are ongoing.

3 WATER FRAMEWORK DIRECTIVE AND BASIN STUDIES

3.1 *Water Framework Directive (WFD)*

The change of EU water policies have been continuing for years. In the literature, the change of EU water policies has been analyzed in 3 trends. By WFD (2000/60/EC) which has been issued in 2000 the changes have got a different vision. The directive is not only important for the innovations but also for determining the framework of water policies.

WFD intends to preserve and check the water resources in EU countries as quantitative and qualitative. As a result, comprehensive policy has been produced to protect the EU water resources

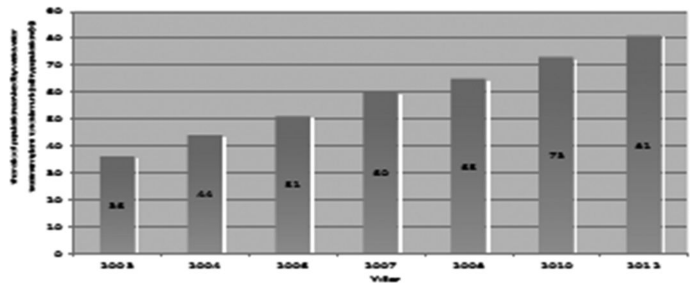


Figure 3. The ratio between the population of waste water treated and total municipality population (Also it is estimated that the number of municipalities that has a waste water treatment facility will be 631 in 2012.)

according to the common standards. Because of this reason, WFD involves all of the legislations like Urban Waste Water Treatment Directive (91/271/EEC), (1991); Nitrate Directive (1991), Domestic Water Directive (1998), Dangerous Substances Directive(1974), Integrated Pollution Prevention and Control (IPPC) Directive (1996), Bathing Water Quality Directive (1991).

The most important provisions of the WFD are; In the future, there will be an integrated water basin management style that cross-border water resources and their basins will be managed by related countries. National or regional management styles will not be preferred.While analyzing the quality of water resources both pollutants and water ecology will be considered.The aim is to reach to the good status for all the water resources until 2015. Whole EU countries will set the measurement methods and management plans to achieve this aim. WFD will provide active participation between EU countries to solve the water problems and water will be able to priced correctly. WFD determines the transition period for the environmental aims to participant countries and it is based on setting reasons to correct data. (2000/60/EC, Directive 2000/60/ec)

3.2 *Basin based studies by ministry of forestry and water affairs*

Besides the regulations about protection of water resources in Turkey; WFD, which aims for the protection of water basins and ecological sustainability, is an important guide for the EU full membership process for Turkey.

The progress on the EU membership process for Turkey has made contribution to apply those terms. Especially, Ministry of Forest and Water Affairs has a very effective role. GDWM is developing some plans considering EU standards. Basin Protection Action Plans which have been prepared by General Directorate of Water Management have the same vision with River Basin Management Plans. It will not be difficult to change those action plans EU standards. The success of Turkey on EU membership process will be moved in practice by those plans.

3.2.1 *Waste water treatment action plan*

Waste Water Treatment Action Plan is prepared for providing waste water treatment facilities which answer country needs and increasing the profit of waste water investments. Technical and financial support is being offered to the municipalities. The time for building waste water treatment facility is till 13 May 2009 for industrial plants and 2010-2017 for municipalities according to their population in Environmental Law. There is an important increase of waste water treatment facility number in municipalities (Fig. 3).

The periods written in Environmental Law were determined according to the policy, strategy and aims of former Ministry of Environment and Forestry and government action plan. As seen in Figure 4, it is estimated that the ratio between the population of waste water treated and total municipality population will be 81% in 2012. (The Ministry of Environment and Forestry 2010).

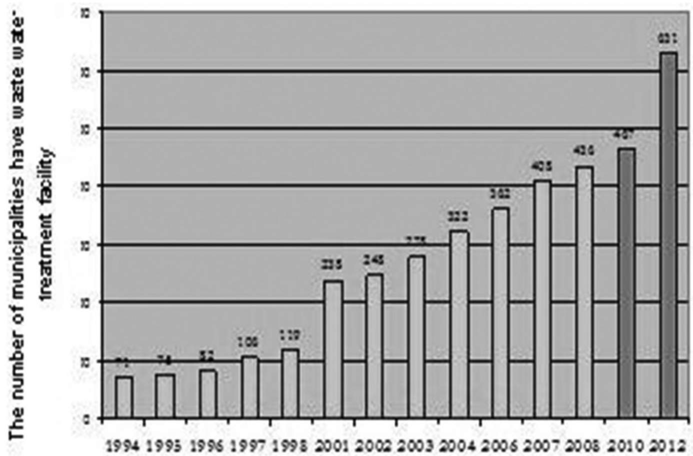


Figure 4. The number of municipalities which that has a waste water treatment facility.

Figure 5. River basins of Turkey.

3.2.2 *Basin protection action plan*

Basin Protection Action Plans for 25 basins in Turkey aims;

1. Protection of the water resources potential in every condition, best use of water resources, prevention of pollution, improving the quality of polluted water resources. When the action plans are implemented, the pressures on water ecosystem will be minimized (Fig. 5).
2. Similar action plans about management and protection of wetland areas are being prepared by Ministry of Forestry and Water Affairs, too.

In this context, a prioritization as in Table 1 has been done between river basins.

In 2011 by the coordination of General Directorate of Water Management; River Basin Protection Action Plans have been prepared for 11 basins (Marmara, Susurluk, Kuzey Ege, Küçük Menderes, Büyük Menderes, Burdur, Konya, Ceyhan, Seyhan, Kızılırmak, Yeşilırmak),

The studies for preparing River Basin Protection Action Plans have been started for 9 basins (Antalya Basin, Doğu Akdeniz Basin, Batı Karadeniz Basin, Fırat-Dicle Basin, Doğu Karadeniz Basin, Batı Akdeniz Basin, Çoruh Basin, Aras Basin) and the studies for revision of River Basin Protection Action Plans have been started for 5 basins (Meriç -Ergene, Gediz, Sakarya, Akarçay, Van) in 2011 and finished in December 2013. Also, The EU supported project "River Basin Management Plans for 4 Basins (Susurluk, Meriç, Konya Kapalı, Büyük Menderes)" which has a 7.840.000 € budget is in tender process and will be started in 2014.

Table 1. The prioritization list of basins.

Urgent Basins	Prior Basins	Other Basins
Akarçay Basin	Yeşilırmak Basin	Ege Suları Basin
Ergene Basin	Sakarya Basin	Doğu Akdeniz Basin
Kızılırmak Basin	Susurluk Basin	Batı Karadeniz Basin
Gediz Basin	Marmara Basin	Fırat-Dicle Basin
Büyükmenderes Basin	Konya Basin	Doğu Karadeniz Basin
	Küçükmenderes Basin	Hatay Suları Basin
	Seyhan Basin	Batı Akdeniz Basin
	Burdur Gölü Basin	Çoruh Basin
	Ceyhan Basin	Aras Basin
	Van Gölü Basin	
	Orta Akdeniz Basin	

Domestic Water Action Plan: If effective use of water resources is managed, the need for domestic and irrigational water will be able to afford. The present situation of water resources for 81 city centers have been analyzed and water need for the years between 2023–2040 have been estimated. Domestic Water Action Plan has been issued to meet those needs. Urgent facilities to be built until 2013; long-term facilities will be built till 2023.

Determination of Special Provisions: Protection and use studies are done within the context of Water Pollution Control Directive to protect the drinking and domestic water reservoirs. There can be seen some problems about the quality of water resources while the rules of the directive are being applied. To protect those kinds of water resources, studies about the characteristics of the water resource and its basin are done to define protection areas and protection rules. Those studies are called as Special Provisions. For that purpose, by our Ministry;

1. For Kartalkaya Dam and Gökçe Dam, Studies of Special Provision Determination have been done in 2009.
2. For 3 basins (Porsuk Dam, Eğirdir and Atatürk Dam Lake), Studies of Special Provision have been done in 2011.
3. For Beyşehir and Karacaören domestic water basins, Studies of Special Provision De-termination have been estimated to be completed in 2014.

3.3 *EU projects*

There are 22 water directives under the water quality title in the EU membership process for Turkey. Fourteen of those directives have been implemented to national legislation. Implementation studies are continuing for the others. Strategy Paper and Negotiation Position Paper have been sent to the EU Commission.

"Capacity Building for Water Sector in Turkey" project was started in 2007 and completed in February 2010 by Ministry of Environment and Forestry. That project aimed to make implementation process within the context of WFD, Urban Waste Water Treatment Directive, Discharge of Dangerous Substances Directive easier and reach good water status in Turkey.

The gap analysis of legislations and institutions for water sector was done by the project. A framework for Water Law was shaped. It is important to prepare a Water Law for the implementation of WFD and this law should be a frame for the directives mentioned above. Studies for Water Law are being carried out by General Directorate of Water Management and it is expected to publish in 2012.

The suggestions about the institutional structure were made by EU member country experts. Those suggestions were very helpful while the new institutional structure had being done. The

Table 2. Application Steps for Member Countries.

2027 – 2033	4. Preparation of River Basin Management Plans	In the situation of not reaching to the environmental targets, transition period requests
2021 – 2027	3. Preparation of River Basin Management Plans	Many EU Member target to reach good status in 2027
2015 – 2021	2. Preparation of River Basin Management Plans	
2009 – 2015	1. Preparation of River Basin Management Plans	

application plans for the implementation cost of WFD and Dangerous Substances in Water Directive have been prepared.

As seen in Table 2, there are 3 times 6 year periods for completing River Basin Management Plans for EU member countries. It is aimed to make good water quality status sustainable in those periods.Turkey is not a EU member, yet. When it is a member, 1st and 2nd periods can be used to complete River Basin Management Plans. It means that Turkey may have a late membership but it will complete the River Basin Management Plans in the same time with early member countries. Turkey should build up its monitoring system and constitute the standards in those periods immediately. (Sarıkaya & Çiçek 2008)

River Basin Management Plan for Büyük Menderes Basin has been finished. By this plan, the characteristics of the river basin and pressures and effects on the basin have been determined. Comparisons between Büyük Menderes Basin and similar basins have been done. As a result of those comparisons, general view of Turkey' s basins has been built. Water bodies in good water status have a 22% percentage in Turkey according to WFD and sister directives. For Büyük Menderes basin, 66 precautions have been defined to reach good water status. The costs of those precautions are being calculated (Çiçek 2010). This value is 70 billion Turkish Lira when it is applied to the whole of Turkey.

It is possible to bequeath a healthy environment, to prevent pollution, to prevent damage by protecting nature, to protect and enhance green fields by raising awareness of the community. Ministry of Forestry and Water Affairs works with the maximum effort to develop this understanding. Based on this understanding, by the period of Turkey's candidacy, in order to talk a common methodology and language throughout the country during the tasks for enhancing water quality to be accomplished, the project "Training for Trainers" is accepted and started with Netherlands within a dual cooperation of framework. It was aimed to train decision makers, implementers, universities, non-governmental organizations at the basins within the scope of all water quality directives especially Water Framework Directive which take part in 25 River Basin Water Quality. A core group of 39 persons trained as "Trainer of the Trainers". (The Ministry of Environment and Forestry 2010)

To maintain the high water quality within the scope of water Framework Directive, the project named "Capacity Development for Water Quality Monitoring System" has started by the coordination of GDWM. This project is going to lead monitoring pollution parameters within the context of which are defined both in our national legislation and EU directives. The project of "Enhancement of Capacity within the scope of Flood directive in order to compose Flood Management Plans" is accepted within 2010 IPA and have started by the coordination of GDBM.

Project on the Determination of Sensitive Areas and the Principles of Urban Waste Water Treatment The project has started on June 2010 and will be finalized by 2013. According to the results of the project; appropriate treatment technologies will be defined through the classification of inland water resources as "sensitive" and "non-sensitive" receiving body. Determination of sensitive and non-sensitive areas and principles of wastewater treatment management will be the most

Table 3. Mean annual total costs of precautions for Büyük Menderes Basin and total costs for 17 years.

Directive	Kind of Cost	Mean Annual Total Cost (Million TL)	Total Costs for 17 Years (Million TL)
DSD	Precaution Program	37,3	633,7
	Implementation Costs	0,9	16,0
	TOTAL	38,2	649,7
UWWTD	Precaution Program	44,6	757,9
	Implementation Costs	0,1	2,4
	TOTAL	44,7	760,3

Table 4. Total costs of additional precautions for 17 years (until 2027) (million TL).

	Additional Costs	DSD	UWWTD
Precaution Program	57,6	231,9	120,3
Implementation Costs	31,9	14,6	4,1
TOTAL	89,5	246,5	124,4

Table 5. Average total annual costs for the precautions (future plans) in case of implementation of WFD, DSD and UWTD at Büyük Menderes River Basin (million TL).

	WFD (additional costs to DSD and UWTD)	DSD	UWTD
Precautions Program	3,4	13,6	7,1
Harmonization Costs	1,9	0,9	0,2
Annual Average Total Costs (million TL)	5,3	14,5	7,3

remarkable output of the project. These remarks will be served as scientific and technological tools for achieving the target of national environmental quality.

Project for Implementation Plan for the Urban Waste Water Treatment Directive, The Project Fiche has been submitted to the Commission. The purpose of the project is to prepare the urban waste water implementation plan defined in Article 17 of the Urban Waste Water Treatment Directive.

Project for Definition and Development of Water Unions in Turkey: The project has started on the 1st of December 2010 and will be finalized by 2012. The purpose of this project is to create one or more organization types within the Turkish legislative and social-cultural context that is able to operate and maintain Waste Water Treatment Plants in an efficient way.

Project on the Implementation of the By-Law on the Control of Pollution Caused by Dangerous Substances in Water and The Aquatic Environment (2011–2014). This project contains;

1. The inventory of dangerous substances
2. Determination of EQSs (except for the priority substances)
3. Determination of discharge standards

The Twinning part of the Project on Implementation of Nitrate Directive has been completed at the beginning of 2010. The Technical Assistance and the Supply part has been tendered in 2010, and these parts started in 2011.

Within scope of Project of Turkey's Water Footprint, Turkey's Water Footprint Report has been prepared and reviewed with a workshop in 1st of October, 2013 in Ankara. This report, which provides the evaluation and calculation of Water Footprint of several areas like industry and agriculture, will be published soon.

4 CONCLUSIONS

The main reasons of water related problems are rapid and unplanned urbanization depending on population growth, industrialization, intense agricultural activities, misuse of the lands and global warming. But the real problem is related on "Integrated Management" which is developed by the targets such as planned and economical usage of water which is a natural source and have no alternative, determination and prevention of the problems which threaten water sources, protection of water and water related ecosystems, obtaining sustainable economic growth etc.

For accomplishment of the implementation; preparation of a Water Law is important to form corporate infrastructure to facilitate the applications within the frame of obligations in the EU membership process and to remove the legal overlapping, to remove corporate conflicts, to realize integrated water management, to provide continuance by rehabilitating of ecological structure of water, to monitor water and to constitute the basis of forming a data base, to form basis to implement the principle "polluter pays" and to integrate all water quality directives. Forming a mechanism to support institutional coordination in our country is also important to prepare such a law and to implement the directive. Especially forming basin based management models for structuring of studies in basins by the owners of the basins will carry out better and effective solutions.

The Ministry of Forestry and Water Affairs coordinates this development and vision in such a way. They are working compatible with the benefits of the country through EU membership process. Especially studies on harmonization of the Directives and studies on reorganization are the indicators of truly comprehending of the process. "Water Management Coordination Committee" is formed to put our targets and strategies, to activate the organizations and institutions with the aim of evaluation of EU membership process in terms of water sector and precipitation of our national based applications and investments.

Turkey specified his priorities to take decisions on correct time and to reach good status targets and to preserve good status continuously and forming his investment plans considering defined time frames. Time has become an important concept for Turkey who wants to be an EU Member. For this reason all the prepared plans will be realized and put into practice.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Critical analysis of the environmental licensing of hydropower plants in Brazil

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ABSTRACT: Faced with the challenge of ensuring the expansion of energy supply in Brazil, which is based on a renewable matrix, with the lowest social and environmental impact possible, this paper aims to make a critical analysis of the environmental licensing process applied to hydropower plants in Brazil. It aims at analyzing the strengths and limitations of this instrument as well as proposing possible adjustments to the rules and procedures in order to contribute to the decision making process so as to expand the supply of renewable energy in the country, through the efficient and environmentally appropriate use of the water resources available.

1 INTRODUCTION

Brazil stands on a privileged position and may possibly become a model in energetic expansion thanks to its impressive hydroelectric potential – about 260.000 MW (SIPOT, 2007). However, for that to happen the government needs to adapt to the challenges brought by the correlation between the increase of demand and the environmental restrictions to hydroelectric use (legislation, land use zoning and environmental licensing).

This issue can be better understood by analyzing three factors of the contemporary historical context. First, there is a global consensus regarding the importance of choosing renewable and clean energy sources, which is demonstrated by the creation of policies by countries and international entities such as the European Union (Bechberger and Reiche, 2004; Georgopoulou et al., 1998; Resch et al., 2008).

Second, the demand for energy is increasing due to the population growth and the increase of the power of consumption of developing countries or countries that are facing a strong economical growth, which is the case of Brazil. In consequence, the Brazilian government has created policies that focus on increasing the energy supply for industries and especially for low income citizens (PEREIRA et al., 2011).

Third, 40% of the Brazilian hydroelectric potential is located on the Amazon Basin, an area that has one of the largest biodiversities on the planet and possibly the largest amount of living biomass in a single country. In addition, it is also where important territories of the remaining indigenous population of the country are located, which is cause for strong socio-environmental restrictions to the use of the hydroelectric potential of the area. According to estimates of the National Energy Plan for 2030, made by the Ministry of Mines and Energy, approximately 62% of the hydroelectric potential of the Amazon has some sort of restriction imposed by socio-environmental zoning

(Permanent Preservation Areas, Conservation Units, Indian Reservations, and other categories) (BRASIL, 2007).

In this context, environmental licensing is an instrument of the National Environmental Policy, which was instituted by Law 6.938 in 1981. Its main objective is to help the decision making process regarding the best alternatives for using natural resources by determining which factors may mitigate or compensate the negative impacts caused by each project. The main instrument of the environmental licensing process is the Environmental Impact Assessment (EIA). For a licensing system to be effective, it must minimize the probability of a project with large environmental impacts being implemented. (Heinma and Põder, 2010). Regarding this subject, several authors have analyzed the capacity that studies and methods of evaluating environmental impacts have in promoting sustainable development and in minimizing the negative impacts of projects and sectoral planning (Che et al., 2011; Nykvist and Nilsson, 2009; Pölönen et al., 2011; Samarakoon and Rowan, 2008; Villarroya and Puig, 2010).

To the contrary, however, there are project managers and specialists who say that environmental licensing in Brazil, especially in the Amazon region, is a factor that limits the development of the hydroelectric sector in the Amazon.

The long period it takes for the environmental licenses to be issued and the sectoral conflicts that commonly end up becoming legal disputes are both obstacles for several projects which were previously classified as technically feasible.

2 BRAZIL'S HYDROELECTRIC POTENTIAL

On the topic of the hydroelectric potential to be explored in the country, the data collected by the Brazilian Hydroelectric Potential Information System – SIPOT (Eletrobrás, 2012) estimate that about 40% of the total potential is located on the Amazon Basin, which goes beyond Brazilian territorial limits to include parts of other South American countries (Fig. 1).

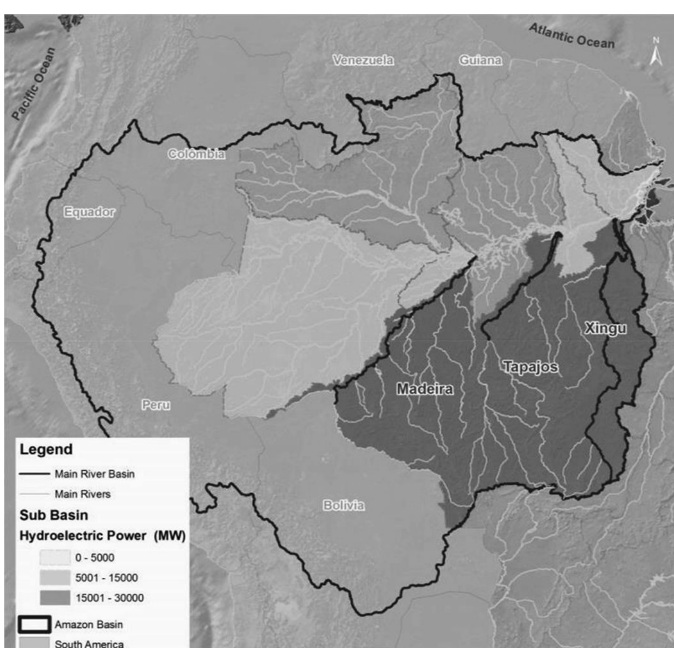

Figure 1. Hydroelectric potential per sub-basin of the Amazon basin.

Excluding the remaining potential of the Amazon Basin (16.000 MW); i.e., considering theoretical calculations without identifying the possible dam, even imprecisely, the potential of the basin was calculated to be 77.058 MW. It is distributed among thirteen sub-basins, four of which (Tapajós, Xingu, Madeira e Trombetas) are responsible for almost 90% of its total.

Nevertheless, it should be emphasized that there is a difference between the available estimated potential and the usable estimated potential, for the use and occupation of the Amazon Basin's territory is limited by several restrictions that prohibit the exploration of natural resources, including the hydraulic force for energy generation. Therefore, only 38% of the hydroelectric potential of the Basin is legally available for exploration.

Even the hydroelectric potential that does not have any legal restrictions is subject to socio-environmental conditions imposed by legislation and agencies involved in the process of environmental authorization and licensing. Thus, it is important to know the institutional and legal system that controls the licensing process in order to understand how these aspects may influence the decision making process concerning the expansion of the energy offer in Brazil.

3 BRAZILIAN LEGAL FRAMEWORK

Brazil is a Federative Republic with a superior paramount law, the 1988 Federal Constitution, which establishes a political and administrative organization divided into: the Union, represented by the Federal Government; the states, represented by state governments; the Federal District, center of federal political power and administrative capital of the country; and the cities, represented by city (local) administrations.

In the beginning of the 1980s, the National Environment System (Law 6.938) was created, involving agencies and entities from the Union, states and municipalities. It would become the foundation for the guidelines of the National Environmental Policy.

Currently, the most important body in the environmental licensing process in the federal context is the Brazilian Institute of Environment and Renewable Sources (IBAMA), created in 1989 and later linked to the Ministry of Environment (1992). Its main responsibilities are controlling the environmental policy, monitoring, environmental control and carrying out the national environmental policies on the federal level, as well as environmental licensing, quality control and inspection.

3.1 *Federal environmental licensing procedures in Brazil*

The process to obtain a federal license in Brazil is divided into three phases: Previous License; Installation License and Operating License. At the end of each phase, an authorization is obtained through a federal license issued by IBAMA and in all of them it may be necessary to obtain licenses and complementary authorizations from other bodies on the state or municipal level.

3.1.1 *Obtaining the Previous License (LP)*

For a Previous License to be obtained, IBAMA opens a process and creates a Term of Reference (TR), which will determine the guidelines and the basic requirements for elaborating the Environmental Impact Assessment (EIA) and its respective Environmental Impact Report (RIMA) that should be made by the project manager.

Both EIA and RIMA have the objective of providing the most information they can about the project's positive and negative impacts.

After the Study is approved, the licensing body may find it necessary to hold a Public Hearing. When the Study is approved and/or after the complementary solicitations are met, the project manager pays the licensing fees and then finally obtains the Previous License.

Similarly to the other licenses, the issuance of the Previous License is subject to several conditions that determine which actions and procedures should be made in order to mitigate and compensate the negative socio-environmental impacts.

3.1.2 *Obtaining the installation license*

In this stage, a Basic Environmental Plan (PBA) and an Environmental Compensation Plan (PCA) should be elaborated. The first document will specify which are the control and mitigation measures, as well as how they should be developed through the Environmental Programs proposed on the EIA. On the PBA, all actions and programs developed over the stages of the project should be mentioned, from the beginning of the construction work to the monitoring that occurs while it is in operation. The actions that will be taken to comply with the conditions from the Previous License should also be determined. In its turn, the PCA determines which measures should be taken to compensate the negative impacts of the project.

Additional complementary plans can be requested before the LI is issued. If the installation of the project requires deforestation or inundating vegetation, a Forest Inventory is required to validate the issuing of the Vegetation Suppression Authorization. In case there is a risk of eroding/degrading the land, a Plan to Recover Degraded Areas (PRAD) is necessary while the enterprise is being installed or while it's operating. Most commonly, this is a requirement for mining enterprises and hydroelectric dams. Once the Basic Plan is approved and the complementary requirements are met, the project manager pays the fees and the Installation License is issued.

3.1.3 *Obtaining the operating license*

The phase of obtaining the Operating License begins with IBAMA analyzing the reports that contain the results of the Environmental Programs proposed on the Basic Environmental Plan. The results presented should prove that all the conditions required by the LP and LI are being met; in case one of previous requirements is not obeyed, the Operating License may be denied. However, it is very common to demand a complementary action or to transfer the condition of a license to the list of requirements of the next license, which in this case is the LO.

After IBAMA approves it and the possible complementary measures are taken, the project manager pays the fees and the Operating License is issued.

It is worth mentioning that, at any moment, in any of the three licensing phases (LP, LI and LO), the Public Ministry (Federal or State) can intervene if provoked by civil society or anybody involved in the process and also if any law is broken. The Ministry can demand explanations, add complementary measures to the environmental requirements and mediate lawsuits that involve the project.

For hydropower plants, it is on the third phase that the licensing process is different. In addition to the final reports of the Environmental Program and the Vegetation Suppression Program that are needed in every environmental licensing, IBAMA requires the presentation of a Plan for Usage of the Reservoir's Vicinity (PACUERA), which analyzes the environment based on the use and occupation of land, as well as the economic situation of the communities that are located on the area that will be inundated.

In addition to the procedures that are part of all environmental licensing, the construction of a hydroelectric installation includes complementary phases to obtain permission to use the water. Regulatory agencies ANA and ANEEL are involved in this final part of the process.

4 METHODOLOGY

To obtain a qualitative analysis of the subject, international references on the topic of licensing and environmental impact were studied. However, international articles on this subject tend to focus more on the analysis of the methods and on the effectiveness of the environmental impact studies; it is not common for them to analyze the licensing process in its entirety. This fact can be explained mainly by the differences in each country's legislation and bureaucratic procedures. In most cases, the only aspect that all countries have in common is the need to create an impact Assessment. Licensing systems of countries such as Canada, United States, Colombia and China were analyzed. Nevertheless, the similarities were rare when these countries were being compared with each other and they were even rarer when international models were compared with the Brazilian model. The few common aspects found were of minor relevance.

Considering that each country's environmental process is very specific, the analysis was based on Brazilian studies and articles. Three studies which analyze the efficiency and the challenges of Brazil's environmental licensing, focusing on hydroelectric installations, were used for reference: the 'Operational Nature Auditing Report on Federal Environmental Licensing,' made by the Court of Accounts of the Union (TCU)[1] in 2008; the World Bank Report 'Environmental Licensing of Hydroelectric Installations in Brazil,' published in March 2008, and the study made by the Center of Research and Studies of the Senate, 'Environment and Energy: Beliefs and Science in Environmental Licensing: Issues that Hamper Environmental Licensing in Brazil,' from June 2011.

For the quantitative analysis, the data considered were available on the Generation Information Bank of the National Electric Energy Agency - BIG/ANEEL and on the Computerized System of the Federal Environmental Licensing of IBAMA – SILAMF/IBAMA.

5 DISCUSSION

For the qualitative Analysis of the Environmental Licensing Process of Hydropower Plants, firstly, it is necessary to take into consideration the challenges inherent to the environmental licensing process of hydropower projects – they are considerable even if institutional organization and normative regulations are ideal. The studies needed to analyze the impacts and the best alternatives are complex and of great importance.

Nevertheless, the difficulties inherent to the environmental licensing of hydropower plants increase due to the existence of institutional and legal deficiencies, or even due to political and economical issues that may arise during the process. In addition, the failure of past hydroelectric projects has created a negative perception of the environmental licensing process in the country. In some cases, it even affects the decision of constructing new hydropower plants.

According to the study made by the Center of Studies and Research of the Federal Senate: there are two different perspectives on environmental licensing in Brazil - "For some segments of society, it is an obstacle, a way to decrease the interest in making large investments on infrastructure, therefore hindering the creation of jobs and more income. To other segments, it is a corrupted process through which capitalism imposes its will, buying consciences and degrading the environment. Between these two extremes, there is only an increase on the level of disinformation and, even worse, a lack of interest in improving this mechanism." (FARIA 2011).

Considering the perspectives of FARIA(2011), LIMA and MAGRINI (2010), TCU (2008) and WORLD BANK (2008) regarding the problems of environmental licensing in Brazil, the challenges and obstacles of the process can be summarized in six different lines of approach.

A – Difficulty in coordinating the different spheres of government involved in the process:

In spite of the legal instruments that try to discipline the relationship among the Union, the States and the Municipalities on the subject of environmental licensing and other issues related to the environment, there are still cases in which there is a clear lack of limits for where each different governmental sphere should act. The functions of the different agencies overlap with each other, which contributes to the delay between the licensing phases.

B – Technical Quality of the Environmental Impact Studies Questionable:

The questionable quality of some EIAs can be attributed to several factors. For instance, the project manager may wish to obtain the license in a faster and cheaper way, making the study in little time and with a small group in order to lower the costs. Also, the database for basic

[1] The Court of Accounts of the Union (Tribunal de Contas da União – TCU) is the external auditing body of the Federal Government. One of its main attributions is to analyze the accounts presented by the Government, the associated agencies and the public bodies. Moreover, it has the prerogative of making operational inspections and technical audits focused on the legality, legitimacy and economic transparency of an activity.

environmental research is very limited, which can be easily observed by the lack of an efficient information system capable of storing and sharing the data from environmental studies, report analysis and technical notes (TCU, 2008).

The low quality of the Impact Studies affects the analyses of potential impacts, which in its turn affects the decisions that are made regarding possible alternatives to the project and the definition of the best mitigation and compensation measures. In addition, the licensing process becomes longer. Where the EIA does not meet all the requirements from the Term of Reference approved by the environmental agency, or in case its quality is not good enough, it must be complemented, corrected and presented again as many times as requested by the agency.

C – Conflicts and Society Participation:

Nowadays, it is through a Public Hearing that society can participate on the decision process. However, the current model and the results obtained through them are questionable. The criticisms to the public hearing model in Brazil state that society participation is usually overestimated, distorted and at times it comes too late. One of the factors that distort the hearing process is the representation, which is questionable quantitatively and qualitatively. According to an analysis of the Center of Research and Studies of the Senate, 'the tendency is that the groups who have a lot to win or lose with one specific project are the ones who participate more intensely than the rest of society and, in these cases, the pressure they create can form a favorable or unfavorable opinion to the project. That is something evident on the environmental sector, where groups fearing negative external consequences of the project mobilize themselves while the sectors who would be benefited - the rest of society - do not have any opinion.' (FARIA, 2011).

D – Regulatory uncertainties and costs associated to the process:

The regulatory uncertainty is one of the factors that increase the financial return, affecting the final price of the MW/h (WORLD BANK, 2008). The most important aspects that increase this uncertainty are:

- The politicization of managing positions of the public sector, which reflect on the quality of the administration, as well as the political conflicts that happen inside the environmental sector agencies;
- A larger influence of subjective and ideological arguments;
- The legal disputes within the decision process, which are common and motivated especially by Public Ministry actions;
- The political pressure for a speedy assessment and approval of projects considered high priority (NEPS, 2011). It is worth mentioning that 68% of the projects analyzed on this article are included on the goals of the Growth Acceleration Program (PAC), a program focused on infrastructure and on primary sectorial investments which have specific deadlines that cannot be extended.

6 CONCLUSIONS

This article aimed to point out which are the main challenges and flaws on the environmental licensing process in Brazil, so as to bring contributions and proposals to make the current model more efficient. Efficiency, in this case, would be evaluated through the following aspects: a higher capacity to mitigate and compensate socio-environmental impacts; a higher effectiveness as an instrument for decision making; greater speediness with a smaller bureaucracy; a less intrusive presence of the agencies and social sectors involved, with less political and ideological interferences.

To reach these goals, a few measures and changes can be suggested, among them, the main ones are:

- The use of planning instruments already existing (Public Policies, Governmental Plans and Programs, Integrated Environmental Assessment – AAI, Strategic Environmental Assessment - AAE) for guiding the construction of the Term of Reference of the EIA and predict which issues and challenges may arise on the licensing phase. In other words, the environmental licensing process should be integrated with the planning process of different areas. In the case of hydropower plants, planning should be integrated with the territorial zoning and the planning of infrastructure, mining, energy and hydro resources. These plans should share the same goals and, more importantly, they should serve as a base for environmental impact studies. Each national hydrographic basin should not only have a Management Plan, but also a viability study before the hydro resources and the land are used. This study should point out fragilities and potential impacts related to each kind of hydro resource use, enabling a faster and more reliable elaboration of the TRs and the EIAs.

- The Previous License should be issued based on the analysis made during the planning stage involving several instruments (Policies, Plans and Programs, AAI, AAE) and interested agencies. Thus, the EIA of the project would be a requirement for the issuance of the LI and it would be based on the engineering project and its local impacts.
- The creation of a more efficient information system that stores and shares environmental studies, analyses, reports and technical notes. This system should provide an environmental database to be a reference for impact studies and environmental programs which are conditions of the licensing process.
- More IBAMA employees with technical skills, with better incomes and career plans, improving the selection process and avoiding the current evasion of technical employees in search of jobs with better salaries and opportunities.
- The creation of other mechanisms through which society can participate and express opinions, complementing the Public Hearings. These could be on-going and used in different phases of the process.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)

Designing a framework for sustainable land use planning

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ABSTRACT: Some motivations like gaining property right or more income has caused land use change and degradation in many natural sites without considering biophysical suitability. Dealing with this problem requires developing a method for the analysis of current situation and reallocation of lands into optimum land-uses on the basis of different stakeholders' attitudes. For achieving in an agreed-upon solution for land allocation, an interactive approach is required to recognize and comprehensively assess different alternatives. This paper aims at suggesting a framework for developing a planning support system which can help in the planning process for sustainable use of natural ecosystems. Also the application of this framework in Central Alborz rangelands will be described as a case study. Results of this study approved the performance of multi-objective and multi-criteria planning support systems for desirable and sustainable management of natural resources.

1 INTRODUCTION

Some motives like gaining property right or more income has caused land use changes in many natural sites without considering biophysical suitability. Dealing with this problem requires developing a method for the analysis of current situation and reallocation of lands into optimum land-uses. Land use decisions are often complicated due to the large number of factors involved and their interactions (Witlox et al. 2009). For achieving in an agreed-upon solution for land allocation, an interactive approach is required to recognize and comprehensively assess different alternatives. For this reason, many computer models and tools have been developed to support land use policy and management decisions using the concept of Decision Support Systems (DSSs) (van Keulen 2007, Rossing et al. 2007, Argent 2004, Oxley et al. 2004, McIntosh et al. 2007).

Many studies on land allocation have used Linear Programming models. For example, Chuvieco (1993) employed single-objective linear programming models to minimize rural unemployment level by maximizing the area of allocated lands into land uses which create more jobs, but the growing complexity of effective factors for land use planning has increased the necessity for using multi-objective models. In this context, multi-objective Linear Programming and related techniques provide a basis for analyzing the relationships and conflicts between different objectives (Xiaoli et al. 2009). Farahpour (2002) designed a Decision Support System for land allocation in Chadegan including land evaluation, district planning and regional planning sub-modules. After evaluating the lands for rainfed agriculture and extensive grazing and producing different scenarios with different objective functions, he found the scenario with the objective function of "vegetation cover maximization” to be the best scenario. Xiaoli et al. (2009) also designed a Spatial Decision Support System (SDSS) for optimizing land use structure in Beijing Pinggu area in China. The system consists of two main steps: optimizing the area under different land uses and spatial allocation of land uses. They used Linear Programming, Fuzzy Clustering and other land use structure optimization algorithms in Matlab and ArcEngine softwares.

According to the approaches and results of related studies, this paper aims at suggesting a framework for developing a Planning Support System (PSS) useful in the planning process for sustainable use of rangeland ecosystems. The suggested framework is designed in a way that enables evaluation and comparison of alternative land use scenarios produced by considering the numerous and often conflicting objectives of different stakeholders. Such a system would be flexible confronting with social and economic conditions, development stages and local and national policies.

2 MATERIAL AND METHODS

2.1 *Land Use System (LUS)*

The concept of land use system has been extensively discussed by Mohamed (1999). The concept of LUS in this paper is very close to the FAO definition (1983; 1991), i.e. a combination of land unit and land use type. Land use system in this study is a combination of homogeneous land units called Land Mapping Units (LMUs) and alternative utilizations as Land Utilization Types (LUTs) based on the land potential in each area.

A land unit is an area of land delineated on a map and embracing specified land characteristic and/or qualities (Fresco et al. 1994). These land characteristics should be homogeneous at an acceptable level. One way to set the units is overlaying of biophysical data layers for creation of homogenous land units. However this method may result in small and unmanageable units.

Land Utilization Type is defined as an actual or alternative way of using land (Beek 1997) and has a decisive effect on inputs required and outputs of the land (Farahpour 2002). Alternative land uses should have performance to contribute to the solution of current problems of land degradation and arrive at a sustainable land use system. LUTs will be defined as to be biophysically and technically feasible, environmentally suitable, socially acceptable, economically viable and legally supported. A Land Utilization Type is specified by its inputs and outputs in quantitative terms (Veeneklaas et al. 1991). Inputs and outputs are usually defined as a set of coefficients that can be incorporated in a linear programming model (Farahpour 2002). After quantification of inputs and outputs of land use system (LMUs, LUTs) in the form of coefficient matrices, different scenarios will be produced using a Linear Programming approach.

2.2 *Multi-objective linear programming*

Different objectives of various stakeholders cause non-unique solution for land allocation. Hence, a multi-objective model should be used for tackling the problem and generating alternative solutions. In this section, possible scenarios for land use allocation will be produced using a Linear Programming Model and based on the objective functions defined on the basis of different stakeholders’ attitudes and objectives, given a set of conditions and constraints. These models have been widely used in solving land use problems (Campbell 1988, Huizing & Bronsveld 1994). Generation of different scenarios as a consequence of inclusion of different objectives enables the land use planner to integrate the results in a way that opportunities and limitations, relationships and interdependencies become explicit.

General linear programming model can be displayed as a set of equations (1) and (2):

$$Max\ (or\ Min)\ Z = c_1x_1 + c_2x_2 \ldots + c_jx_j + \cdots + c_nx_n \quad (1)$$

$$
\begin{aligned}
&a_{11}x_1 + a_{12}x_2 + \cdots + a_{1j}x_j + \cdots + a_{1n}x_n \le b_1 \\
&\qquad\vdots \\
&a_{i1}x_1 + a_{i2}x_2 + \cdots + a_{ij}x_j + \cdots + a_{in}x_n \le b_i \\
&a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mj}x_j + \cdots + a_{mn}x_n \le b_m \\
&x_1, x_2 \ldots, x_j \ldots, x_n \ge 0
\end{aligned} \tag{2}
$$

In this model, Z is the objective function, other functions are constraints, x_j $(i = 1, \ldots, n)$ are decision variables and c_j, a_{ij}, and b_i are model parameters.

2.3 *Multi-criteria evaluation model*

Scenarios will be ranked and prioritized based on the specified criteria and their attributed weights which reflect preferences and priorities of decision makers. This process allows the most desirable scenario to be selected. To this end, the effects of applying each scenario on each criterion will be calculated or estimated. These measures will be set in a table called Effects Matrix. There are different methods for evaluating and ranking of scenarios, such as compensatory approach and weighted summation, outranking and non-compensatory approach. The data must be standardized using the conventional techniques like maximum standardization, interval standardization, goal method, etc. and then, logical weights are attributed to the criteria using prevalent methods like direct weighting, pair-wise comparison or random method.

Within the proposed framework to find the best combination of land use types in Central Alborz rangelands, various scenarios were produced on the basis of different stakeholders' objectives and then, these scenarios were ranked based on socio-economic and ecological criteria.

3 CASE STUDY: CENTRAL ALBORZ RANGELANDS

3.1 Methods

Number of existing livestock grazing on the rangelands of the study area is equal to 34705 animal units; however, studies show that the capacity of this area is 10119 animal units for a 90-day grazing season. Additionally, this rangeland is being converted to other land use types with more income or property motivations and without required biophysical merit. Due to these issues, it seems necessary to develop a method to analyze the current status of the rangeland and, if necessary, reallocation of it to improve the situation.

Four Land Utilization Types were defined in this study according to environmental conditions and recognized potentials of rangelands, including:

- LUT1: limited forage harvesting for livestock
- LUT2: structured tourism
- LUT3: beekeeping, and
- LUT4: structured conservation of rangelands.

Also 17 homogenous Land Mapping Units were identified by overlaying environmental data layers. In order to generate different scenarios, the effect of implementing each LUT/LMU on different criteria (inputs/outputs) was calculated and following matrices were set up:

- Costs
- Gross direct benefits
- Grazing capacity
- Economic value of soil conservation function
- Economic value of water retention function
- Economic value of gas regulation function, and
- Job creation.

Linear programming technique was applied for generating different scenarios according to objective functions of different stakeholders, including:

- SC1: Net direct benefits maximization
- SC2: Minimization of livestock number
- SC3: Job creation maximization
- SC4: Maximization of the economic value of water retention function
- SC5: Maximization of the economic value of soil conservation function
- SC6: Maximization of total economic value of water and soil conservation functions
- SC7: Maximization of the economic value of gas regulation function, and
- SC8: Maximization of total economic value of (water, soil and gas) regulation functions.

Scenario assessment and ranking was performed using Definite software. Desired criteria for scenario assessment include the following:

- Economic criteria
  - Gross direct benefits
  - The costs of direct benefits
  - Grazing capacity
- Social criteria
  - Job creation
  - Diversity of proposed land utilizations as a proxy for risk
- Environmental criteria
  - Economic value of water retention function
  - Economic value of soil, water and gas regulation
  - Area of the current situation.

Then the effect of implementation of each scenario on each criterion was calculated and these values were standardized by Goal method. The criteria were weighted by pair-wise method and scenarios were ranked using weighted summation method.

Finally sensitivity analysis was performed in order to assess the strength of ranking and its sensitivity to uncertainties in the criteria, their values and attributed weights, using MonteCarlo method.

3.2 *Results*

Eight scenarios have been generated on the basis of objectives of different stakeholders. For example, the structure of the model with the objective function of 'net direct benefits maximization' is given in the following:

Objective function:

```
Rev..z =e= sum((lut,lmu),(x(lut,lmu))*((nngdiben(lut,lmu))-(ncodiben(lut,lmu))));   (3)
```

In mathematical notation:

$$Max\ z = e = \sum_i \sum_j x_{ij}\left(nngdiben_{ij} - ncodiben_{ij}\right) \quad i = 1,\dots,n; \quad j = 1,\dots,m \tag{4}$$

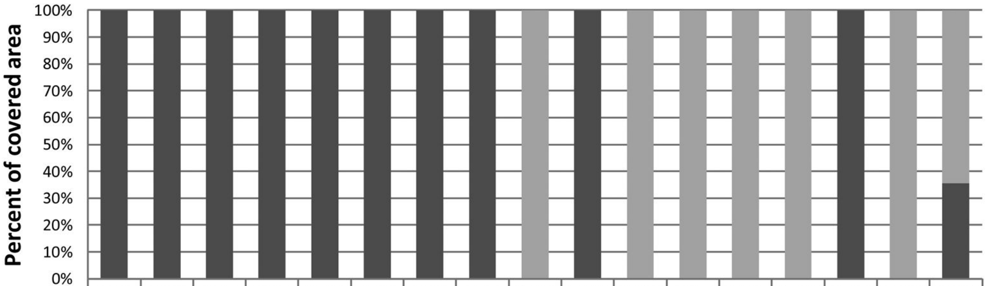
Where x_{ij} = area of the land; i = index of LUT (n); j = index of LMU (m).

Land constraint:

```
landlimit(lmu)..sum(lut, x(lut,lmu)) =l= lnda(lmu);   (5)
```

In mathematical notation:

$$\forall j \quad land\ x_j \geq \sum_i x_{ij} \quad i = 1,2,\dots,n \tag{6}$$



	lmu1	lmu2	lmu3	lmu4	lmu5	lmu6	lmu7	lmu8	lmu9	lmu10	lmu11	lmu12	lmu13	lmu14	lmu15	lmu16	lmu17
lut5																	
lut4																	
lut3																	
lut2									3050,1		360,16	588,04	352,88	762,21		1191,7	689,85
lut1	6126,1	815,47	1016,6	1673,8	809,42	788,92	1133	1036,4		4501,3					684,12		378,61

Figure 1. Land use schema in SC1. Rangeland areas are allocated to 'forage utilization in the permitted level' and 'structured tourism'.

In words: summation of the area over all LUTs on one LMU must not exceed the area of that LMU.

Livestock constraint:

$$\text{lnn..sum((lut,lmu),x(lut,lmu)*nln(lut,lmu))=l= 13406;} \quad (7)$$

In words: The number of livestock must not exceed the carrying capacity.

Employment constraint:

$$\text{jobb..sum((lut,lmu),x(lut,lmu)*njob(lut,lmu))=g= 53;} \quad (8)$$

In words: rangeland-based employment rate should not be lower than the current situation.

Result obtained from the implementation of this model is considered as the first scenario (SC1) as shown in Figure 1. This figure shows that following this objective will result in allocating rangelands to LUT1 and LUT2, i.e. only forage utilization and structured tourism will be allowed in these areas.

Based on the designed scenarios and selected criteria to compare the scenarios, the effect table was set up and its values were standardized using goal method. The criteria are compared and allocated weights are determined. Incompatibility of criteria weights in this study were less than 0.1 showing the consistency and plausibility of the assigned weights (Saaty 1994). Then scenarios were ranked using the weighted summation method (Fig. 2). This figure shows that the scenario SC3 is placed in the first rank and the current situation is far from other scenarios in the lowest rank. Land use combination in SC3 shows that the rangelands must be allocated to forage utilization and some parts should be protected and excluded from any type of utilization.

Results of sensitivity analysis reflect the strength of ranking, i.e. any change in the criteria scores and their weights keeps SC3 in the first rank. For example, Figure 3 shows the probability of different ranks for each scenario supposing 30 percent change in criteria measures and weights. This figure shows that SC3 remains in the first rank after 30 percent of change in the weights and only the probable positions of SC2 and SC5 will slightly change.

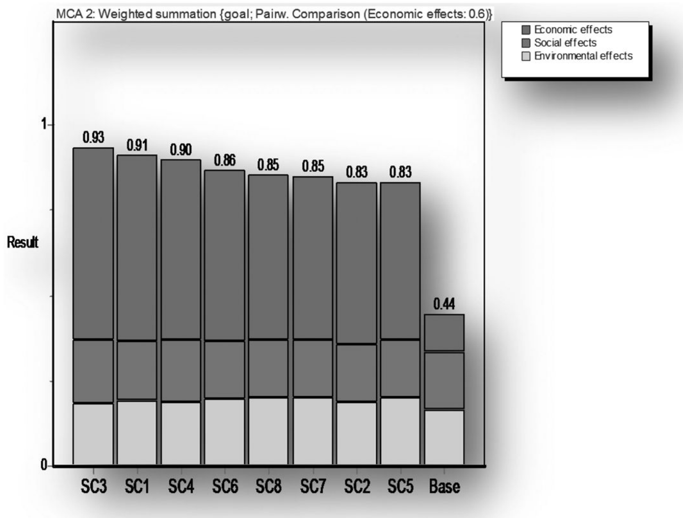


Figure 2. The result of multi-criteria analysis. SC3 is placed in the first rank.

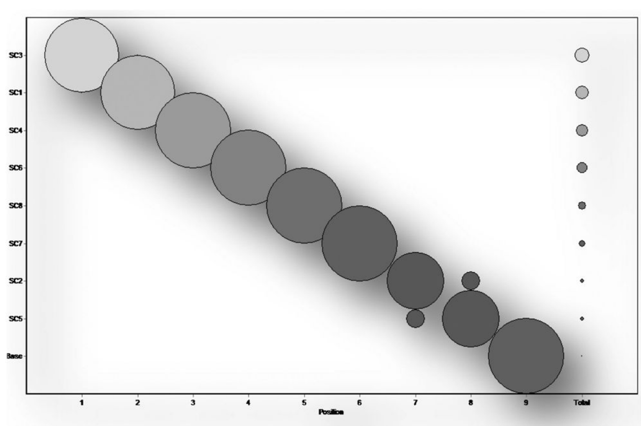


Figure 3. Probability of different ranks for each scenario supposing 30 percent change in the criteria measures and weights.

4 CONCLUSION

Discussions and the mentioned case study indicate that the use of planning support systems help to make more precisely the decisions about the important subject of land use planning. By using these systems and considering different stakeholders' attitudes and effective socio-economic and ecological criteria, the conflicts between operators and planners will be minimized which will result in a more sustainable utilization system. According to the designed softwares capabilities, these systems are highly flexible for updating the criteria and assigned weights on the basis of spatial and temporal circumstances. Other researchers such as Campbell et al. (1992), Jankowski et al. (1997), Tecle et al. (1998) and Farahpour (2002) also confirmed the ability of these systems in land use planning and management.

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Section 3: Modelling

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Models for the water framework directive – Using RIBASIM and WFD Explorer

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ABSTRACT: River Basin management can be facilitated by using suits of models, such as RIBASIM and the WFD Explorer. While RIBASIM focusses on hydrological cycle and options for different users of water, the WFD Explorer translates hydrology and emissions into water quality. Build-in ecological response models make it possible to assess the targets for the WFD. The added value of using these user-friendly models with their results on effects of management options in the river basin planning for the WFD is discussed.

1 INTRODUCTION

Nowadays, the well accepted approach in water management is to make basin-wide management plans wherein different aspects of society are integrated: economic values, environmental values and societal values. The main objective is no longer to only prevent people from floods and droughts, but to make an inventory of human use and available natural resources and to attune them. Thus, more integrated and consistent policy decisions can be made.

Integrated water management is a prerequisite for compliance with the EU regulations, i.e. the EU Water Framework Directive (WFD). Main aim of the WFD is to guarantee healthy water systems for current and future use. To facilitate the implementation of the directive, models can be used in different phases and to different means in the planning process. The use of models in management processes is often described in relation to a framework in which a structured approach towards societal drivers, environmental pressures, ecological status, impacts and policy responses is used (DPSIR approach, Fig. 1; Rekolainen et al. 2003). Models can be used to identify opinions and to demystify arguments used in public debates (Penn et al. 2010, Van Vliet et al. 2013) and to improve communication between scientists and stakeholders and induce social learning (Bots et al. 2011, Hirsch et al. 2010, Pahl-Wostl 2006). Scenario analysis, presenting different futures as a consequence of possible, likely of less likely, choices that policy makers of today can make, provides insight into the consequences of policy making of today for the situation in the future (Wortelboer & Bischof 2012). Overall, analysis of and communication on the uncertainties of modeling exercises in all its aspects will improve expectancy management and probably the usability of model results in the public planning process as well (Refsgaard et al. 2007).

2 THE EU WATER FRAMEWORK DIRECTIVE AND THE USE OF MODELS

The Water Framework Directive (WFD), which came into force in December 2000 (EC 2000), provides a framework for actions of the European member states in the field of water policy, with the key objective of achieving a "good water status" for all waters in the European Union (EU) by

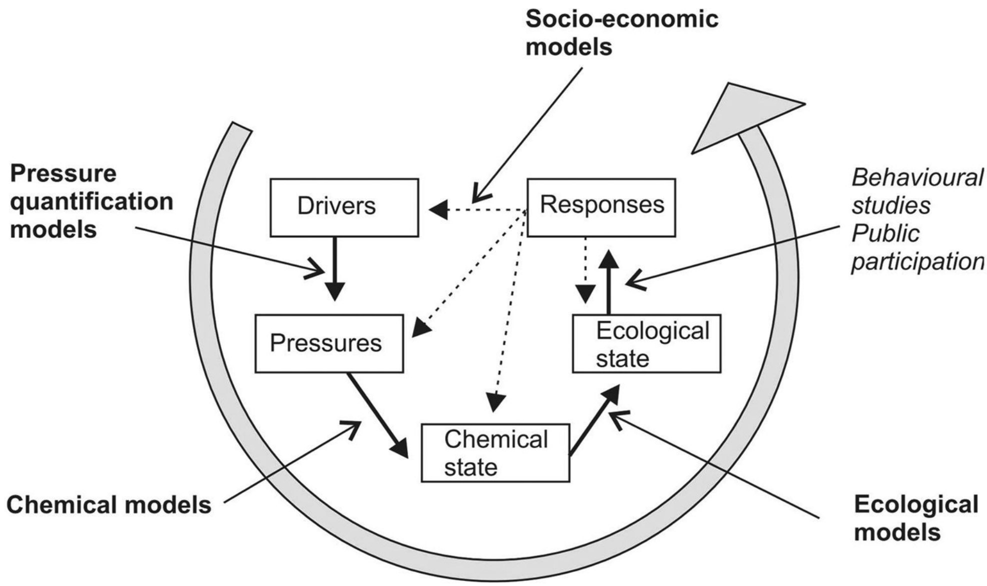

Figure 1. Schematization of the modelling cyclus using the DPSIR-framework. From: Rekolainen et al. 2003.

2015. It is a framework for European environmental legislation that aims at improving water quality by using an integrated approach to implement the necessary societal and technical measures.

The Directive imposes legal obligations for the authorities in EU Member States. In order to assist the EU Member States and, in particular, the water managers within river basin districts in implementing the Directive, a number of activities have been launched. The EU Member States, Norway, and the European Commission have developed a common strategy for supporting the coherent and harmonious implementation of WFD, which has led to the publication of practical guidance documents on various technical issues related to the Directive. In addition, a number of scientific efforts at the European level and associated with the WFD have been made with the aim of providing the scientific support in implementing the Directive.

The implementation process of WFD includes several consecutive steps, and the successful implementation of these steps requires different kinds of tools, such as pollution quantification algorithms, decision support systems and dynamic simulation models. An extensive description of the use of models in the implementation process of the Water Framework Directive is given by Hattermann & Kundzewicz (2010). The Harmoni-project (an EC-supported project under the fifth action programme) focussed on different aspects of the WFD implementation in river basins, including development of tools and models (Harmoni-CA 2007), social learning (Harmoni-COP 2007), quality assurance using models (Harmoni-QUA 2007), and uncertainty in integrated river basin management (Harmoni-RIB 2006).

In the WFD, modelling is also offered as a tool for the establishment of type-specific reference conditions for surface water body types (WFD, Annex II) and as a procedure for the setting of chemical quality standards by member states (WFD, Annex V).

Furthermore, under the framework of the "Common Implementation Strategy" (CIS) for the implementation of the WFD guidance documents have been prepared by EU Commission. In particular the Guidance Document No. 11 (GD 11) on planning processes (EC 2003), which presents a general overview of the whole planning cycle and provides recommendations for its successful implementation. The document offers a contribution to guidance on model-supported implementation of the WFD, in particular on the use of models for the planning measures and

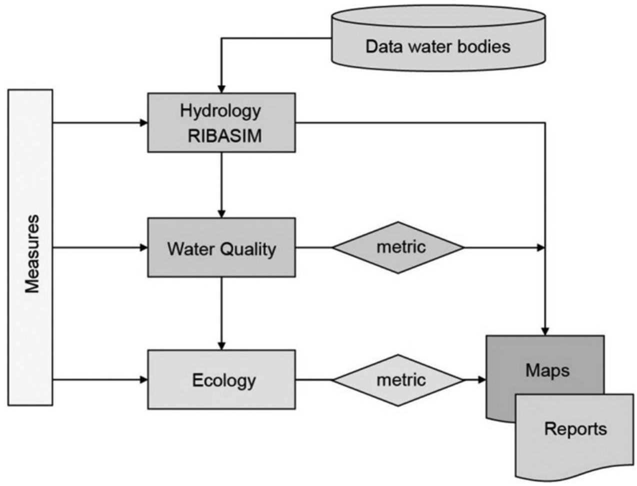

Figure 2. Schematization of the WFD Explorer with RIBASIM hydrology included.

integrated river basin management. It helps water managers to better understand how models may be used for planning purposes (see also WISE-RTD 2014).

The GD 11 states that models exemplify the systems approach to water resources planning and that a rigorous and objective analysis in particular should help to identify the possible trade-offs between quantifiable objectives so that further debate and analysis can be more informed. It also supports the broad use of models to study important interdependencies, trade-offs and different societal perceptions on water management. In general, models can give answers to well-posed questions about the behavior of the system being studied. However, it is useful to feed answers derived from the models back into questions and to examine whether or not rephrasing the original questions is necessary. That is, models can be used in a two-way process: the model results provide information that is fed into the decision making process (formulation of plans, the response side of the DPSIR framework) and the model results can be confronted with the initial assumptions to help in redefining the problem (Rekolainen et al. 2003).

In this paper we illustrate how the combined use of the river basin model RIBASIM and the assessment model WFD Explorer can be used to support integrated river basin management.

3 MODELS FOR INTEGRATED RIVER BASIN MANAGEMENT

3.1 *Rationale*

For river basin management to meet the requirements of the WFD an evaluation tool needs to include both water uses (and users) and ecological effects. Thus an integrated approach can link hydrological changes at one end of the basin with ecological impacts at the other end. Especially in arid and semi-arid regions the allocation of water within the river basin, and all the priorities and policy decisions that govern it, are important factors that determine water quantity and quality. The ecological quality is assumed to react to overall, yearly-averaged, environmental conditions. Therefore a detailed hydrological model giving results every meter each minute is not the first choice. The link between hydrology, emissions, water quality and ecological impact is essential for assessment of ecological quality and is reflected in the setup of the models used (Fig. 2).

3.2 *River basin simulation model: RIBASIM*

RIBASIM is a generic model package for simulating the behavior and characteristics of water in river basins under various hydrological conditions (Van der Krogt & Boccalon, 2013; Fig. 3). The

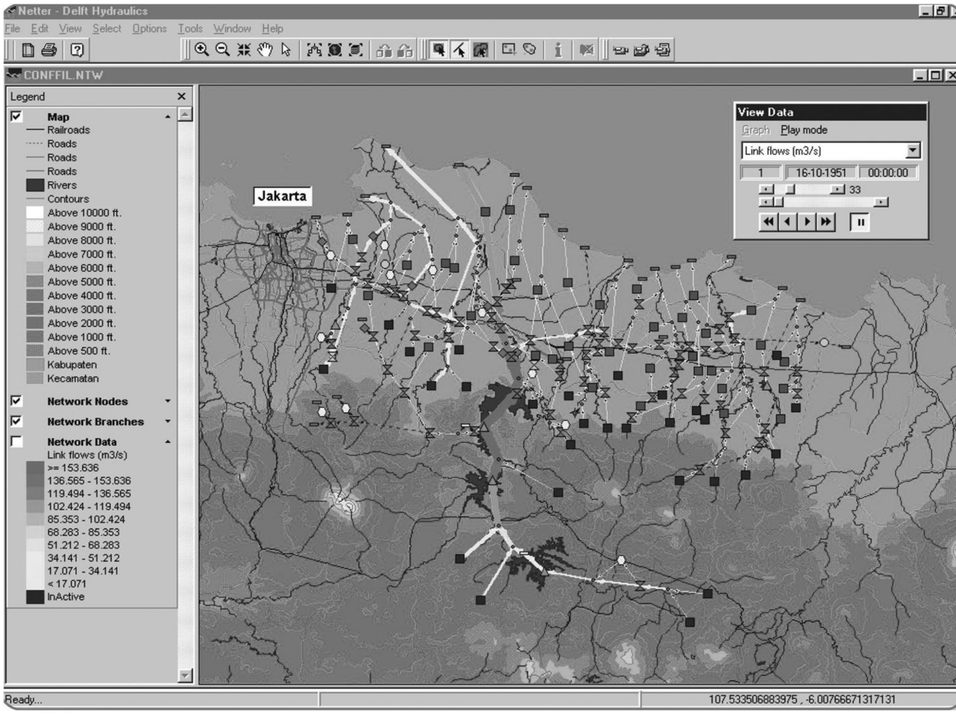

Figure 3. Interactive schematization of a river basin using RIBASIM. From: Van der Krogt (2013).

model links the hydrological water inputs at various locations with the specific water-uses in the basin. The approach is that of a 0D model wherein the allocation of water to users within the river basin can be controlled on the basis of sets of simple to complex rules. The typical time step of RIBASIM is weeks to months, thus changes in water use during the seasons can be implemented in detail. RIBASIM generates flow patterns which provide a basis for detailed water quality and sedimentation analyses in river reaches and reservoirs. RIBASIM enables the user to evaluate a variety of measures related to infrastructure, operational and demand management and to see the results in terms of water quantity, water quality and flow composition. RIBASIM has been applied in more than 20 countries by both national and regional agencies.

3.3 *The Water Framework Directive explorer (WFD explorer)*

The WFD Explorer is a general framework for the calculation of water quality and the assessment of ecological status for the WFD (Fig. 2).

The frameworks interface is programmed in Microsoft C# and has an explorer-like style. It includes GIS functionality for easy schematization of river basins. The program reads schematization data and water quality data and stores it in a local SQL database. The modular setup of the WFD Explorer allows for the inclusion of specific modules that have been used and tested in other contexts. These are:

1. A steady state water balance model Wabacore. A semi-steady state solution is reached by allowing for a changing water storage;
2. A water quality model for the calculation of concentrations of the dissolved substances: the Delwaq model (Deltares 2012);

3. A neural network model linking substances and environmental characteristics to Ecological Quality Ratios (EQR's);
4. A module for the definition of measures and their costs.

Additionally, an external program for the calculation of the specific metrics for the WFD is used. The schematization of the river basin is the basis of all calculations. It contains:

1. Drainage areas from which water enters the network of river stretches and reservoirs;
2. Surface Water units (SWU's), i.e. segments of the river and reservoirs in the river basin;
3. The relations between drainage areas and SWU's and between SWU's; these are the links that determine the direction of the water flow and the distribution of the water within the network;
4. Water discharges into and extraction from the SWU's.

The WFD Explorer uses quarterly data for the water balance and substance balance calculations. Ribasim can provide the hydrological data, which assures the different flow data are consistent. For each link and time period hydrological data are needed.

The water quality calculations are driven by emissions of substances into the network. Currently, the interface facilitates four substances: Total nitrogen, Total phosphorus, Biological oxygen demand (BOD) and Chloride. A first order decay rate can be defined. The Delwaq module contains numerous substances and their processes which can be facilitated by the interface additionally. The four substances are sufficient for providing the most important dynamic input for the ecological response models within the WFD Explorer.

The ecological response models currently linked to the WFD Explorer are empirical (statistical) models based upon many years of water quality and ecological monitoring in many Dutch regional waters. The neural network models (one for each water type and ecological quality element) link the physical and chemical characteristics of the regional (smaller) Dutch SWU's directly to the results of the WFD metrics. The WFD Explorer provides the water quality data for each SWU for these models. Other, similar input-output models can be linked to the WFD Explorer to incorporate knowledge on pressures and ecological responses.

For the larger Dutch SWU's, of which less monitoring data are available, a different approach is used whereby SWU's are characterized by a collection of habitats each of which has its own list of species data and their abundance and therefore EQR. The EQR of the total SWU is calculated as the area-averaged EQR of the habitats included. Measures are defined in changes of type and quality of the habitats. This is also a quite general approach which can easily be translated into another regional setting.

In the WFD Explorer, measures can be defined and evaluated both by input tables and interactively (Fig. 4). Measures can be combined into sets of measures to evaluate combinations of policy options. Measures and their costs can be specified for an individual point source or emission point of a diffuse source or for each type of emission at once (e.g. for a sector such as agriculture or for all waste water treatment plants at once). Measures that involve changes in hydrology need recalculation of the hydrological variables using RIBASIM. Similarly, measures involving changes in habitats need recalculation of input data as the WFD Explorer's interface does not include this kind of measures yet.

In the Netherlands, and several other countries, the use of the WFD Explorer facilitated:

- Easy and quick schematization and visualization of river basins with their catchment and sub-catchments, water bodies, pressures and impacts – in line with EU requirements;
- Ability to model complex hydrological and water quality relations and handle large amounts of diverse data in a transparent and robust manner;
- Ability to define a wide variety of measures, both on point sources, diffuse sources and ecological and hydro-morphological aspects of the water systems;
- Definition of the costs of measures and calculation of the cost-effectiveness of measure packages;
- Reporting in EU-compliant maps and reports, develop River Basin Management Plans and facilitate consultation and prioritization of measures.

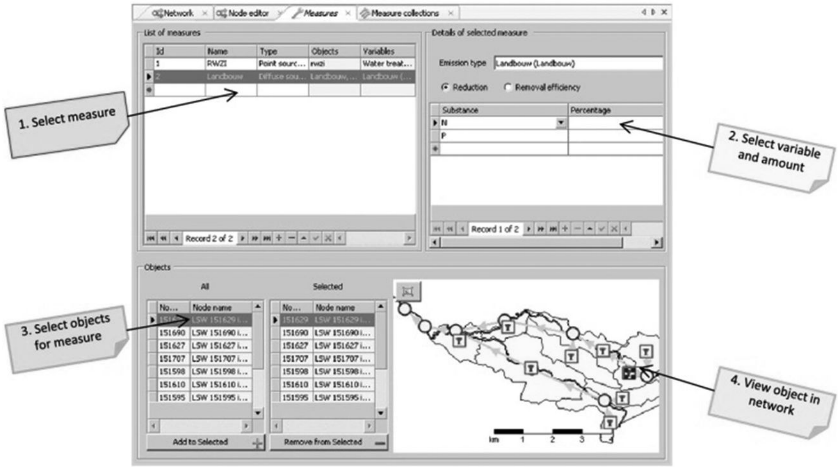

Figure 4. The WFD Explorer facilitates the selection of combinations of measures to be evaluated in terms of costs and WFD targets.

4 LESSONS LEARNED

The lessons learned from a number of WFD Explorer applications in the Netherlands are:

- The tool plays an important role in the determination of the good chemical and ecological status / potential of the water bodies;
- The measure selection procedure allows for switching on and of certain categories of measures, thereby evaluating the impact of and the prediction of the effects of single measures and combination of measures;
- Using the cost module, the most cost effective measures can be identified and in this way the WFD Explorer helps in prioritizing them;
- It gives a clear insight in available knowledge and missing data, and stimulates the exchange of knowledge between scientists; for a module to be included the available expert knowledge needs to be formalized; a discussion on ecological response model implementation led to three different types of models (two types of neural networks and regression trees) which were all three linked to the WFD Explorer and assessed on the consistency of their results;
- The tool stimulates the consistency and efficiency of the monitoring programs; if the impact of certain measures must still be assessed, then dedicated project monitoring is needed, and overall monitoring for ecological status does not suffice;
- The tool does encourage uniformity in the data that is being used by different stakeholders; this brings the people that are involved in the public debate on policies and measures on a level playing field with shared knowledge, which enables reaching a common understanding about the problems at hand and the type of measures to be taken;
- It can be used as a platform in the communication with stakeholders;
- The WFD Explorer functions as a center point around which additional tools are developed that can exchange information with it. By linking to ecological targets for the North Sea and a optimization and back-tracking module, nutrient reduction in the sea can now be related to measures on land (Los et al. 2014). Doing this for all the countries surrounding the North Sea supplies arguments in international discussions on the contributions of individual countries or regions to the loads of a shared ecosystem;
- It facilitates the consistency of reporting on different levels: regional, national and to the EC. The reported information is both transparent and reproducible.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Modeling antibiotic transport and mapping the environmental risk in the Marmara Region by using Geographical Information Systems (GIS)

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ABSTRACT: Veterinary antibiotics are one of the most widely preferred drugs for promoting animal health. Since a considerable fraction of antibiotics is excreted in animal waste; antibiotics can affect both soil quality by leaching from manure to soil and water quality by transporting to surface waters via runoff following to application of animal waste as manure on agricultural lands. Due to the fact that released antibiotics can lead to toxic effects and development of antibiotic resistant bacteria in the environment, there has been an increased concern about the adverse impacts of these micro pollutants on the environment. The aim of this study is to create environmental risk maps of the Marmara Region regarding antibiotic transport by determining risky pasture lands, where risk mitigation actions would be essential. The antibiotic concentrations data are obtained from previously analyzed soil and manure samples collected from various agricultural lands of the Marmara Region (Balcıoğlu et al. 2007). Environment Protection Agency's Storm Water Management Model (SWMM) is used to simulate rainfall-runoff relationships. The study area is divided into 499 subcatchments having different hydrological characteristics (Fig. 1).

55 years of precipitation data (1950–2005) are used for rainfall-runoff simulations. The % imperviousness values are computed for each subcatchment by measuring commercial, residential, and undeveloped areas by using GIS-based land use maps provided by the Republic of Turkey Ministry of Food, Agriculture and Livestock. Transport of previously analyzed antibiotic groups including oxytetracycline (OTC), chlorotetracycline (CTC), sulfadiazine (SDZ), sulfachloropyridazine (SCP), sulfathiazole (STZ), sulfamethoxazole (SMZ) and enrofloxacin (ENR) in the Marmara Region are investigated by using an exposure model developed by Montforts (1999). Figure 2 suggests that, predicted antibiotic concentrations (PEC_{soil}) are consistent with measured concentrations (MEC_{soil}).

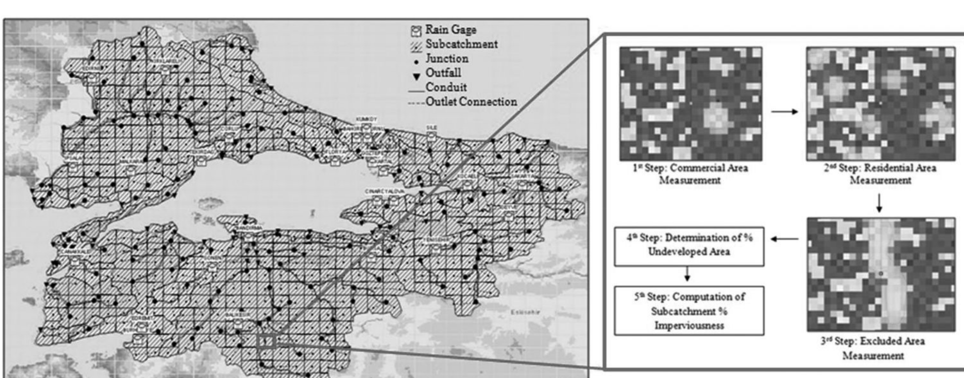


Figure 1. SWMM layout map with discretized 499 subcatchments.

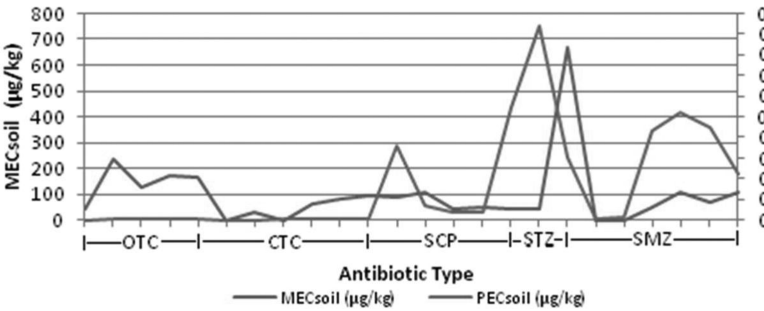
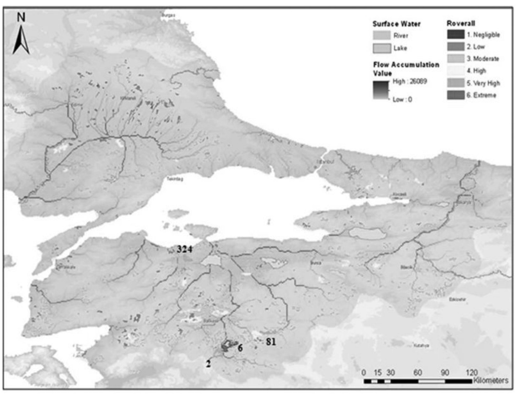


Figure 2. The comparison of MEC_{soil} and PEC_{soil} values at the sampling locations.



Cattle number	Poultry number	Distance (m)	Runoff coefficient	Slope class	Erosion degree	Risk value
0- 3,000	0-200,000	25,000<	0-0.1	1	1	1
3,000-6,000	200,000-400,000	20,000–25,000	0.1-0.2	2	2	2
6,000-9,000	400,000-600,000	15,000–20,000	0.2-0.3	3	-	3
9,000-12,000	600,000-800,000	10,000–15,000	0.3-0.4	4	3	4
12,000-15,000	800,000-1,000,000	5000 – 10,000	0.4-0.5	5	-	5
15,000-18,000	1,000,000-1,200,000	0 – 5,000	0.5<	6	4	6

Figure 3. The overall environmental risk map of the Marmara Region together with the assigned risk values to each criterion.

Environmental risk maps are created by using a Multi-Criteria Decision Analysis (MCDA) approach for all pasture lands. It is assumed that the antibiotic pollution in terrestrial and aquatic environment originates from pastures, where cattle and poultry excrete their faeces and urine. In this respect, weighting criteria defined as characteristics of pastures influencing surface water contamination rate are as follows: animal population (cattle- poultry) in the given pasture land; pasture proximity to the nearest surface water resource (rivers, lakes, dams); produced runoff coefficient for any subcatchment; slope class of pasture land; and water erosion degree of pasture land. The risk values subjectively ranked to each criterion with respect to determined ranges are given in Figure 3. In order to determine the weight of each criterion, pairwise comparison matrices are constructed, where each criterion is compared with other criteria relative to their importance. Field calculations are performed for 1568 pasture land polygons and risk weights ranging from 1 to 6 were calculated for each created field in the GIS environment. Consequently, overall environmental risk map representing the potential risk of antibiotic transport from pasture lands to the nearest surface water resources are determined (Fig. 3).

According to the risk map, most of pasture polygons' risk levels are described as moderate, and they are homogeneous in all over the Marmara Region. The risk map indicates that the only extreme risk level is assigned to pasture polygon number 6 that is located in the south of Balıkesir province. Except from poultry population criterion, highest risk values were ranked to the pasture polygon in terms of other criteria. As a receiving water body, Simav Creek is located just near the pasture land. In this study, the role of GIS in decision-making process was reviewed in order to develop an evaluation approach for cattle and poultry existences in pasture lands leading to antibiotic transport to surface waters via runoff. It can be concluded that GIS aided MCDA is an efficient tool in the case of risk mapping, since it is possible to monitor and analyse spatial and attribute data regarding study area to support the environmental decision making process. The ranking and pairwise comparison methods have subjective natures; this could lead to inconsistency between the outcomes of the decision analysis and real situation. However, environmental risk evaluation has complex structure and application of these methods is simple and flexible.

ACKNOWLEDGMENTS

This work was financially supported by Research Fund of Boğaziçi University (Project No. 12Y00P2).

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
 ISBN 978-1-138-00018-6

WEAP model as a tool for integrated water resources management in Merguellil watershed (central Tunisia)

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EXTENDED ABSTRACT

Nowadays, water resources management is the key task in semi arid regions in order to fill the gap between water supply and the increasing water demand of different sectors, therefore, consistent tools are considered necessary to support the management and planning. In this framework, the Merguellil catchment is taken into consideration. It is situated in center of Tunisia, characterized by a semi arid climate but also by the most important groundwater resources. It is divided into two distinct areas by El Haouareb dam. The upstream catchment (1200 km^2) presents a hilly topography and has diversified conditions of geology, morphology, vegetation and land use. The Merguellil downstream catchment is part of the very large and flat Kairouan alluvial plain that extends over about 3000 km^2. Our research in the downstream part covers an area of 300 km^2 close to the dam, west of the city of Kairouan. The agriculture is the main consumer with about 80% of the total water resources because of the continuous increase and intensification of irrigated area. The surface water represented by El Houareb dam can satisfy a very low portion of this demand; consequently, the groundwater is overexploited with a drawdown of its water level ranging between 0.25 m and 1 m per year. The public irrigated area is well controlled in terms of cropping pattern, surface related to each crop and their specific water demands and consumption rates. However, the private one is not very known particularly in terms of water volumes pumped from the aquifer which is representing the main pressure on the groundwater resources, therefore, sustainable management of the different water resources, while meeting as much as possible all water demands, is crucial.

To analyse the current and the future situation until 2050 of the water balance of the Merguelllil watershed, WEAP (Water Evaluation and Planning system) was used. This model aims to incorporate supply, demand, water quality and ecological considerations into a practical yet robust tool for integrated water resources planning. Based on the actual situation of economic, demographic, hydrological, and technological trends, a "business-as-usual" scenario is established. The future planned data declared by the concerned authorities of water demand and supplies in the system are also set to constitute the Reference Scenario. Based on which one or more policy scenarios with alternative assumptions about future developments can be elaborated.

The year 2009 is considered as the current account which represents the basic definition of the water system as it currently exists, and forms the foundation of all scenarios analysis. The reference scenario starting from 2010 to 2050 considers an increase in drinking water and industrial demands; the same touristic demand and a decrease of water transfer from Kairouan aquifers to coastal city.

A fundamental input data to the WEAP model is the quantification of the irrigation water consumed by the private and the public sectors.

The agricultural water needs of the study area related to this year are calculated after the determination of the cropping pattern aggregated to the following classes: Early vegetables, winter vegetables, summer vegetables, irrigated cereals, and irrigated trees. The crop water requirements are calculated using CROPWAT 8.0 model. To calculate the ET0, CROPWAT uses the Penman-Monteith formula. The climatic input data are: Minimum and maximum temperature (°C), humidity (%), wind speed (km/day) and sunshine (hours). The estimation was done using the climatic data of the Chebika station, the total potential evapotranspiration is equal to 1641.8 mm/year which is in perfect agreement with the literature. The characteristics of each crop (Stage development, Kc values, rooting depth, critical depletion, yield factor and crop height) needed as input to calculate the crop water requirement are taken from FAO 56. Having consolidated all the required data, Three management scenarios were tested. The first one simulates the reduction of 10% in precipitation as it is forseen by the regional climate model RCA (driven by ECHAM5) that provides climate data of precipitation until 2050 (Pizzigalli, 2011, WASSERmed project) and the increase with 2% of the irrigated area situated downstream El Houareb dam that was deduced using crop pattern maps obtained by remote sensing data from 1986 to 2010. As a result to this scenario, a decrease in the Kairouan aquifer storage compared to the reference scenario was observed.

The second scenario concerns the application of a deficit irrigation that respects an acceptable yield reduction related to each existing crop (FAO N°33) gives an improvement of the groundwater resource budget with about 13 Mm^3 (Calculated for 2009) and consequently the unmet demand for the private irrigated areas decreases in respect to the other scenarios of 10% decrease in precipitation and 2% increase in irrigated areas when considered separately.

The third scenario tests the effect of the three hypotheses together: the reduction in precipitation, the increase in irrigated area and the application of deficit irrigation. This solution will ameliorate considerably the water storage in the Kairouan aquifer when compared to the reference scenario and the first scenario.

This study illustrate that WEAP results offer a solid basis to assist decision makers in developing their recommendations for present and future water balance situations.

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Comparative analysis of Darlık river watershed hydrology: WEAP and SWAT model

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EXTENDED ABSTRACT

In addition to being most crowded city of Turkey, Istanbul is also among the world's most populous cities and its population is increasing day by day so that water resources of this metropolitan are under excessive stress. Today, this huge metropolitan area needs approximately 2.250.000 m^3 water per day. Considerable amount of this demand -almost all- is supplied from dams around the city. Darlık Reservoir, in the North-East of Istanbul (Fig. 1), supplies the 12% of this demand, has 207 km^2 catchment area is one of the important reservoirs of this city.

It is very important that, Darlık watershed is not urbanized area. It is covered by forests, mid-sized agricultural areas and with only nine small villages. Despite the fact that land use of Istanbul has changed dramatically over the past decades, Darlık watershed has not been severely affected by this conversion. For these reasons Darlık Reservoir is an important water resource of Istanbul. Darlık watershed that is relatively pristine compared to the other watersheds in Istanbul could also be used for generating background conditions as defined by the European Community based Water Framework Directive (WFD) for the Region.

Megacities of the world must find ways for providing their inhabitants with water of acceptable quality and quantity. This necessitates the formulation and implementation of sound, well-coordinated, and integrated water resource management plans that must be prepared separately for each water resource and handled in a holistic perspective. While planning and assessing future water budget of big cities resources hydrologic models are the integral part of sustainable watershed

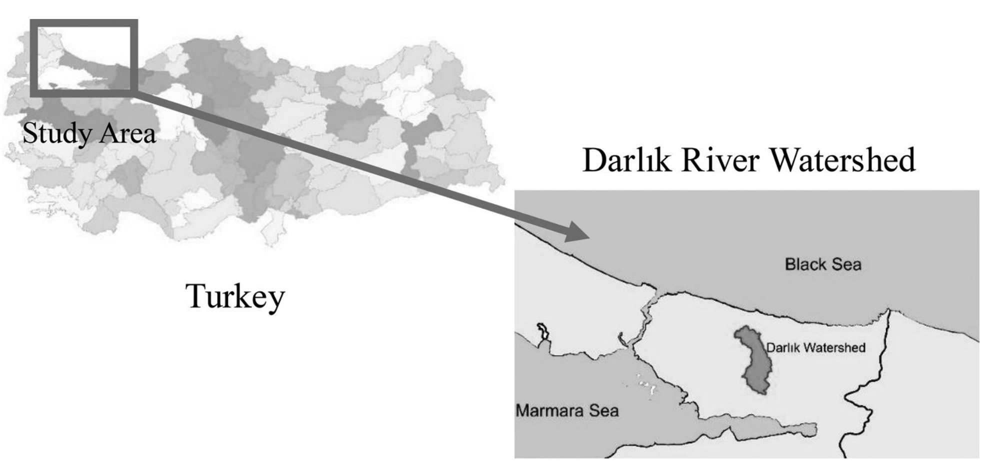

Figure 1. Darlık watershed.

Table 1. Model calibration and validation results.

Models		NSE	RSR	R^2
WEAP Model	Calibration	−1.75	1.66	0.57
	Validation	0.46	0.74	0.74
SWAT Model	Calibration	0.73	0.52	0.78
	Validation	0.53	0.68	0.66

management approach. Using hydrological models play significant role in watershed management. They give practical and useful information to municipal, decision makers and also scientists who concerned about.

This presentation includes the models based hydrological study and analysis an ongoing long-term research on the Darlık watershed. Water Evaluating and Assessment Tool (WEAP) that is a practical tool for water resource management, and is distinguished by its integrated approach for simulating water systems and by its policy orientation and Soil and Water Assessment Tool (SWAT) a free and open source model that had been applied effectively and successfully in many different scale watersheds all over the world is selected for this study as the hydrological modeling tool. Soil Moisture Method of WEAP model was applied and calibrated manually. The detail o WEAP model setup are given Cüceloğlu and Erturk (2014). On the other SWAT model was calibrated by using SWAT-CUP (Abbaspour et al. 2004, 2007, Schuol et al. 2008) program and validated with daily flow rate time series between the years 1968 and 1986, is given from General Directorate of State Hydraulic Works (DSI) for Darlık River.

Results of the study revealed the Darlık's current condition and water budget according to two models (Table 1). WEAP and SWAT revealed the water budget components of the Darlik River Watershed. Results of water budget components obtained from models and detailed comments about results will be presented. Comparison of NSE, RSR and R^2 value of these two models are given in table below. The table shows that the SWAT model was calibrated with a better goodness of fit, that is generally acceptable according to the model goodness of fit criteria proposed by Moriasi et al. (2007). This is because SWAT benefits from a highly developed automatic model calibration tool, the SWAT-CUP.

This study will contribute to the knowledge of one of the surface water resources of Istanbul which is still not under urbanization stress.

It is expected that these models will be useful about addressing the water resources management problems of watersheds of Istanbul with comparative analysis. Hydrological model of Darlık River Watershed that is the subject of this paper is the integral part of an integrated watershed modeling and management studies. Results from this study (The hydrological models and spatially and temporally high resolution water budget components) will be used to develop water quality, sediment transport and ecosystem models of the watershed. On the other hand these models can be used to examine the impact of the climate and land use changes in watershed in the future.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Climate change impact assessment on river basin: Sarisu-Eylikler river, Turkey

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ABSTRACT: Climate variability and change are supposed to change regional hydrologic conditions. These changes frequently cause excessive outcomes such as floods, heat waves, and droughts. Quantitative estimations of the hydrological effects of climate change is useful for understanding future water resource problems and hence, managing them. The aim of this paper is to represent preliminary results of a study on determining the effect of climate change on stream flow using the SWAT model so as to establish sustainable watershed management and to assess the impacts on various parameters so that policies can be prepared to mitigate negative results. The SWAT model was run for Sarısu-Eylikler river basin in Central Anatolia. HadCM3 General Circulation Model simulations were downscaled to obtain predicted meteorological parameters of the period 2040–2049 and stream flow was estimated using calibrated hydrologic model. Possible impacts of changes in the meteorological variables and stream flow are briefly visited considering increase flood risk and change crop pattern in the area.

1 INTRODUCTION

Third Assessment report of the Intergovernmental Panel on Climate Change (IPCC 2001) has indicated the general impact of climate change on water resources. Climate variability and change are expected to transform regional hydrologic conditions among others (Loaiciga 1996, Fujiharai, 2008). Potential impacts on hydrological process may be on evaporation, soil moisture, water temperature, stream flow volume, timing and magnitude of runoff, and frequency (Chiew et al. 1995, Arora 2002, Stone 2001, Conway 2010, Arnell et al. 2014). Agricultural productivity, land use, water demand, population in the watershed will be affected by hydrologic changes. Effects of global change on the hydrologic cycle should be studied for hydrological research. Quantitative estimations of the hydrological effects of climate change will be useful for understanding water resource problems and managing them.

Many researchers have studied climate change impact on river basins. For instance, Jha et al. (2004) studied the effect of climate change on stream flow in the Upper Mississippi River Basin by use of a regional climate model (RCM) combined with a hydrologic model, Soil and Water Assessment Tool (SWAT). Githou et al. (2008) investigated Climate change impact on stream flow in western Kenya, which was simulated by SWAT. They established the model by using readily available spatial and temporal data, and calibrated against measured daily stream flow. Fujihara et al. (2008) studied the possible impacts of climate change on the hydrology and water resources of the Seyhan River Basin in Turkey. They applied a dynamical downscaling method, indicated as the pseudo global warming method (PGWM). It was used to connect the outputs of general circulation models (GCMs) and river basin hydrologic models.

Hydrological conditions are simulated for observing the climate change effect on water resources under the projected weather conditions in an area (Gosain et al. 2006). The SWAT (*Soil and Water Assessment Tool*, Arnold et al. 1998) water balance model has been frequently used to carry out hydrologic modeling of river basins.

Several researchers have claimed that the long-term predictions of climatic models for the Mediterranean region are alarming since the number of extreme weather events appears to increase during the last decade over much of the Mediterranean region (Tayanç et al. 2006, Xoplaki, E. 2002, Feidas, 2001). In this study, the proposed methodology was applied to Sarisu-Eylikler river basin, which is a sub-basin of Beysehir Lake Basin, located in the Mediterranean region. Beysehir Lake Basin supplies the drinking water to Beysehir district and to nearby settlements and it is the third largest lake in Turkey. Since Sarisu river is the most important river to recharge Beysehir Lake, the effect of climate change on the river basin will be examined.

The aim of this study is to determine the impact of climate alteration on stream flow in Sarisu-Eylikler basin using the SWAT model in order to help sustainable watershed management. The objectives of this study are (1) creating and calibrating a SWAT model of the basin, (2) downscaling the results of a general circulation model (GCM), (3) running the SWAT with future meteorological variables and predicting the outcomes of climate change on stream flow and (4) determining the conclusions of climate change on water resources and environment in the area under question and lay the groundwork for further research on the subject.

2 HYDROLOGIC MODEL

2.1 *The study area*

The proposed methodology will be applied to Sarisu-Eylikler stream basin, which is located between 37.47°–38.15° latitudes and 31.73°–32.47° longitudes (Fig. 1). The area of the basin is 1040 km^2 and the average total annual flow of Sarisu-Eylikler river was 68 million m^3 between 1992 and 2010.

2.2 *Input layers*

Soil and Water Assessment Tool (SWAT) has been used as a hydrological transport model. The model simulates the hydrologic cycle of the basin in daily and monthly time steps. Major model components are Digital Elevation Model (DEM), land use, soil properties, land slope, weather and hydrologic parameters. The Sarisu-Eylikler stream watershed was divided into a number of sub-watersheds based on the DEM (Fig. 2 and Fig. 3), which was produced from 1:25 000 scale topographic maps. The land cover/land use map was generated using Landsat-5 TM (2009) images in the framework of a Ministry of Forestry and Water Affairs project as well as the soil map. SWAT simulates the rainfall-runoff process at the sub-catchment level by deriving hydrological response units (HRUs), which were determined based on land use, soil type and land slope combinations (Fig. 4).

2.3 *Meteorological data*

For the study area, The National Centers for Environmental Prediction/Climate Forecast System Reanalysis data (NCEP/CFSR)is available along with in situ measurements from several ground stations. However, in situ data has continuity problems, so reanalysis data is used. In situ data will be incorporated into the analysis in the future.

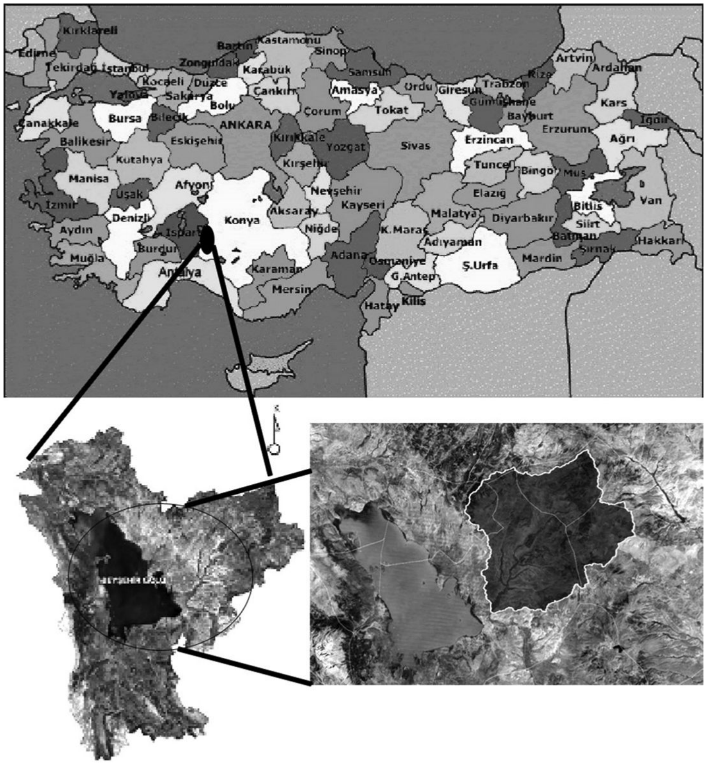

Figure 1. The study area.

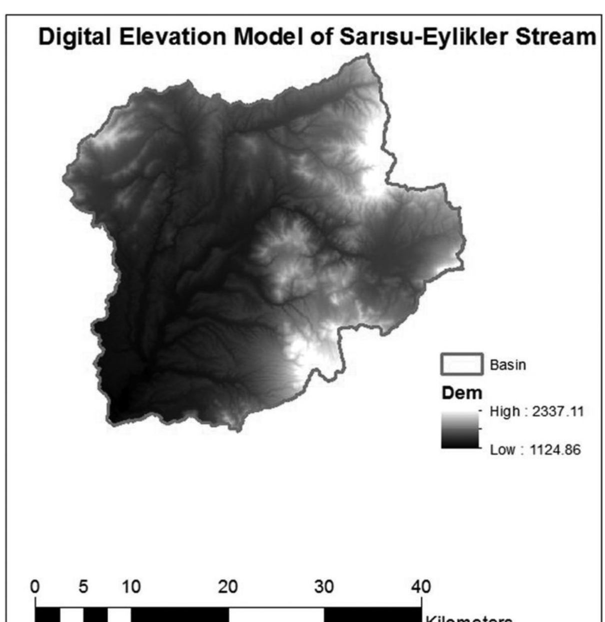

Figure 2. Digital elevation model of Sarisu-Eylikler stream.

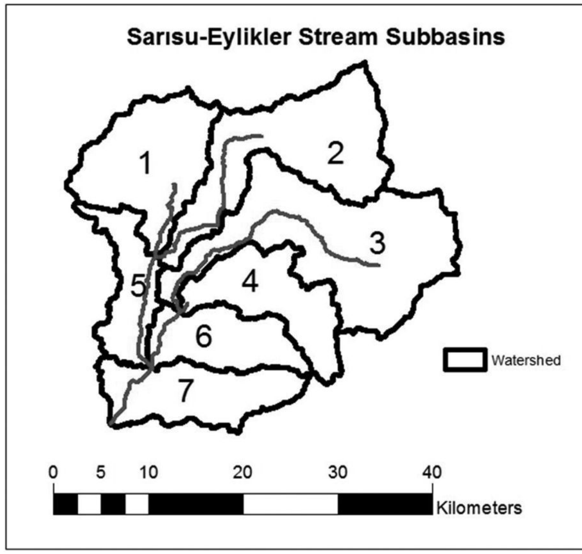

Figure 3. Sarisu-Eylikler stream subbasins.

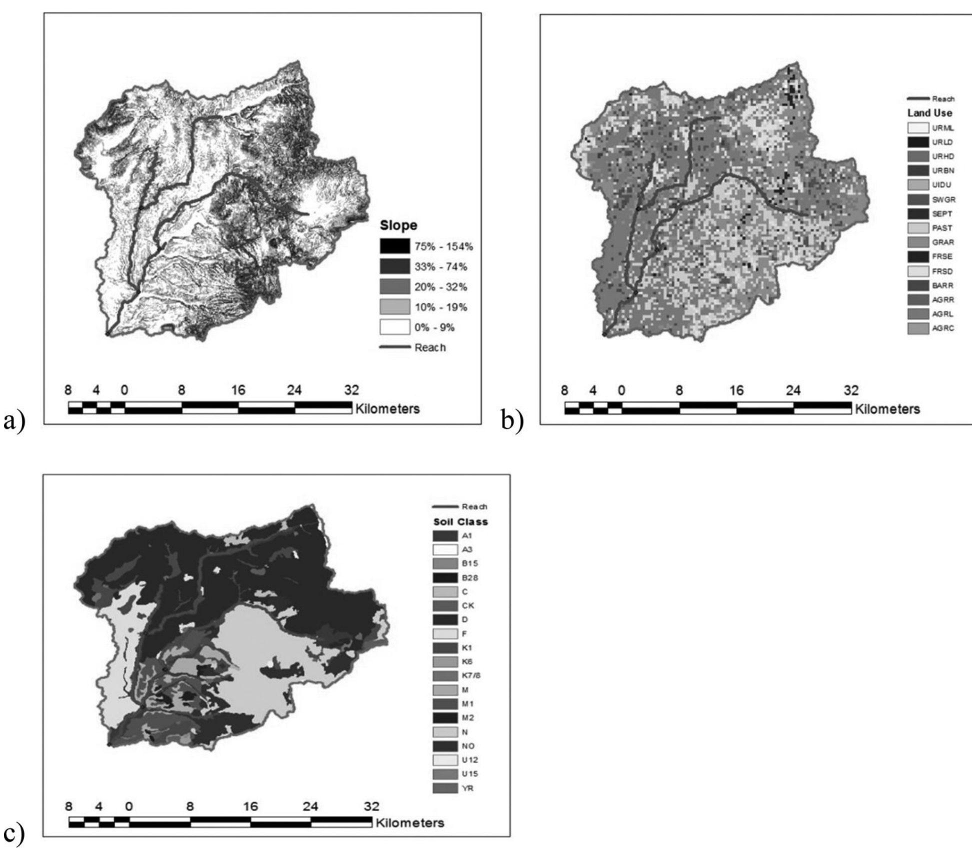

Figure 4. a) Land slope, b) Land use and cover map and c) Soil type.

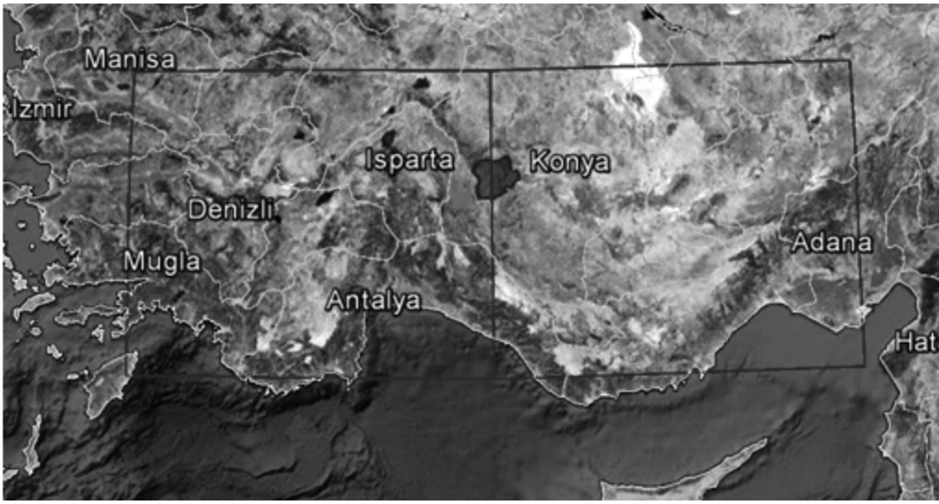

Figure 5. The HadCM grid cells (9, 20) and (10, 20) over the basin. Using these large scale simulations, we need to predict relevant meteorological parameters for future, necessary to run our hydrological model based on our observations in the past.

Although various simulation results of global climate models are available under several climate change scenarios, the spatial resolution of these simulations are too coarse to be used directly for studies in local analyses. These global simulations do not consider local variables like topography either. Through downscaling, we can correlate our local observations to GCMs and we can project the observations to future in parallel to the GCM simulations that cover both the observation period and the future period that we are interested in.

HadCM3 (Hadley Centre Coupled Model version 3) is a coupled climate model that was developed by UK Med Office Hadley Center (Gordon 2000). HadCM grid cells are 3.75 degrees wide in the East-West direction and 2.5 degrees in the North-South direction. In this grid arrangement, the cells (9, 20) and (10, 20) cover our test area. Each cells size is approximately 325 km by 280 km (Fig. 5).

We have downloaded predictors derived from HadCM3 under the scenario of A2 as defined in IPCC Special Report on Emissions Scenarios (SRES) (IPCC 2000) from Canadian Climate Change Scenarios Network (CCCSN) web site. Daily observed NCEP predictor data, which is obtained from NCEP reanalysis data set (Kalnay et al. 1996) and resampled and interpolated over the same grid with the HadCM, was also downloaded from the same site.

Although the NCEP data uses 365 day calendar with leap years, HadCM3 simulations use a 360 day calendar where each month is 30 days. The HadCM3 data was converted to normal calendar days by repeating certain days of the year using a MATLAB script.

Automated Statistical Downscaling Tool (ASD) (Hessami 2008) version 1.1 was used for downscaling. We have chosen the period 1979–2010 as current data and created following meteorological variables on a daily basis for the period 2040–2049: precipitation, wind speed, solar radiation, maximum temperature, minimum temperature and relative humidity.

In Figure 6 and Figure 7, maximum temperatures and precipitation are compared, respectively, for two periods: 1979–1990 and 2040–2049 and for one location around the basin.

As can be seen in Figure 6, the maximum temperature is anticipated to increase, however, it is more pronounced in the months July and August. On the other hand, the annual precipitation does not seem to change much, but the distribution within year will change considerably. Although precipitation will increase in January, April and May, it will decrease considerably in July and August.

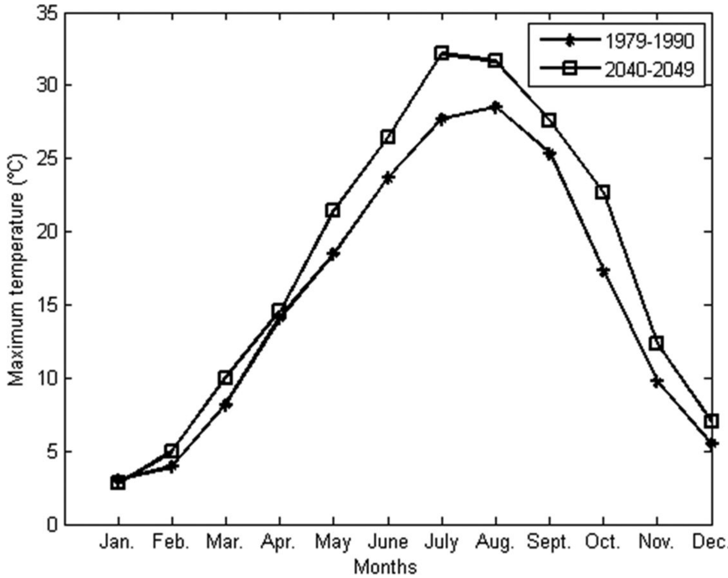

Figure 6. Monthly average maximum temperatures over two periods.

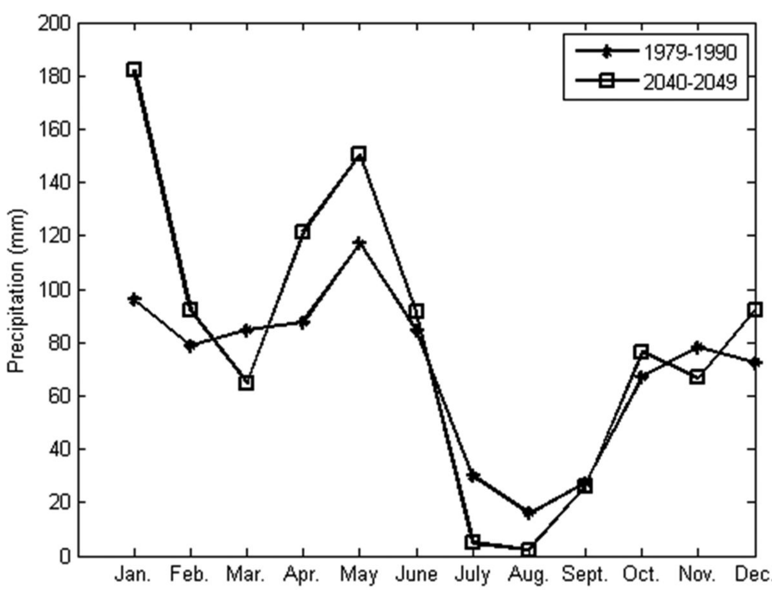

Figure 7. Monthly average precipitation over two periods.

2.4 *Calibration*

The hydrological model SWAT used in this study is continuous time. It is physically based and can operate on large basins for long periods of time (Arnold et al. 1998). SWAT includes various processes which are hydrology, weather, erosion and sedimentation, soil temperature, plant growth,

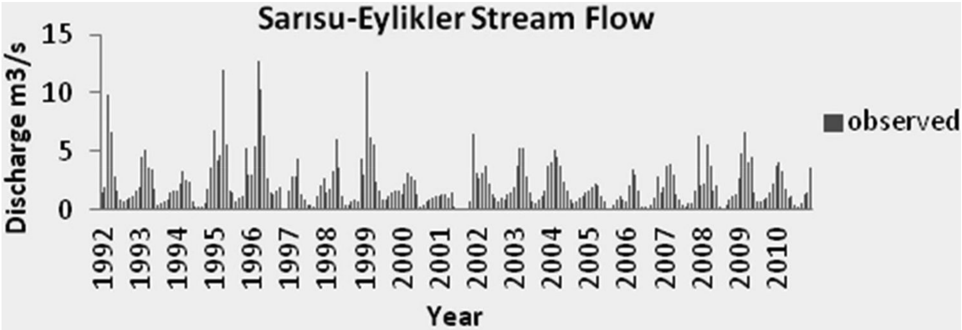

Figure 8. Sarisu-Eylikler stream discharge values from 1992 to 2010.

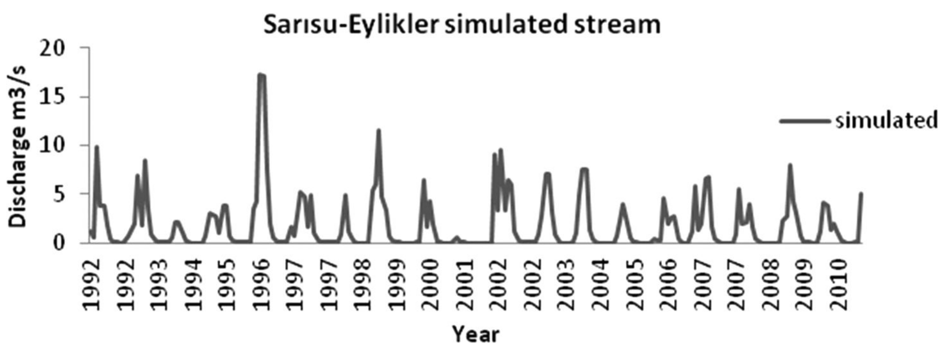

Figure 9. Sarisu-Eylikler stream flow values from the SWAT model.

nutrients, pesticides, and land management. Stream flow simulation was the main focus in this study. Sarisu-Eylikler stream discharge values were obtained from Sarisu-Eylikler stream gauging station. The discharge values are being measured since 1992 (Fig. 8) and SWAT was run for this period (Fig. 9). The model was calibrated against measured stream flow for the period 1992–2010 near the outlet of the river basin (Fig. 10). The calibration will be elaborated further and validation will be performed in the future.

The Sequential Uncertainty Fitting (SUFI) algorithm was used to calibrate the model because it is most commonly used, well documented and reported to produce satisfactory results (Abbaspour 2012). Parameters controlling surface runoff and groundwater were rectified until a good fit was obtained between the observed and simulated stream flow. The model performance was evaluated with the coefficient of determination R^2 and visual comparisons of observed and simulated stream flow.

3 IMPACT OF CLIMATE CHANGE

3.1 *Simulation results*

The calibrated model was run for the periods 1992–2010 and 2040–2049. In Figure 11, Sarisu-Eylikler stream flow predicted for period 2040–2049 is shown. Average flow of the stream from 2040 to 2049 is 4.95 m^3/s while the stream flow for the periods 1992–2010 is 2.16 m^3/s. It was clearly observed that discharge values of the stream are expected to increase during springs of the range 2040–2049.

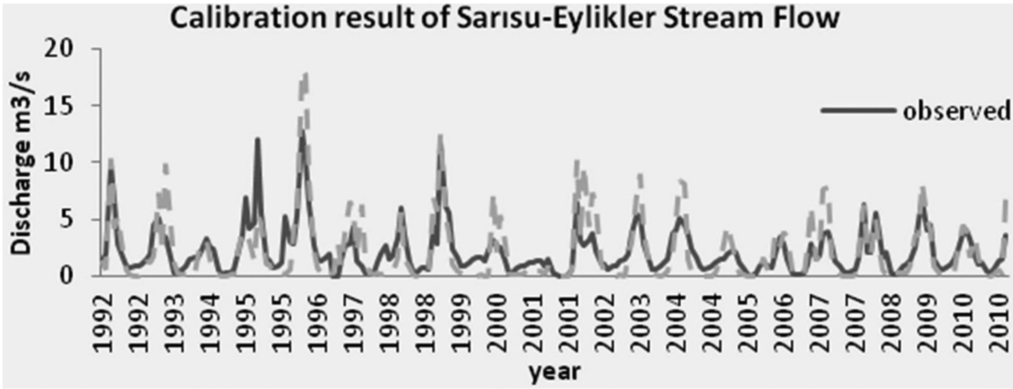

Figure 10. The calibrated stream discharge values of Sarisu-Eylikler stream.

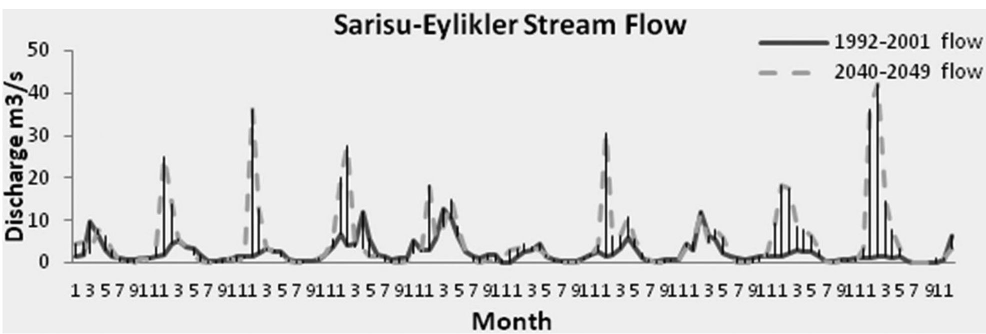

Figure 11. Sarisu-Eylikler stream flow (2040–2049).

3.2 *Possible impact on urban water use agriculture and environment*

Although the total annual precipitation isn't expected to change wildly, the change in the pattern is significant. We can expect more floods in winter/spring period. Especially, agricultural areas in the basin near the river can be damaged from these floods. Sarisu-Eylikler Stream basin is mainly used for agriculture and mostly for dry farming. Increased winter precipitation combined with reduced summer precipitation linked with increased summer temperature can even have a positive effect on wheat and a detailed analysis should be performed considering phonological cycle of various frequently planted crops in the area. We will use the future daily data in a crop growth model for various crops cultivated in the area.

There is also the risk that some branches will completely dry up during summer. This will have negative effects on both the wildlife in the riparian zone and on irrigated areas. Extreme and frequent floods may also erode the riverbank and damage the riparian zone. To mitigate the effects, a network of small dams and barrages, dikes, floodgates can be established. On upper parts of the basin, there are large deforested areas which are prone to soil erosion. A carefully planned reforestation plan can reduce surface run-off and reduce the severity of the floods.

Water use for both households and agriculture is expected to increase in near future. Since, the water balance is already critical in the area, expected constancy of annual precipitation is not relieving.

4 CONCLUSION

Climate change causes the extreme events such as floods, heat waves, and droughts. Water availability and runoff in the watershed will be affected from changes in the hydrological cycle..This study is significant for realizing the impression of A2 climatic change scenario on stream flow, which can be used for better management and development of water resources in this region.

The purpose of this study was to analyze the impact of climate change on stream flow using the SWAT model in small scale. Synthetic meteorological time series were created based on global climate change scenarios, where global circulation model results via downscaling. After the SWAT model was calibrated, the effects of climate change scenarios on runoff were determined.

Automated Statistical Downscaling Tool (ASD) projections were used for observing the changes in temperature and precipitation in the future. The analysis was performed on the Sarisu-Eylikler stream basin in order to examine the stream flow. According to the climate change model, the maximum temperatures are expected to increase, however, it is more pronounced in the months July and August. On the other hand, the annual precipitation does not seem to change much, but the distribution within year will change considerably. Although precipitation will increase in January, April and May, it will decrease dramatically in July and August.

The temperature and precipitation changes from period of 2040–2049 will affect the stream flow. We can expect more floods in winter/spring period because rainfall in winter/spring months between 2040–2049 is anticipated to increase. Especially, agricultural areas in the basin near the river can be damaged from these floods. The riverbank may be also eroded and the riparian zone may be damaged due to extreme and frequent floods. A network of small dams and barrages, dikes, floodgates can be established in order to mitigate the effects. On upper parts of the basin, there are large deforested areas which are prone to soil erosion. A carefully planned reforestation plan can reduce surface run-off and reduce the severity of the floods.

Sarisu-Eylikler stream basin is mainly used for agriculture and mostly for dry farming. Increased winter precipitation combined with reduced summer precipitation linked with increased summer temperature can even have a positive effect on wheat and a detailed analysis should be performed considering phonological cycle of various frequently planted crops in the area.

This study presented the preliminary results. After better calibration and validation of the model, the authors will make detailed analyses of the impacts and extend the results up to 2070s.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Review of drought contingency plans for Army Corps of Engineers projects

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ABSTRACT: The Corps of Engineers (USACE) operates 541 reservoirs throughout the United States. These reservoirs serve many authorized purposes including flood control, hydropower generation, water supply, water quality, navigation, and recreation. In 1988, maintaining Drought Contingency Plans (DCPs) at USACE reservoirs was identified as an operational weakness. A major effort to develop or update the DCPs at all USACE projects was initiated and largely completed in the early 1990s. USACE is currently reviewing the status and content of the existing DCPs and determining how to best update them for greater consistency of information and to address local and global changes that have or are expected to occur in the future. This manuscript represents an initial step within this process. The plans were critically reviewed for their operational flexibility for responding to uncertainties in the progression of a drought as well as climatic changes that affect the project.

1 INTRODUCTION

WEST Consultants (WEST) was contracted by USACE to perform a review of all available DCPs. For this analysis, 140 DCPs covering 301 USACE projects were reviewed. Of the 240 USACE projects not reviewed, 137 are lock and dam projects. Although navigation can obviously be affected during a drought, these projects appeared to have no DCPs associated with them. The remaining 103 projects either have no DCP associated with them, or the DCP was not supplied by the District responsible for the project.

Each DCP received was evaluated across seven considerations:

- Water Law
- Water Supply
- Surplus Water Available During a Drought
- Drought History
- Drought Monitoring and Drought Level Determination
- Drought Issues and Drought Actions
- Drought Coordination

2 REFERENCE DOCUMENTS

The review of reference documents included the 1944 Flood Control Act, the 1958 Water Supply Act, and various engineering manuals and regulations produced by USACE.

Section 6 of the 1944 Flood Control Act provides authority to allow for the sale of water stored in USACE reservoirs that is deemed surplus. Water that is deemed surplus can only be used for domestic, municipal, and industrial uses. These surplus agreements are temporary and, therefore, do not provide a permanent right to the storage. In the 1958 Water Supply Act, Congress recognized that the states and local interests have the primary responsibility for developing water supplies, and the Federal Government should participate and cooperate by making provisions for water supply in the construction, maintenance, and operation of Federal navigation, flood control, irrigation, or multiple-purpose projects.

Engineering Pamphlet (EP) 1165-2-1 titled, "Water Resources Policies and Authorities", provides a summary of the existing administrative and legislative water resource policies and authorities pertinent to the civil works activities of USACE. This document details several important points regarding water supply at USACE projects:

- Public Law 88–140 grants permanent rights to use storage to local interests when they have paid the cost of including the storage in the project under an agreement with the Government
- Reallocation of reservoir storage that would have a significant effect on other authorized purposes or that would involve major structural or operational changes requires Congressional approval
- Single-purpose water supply projects are typically not recommended by USACE since they are usually not economically justifiable. There needs to be other purposes such as flood control, hydropower, or navigation.

3 WATER LAW

Water law in the United States is normally determined generally in one of two manners: 1) riparian water rights or 2) appropriation. Riparian water rights are rights on land that immediately adjoins a river. The owner of the land has a right to use an amount of water that is considered reasonable, with reasonable being defined as that amount which allows maximum use by a riparian landowner without unreasonably impairing other riparian owners. Appropriation is commonly referred to as "first in time, first in right". This type of water law is predominant in western states. Allocations among users are made by temporal priority. The two general types of water rights impact the allocation of water resources during times of droughts.

The application of riparian or appropriation water rights tend to vary between the states. In some states, riparian municipalities have the same rights to withdraw water as private riparian proprietors, and all uses of water throughout the riparian municipality are considered riparian uses. In the state of Ohio, withdrawals for domestic uses have priority over withdrawals for other types of uses. Some municipalities can use their power of eminent domain to take, with just compensation, private land adjacent to watercourses to provide the town with water supply. In the state of New Mexico, appropriation water rights are applied. Under drought conditions, shortages are not shared proportionately among all water right holders. Instead, the senior rights are satisfied in chronological order of appropriation and junior users are simply cut off when the water runs out.

Riparian water rights are rights that are associated with a particular piece of property. Appropriation water rights are treated as a vested property right that can be sold, leased, or traded freely. The water rights issues are handled by the states. The U.S. Government, however, does regulate the use of dedicated water from its projects. For example, if a release is made from a USACE project for water quality enhancement, riparian water users are not allowed to use or interfere with these augmented flows.

In addition to the water rights described previously, there also exist compacts between the states to determine the use of water from specific watercourses. The Rio Grande Compact, signed in 1938,

Table 1. Distribution of M&I water supply projects by state.

State	Number of Projects	Storage Space (acre-ft)	State	Number of Projects	Storage Space (acre-ft)
Arkansas	13	613,723	North Dakota	2	69,890
California	3	387,000	New Mexico	1	178,000
Connecticut	1	50,200	Ohio	7	190,964
Georgia	4	47,775	Oklahoma	18	1,521,006
Iowa	2	21,580	Oregon	1	10,000
Illinois	3	166,406	Pennsylvania	5	69,790
Indiana	3	378,958	South Carolina	1	3,833
Kansas	14	1,068,593	Tennessee	3	27,402
Kentucky	9	15,611	Texas	25	4,509,511
Massachusetts	1	9,400	Virginia	3	24,575
Missouri	5	189,993	Washington	1	20,000
Mississippi	2	17,608	West Virginia	4	45,435
North Carolina	3	123,800			

is a legal agreement among the states of Colorado, New Mexico, and Texas. The Colorado River Compact, signed in 1922, divides the water of that basin among seven states including Colorado, Utah, Wyoming, New Mexico, Arizona, California, and Nevada.

4 WATER SUPPLY

According to the 2011 Municipal and Industrial (M&I) Water Supply Database developed by USACE, there are 134 water supply projects containing 9.8 million acre-ft of storage space. From these 134 projects, there are 335 separate repayment agreements through which local sponsors have repaid 55% of the investment cost including any outstanding interest. The distribution of M&I water supply storage by state is shown in Table 1.

The water stored in USACE reservoirs can be directly taken from the reservoir or can be used by downstream users. Users of this water must have purchased storage within the reservoirs. Water stored in USACE reservoirs may be allocated to additional purposes other than water supply such as hydropower, water quality enhancement, and fish and wildlife.

In some cases, minimum releases requirements are made from the projects for various purposes. Fort Peck Dam on the Missouri River has minimum release requirements for fisheries and irrigation in addition to water supply. Garrison Dam, also on the Missouri River, has a minimum release requirement for powerplant intakes in addition to municipal water supply and irrigation.

At some USACE lakes, the minimum flow requirements downstream of the reservoir vary at different locations and also may vary throughout the year. At Philpott Lake, in the state of Virginia, the minimum release requirement is defined at three different locations, Stanleytown, VA (59 cfs in summer), Fieldale, VA (45 cfs in summer), and Martinsville, VA (90 cfs October-May, 125 cfs in June, 140 cfs July–September 15, and 125 cfs September 15–30).

For projects that have both water supply and hydropower, the conservation storage that is allocated for each purpose must be defined. The allocated conservation storage for the White River projects located in the states of Arkansas and Missouri are shown in Table 2. Over the history of these projects, hydropower storage and flood storage has been reallocated to water supply storage as the need has arisen.

Table 2. Conservation storage allocations for white river projects.

Project	Water Supply Storage (acre-ft)	Hydropower Storage (acre-ft)	Total Conservation Storage (acre-ft)
Beaver	128,995	807,505	936,500
Table Rock	27,000	1,154,500	1,181,500
Bull Shoals	12,613	990,387	1,003,000
Norfork	2,400	704,600	707,000
Greers Ferry	29,133	696,767	725,900

5 SURPLUS WATER AVAILABLE DURING A DROUGHT

During a drought situation, the Secretary of the Army is authorized to make contracts with states, municipalities, private concerns, and individuals for water that is deemed surplus. Typically, surplus water consists of water that is allocated for water supply but has not been contracted by any user and water that is stored in the inactive pool. Surplus water may be used for domestic, municipal, and industrial uses; however, it cannot be used for crop irrigation.

When low flow conditions are anticipated, some projects have the flexibility to store water up to a higher elevation than normal if doing so does not impact other authorized purposes such as flood control or recreation. This type of operation occurs at many of the projects found in the Huntington District of USACE. Additionally, flood storage in many of the Los Angeles District projects is utilized for a longer period of time to allow for releases into nearby spreading grounds for groundwater recharge.

The White River projects discussed earlier have a total of 6.03 million acre-ft of inactive storage. It has been estimated that the inactive storage at these projects could meet the anticipated needs from M&I, hydropower, agriculture, fishery, and other uses for at least one year and probably longer. However, use of the inactive storage could present issues among competing users. It has been noted by the Tulsa District that use of the inactive storage with projects having hydropower could result in the request for a credit by the Southwestern Power Administration (SWPA), the federal agency responsible for the marketing of the power produced by USACE projects in this region of the country. This request for credit results from reduced head differential and the delaying of conservation pool filling.

The validity of contracts during a drought also differs among the individual states. In California, the Governor may nullify contracts during a drought if another use is considered more critical. Other states consider the contracts to be valid at all times and leave it to the individuals or entities in need of water to negotiate with those contract holders.

6 DROUGHT HISTORY

One of the most significant droughts that has occurred in the United States was during the 1930's. During this period, known as the Dust Bowl, there was significant crop and livestock damage. Some of the impacts identified within USACE DCPs are as follows:

- Taylorsville Lake in Louisville District
  - Maximum temperature of 114°F was recorded with temperatures between
  - 100°F and 110°F commonly being reported
  - Caused enormous damage to corn and increased suffering of animals from thirst
  - Wells and springs that had never been known to fail became dry

Table 3. Rio Grande basin, Rio Grande drainage historical drought periods.

Drought Period		Number of Months				
Start	End	Mild	Moderate	Severe	Extreme	Total Months
Apr 1899	Dec 1904	10	7	22	30	69
Jan 1931	Oct 1940	5	10	9	91	115
Aug 1948	Mar 1957	10	14	30	50	104
Jul 1962	Oct 1964	9	15	2		26
Dec 1976	Oct 1978	4	9	10		23
Nov 1980	Jul 1982	12	7	1		20
Total		50	62	74	171	357

Table 4. Annual firm energy at white river projects.

Project	Critical Dry Period	Annual Firm Energy (mwh)
Beaver	1953–54	86,000
Table Rock	1962–65	242,000
Bull Shoals	1962–65	345,000
Norfork	1953–54	100,000
Greers Ferry	1953–54	109,000

- St. Paul District
  - Outdoor water use was banned in St. Paul and Minneapolis, Minnesota
  - Many cattle died from lack of food and water or from dust that accumulated in their lungs
  - Some people died from "dust pneumonia"
  - Crops yield were the worst in history
  - Livestock were shipped to other parts of the county because of a lack of food and water
  - Thousands of farmers moved to other parts of the country

Other drought periods have been described in the DCPs. For some projects, the number of months of mild, moderate, severe, and extreme drought is detailed. An example of this is the historical drought periods in the Rio Grande Basin shown in Table 3.

Historical drought periods are also used for the determination of operational criteria at some of the projects. The critical period for operational power planning in the Columbia River basin consists of the years 1928 to 1932. Public concern over the drought conservation plan presented in the 1979 version of the master manual for the Missouri River basin was brought about from the 1987 to 1993 drought. The Northwestern Division of USACE initiated an update of the water control plan in 1989 due to these concerns.

Historical droughts are also used to determine the firm energy amounts at some of the projects. Firm energy is the amount of energy which a system can produce over the term of a specific drought without depleting its allocated conservation storage. Firm energy values along with the critical dry period for the White River projects are given in Table 4.

7 DROUGHT MONITORING/DROUGHT LEVEL DETERMINATION

In the United States, the Palmer Drought Severity Index (PDSI) is used to determine the level of drought throughout the nation. The PDSI uses both temperature and rainfall information. It is most effective in determining long-term drought and not as applicable with short-term forecasts. Drought

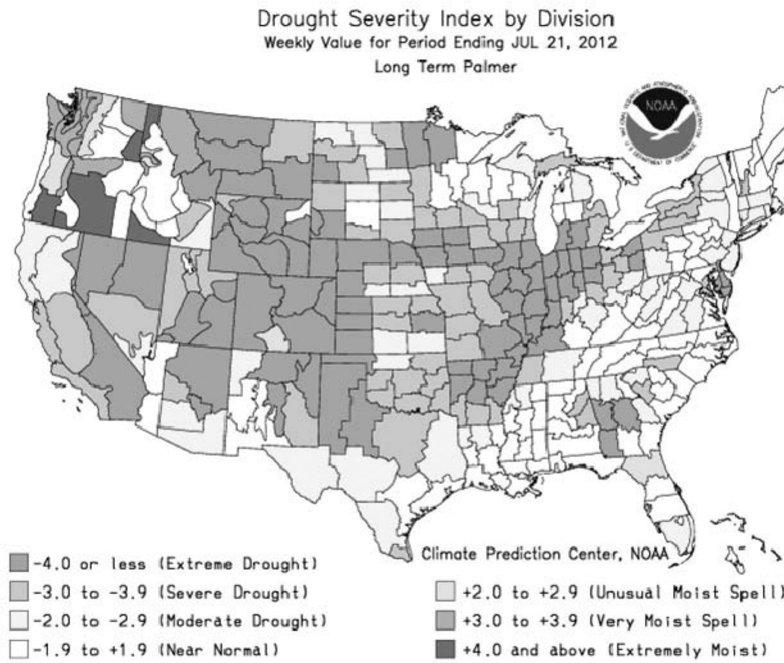

Figure 1. PDSI values for July 21, 2012.

is defined with negative numbers while moist conditions are defined with positive numbers. The PDSI for the contiguous United States for the week ending July 21, 2012 is shown in Figure 1. From this figure, it can be seen that much of the United States was in a drought during this period with many areas in extreme drought.

The PDSI is one of the variables used at some of the projects to determine drought levels. The criteria for determining the drought level at projects in the Baltimore District of USACE are drought duration and the ratio of precipitation deficit to normally expected precipitation. The drought duration is determined by the number of consecutive months that the PDSI is below zero. The Baltimore District uses three levels of drought: Drought Watch, Drought Warning, and Drought Emergency. The determination of drought level for Baltimore District projects is shown in Table 5.

The New England District of USACE uses what they term as "guide curves" to monitor the onset of a drought. These curves show the frequency values for annual duration, 6-month duration, 3-month duration, and 1-month duration for rainfall and flow at various locations. These curves allow the operators of the projects to easily compare the current conditions with historical data. They also provide a useful communication tool especially when historic drought events are plotted along with the current conditions.

The 7Q-10 flow can also be a useful tool for determining drought severity. The 7Q-10 flow is the 7-day average flow that is expected to occur on average once every 10 years. The length of time over which the flow is averaged can vary depending on the applicability to the system. For the Jackson and James Rivers in the Norfolk District, the flows are also averaged over a 30-day and a 60-day period. As with the "guide curves" used in the Baltimore District, this variable can be a useful comparison and communication tool. These values for the Jackson and James Rivers in the Norfolk District are shown in Table 6.

One of the drawbacks of using PDSI for drought level determination is that it fails to account for several items such as mountain snowpack, snowmelt, urban water supply, irrigation, recreation, navigation, and hydropower. Because of this, the Surface Water Supply Index (SWSI) was designed

Table 5. Drought assistance triggering criteria for Baltimore district projects.

	Ratio of Precipitation Deficit to Normally Expected Precipitation		
Duration (months)	Drought Watch	Drought Warning	Drought Emergency
3	18	31	35
4	15.5	27	32
5	14	24	29
6	12.5	22	26.5
7	12	21	25
8	11.5	20	24
9	11	19	23
10	10.5	18.5	22
11	10.5	18	21
12	10	17.5	20.5

Table 6. Jackson and James rivers low flow data.

		10 Year Flow Frequency for:		
Station	Period of Record	7 day flow (cfs)	30 day flow (cfs)	60 day flow (cfs)
Jackson R. below Gathright Dam nr. Hot Springs, VA	1974–80	64	69	72
Jackson R. at Falling Springs, VA	1925–80	64	70	73
Jackson R. below Dunlap Ck. At Covington, VA	1975–80	92	93	99
James R. at Lick Run, VA	1925–80	184	201	214
James R. at Buchanan, VA	1911–80	272	302	326
James R. at Holcombs Rock, VA	1927–80	400	456	497
James R. at Bent Ck., VA	1925–80	449	544	598
James R. at Scottsville, VA	1925–80	510	614	675
James R. at Cartersville, VA	1925–80	587	735	823
James R. at Richmond, VA	1937–80	719	893	1,034

to account for these added variables. The three categories of drought used for the Columbia River basin in the Pacific Northwest are determined using the SWSI rather than the PDSI.

At some projects, a drought is simply determined when that project is not able to meet its targets. For example, at Howard Hanson Dam, a drought is said to occur when the flow in the Green River below the diversion for the city of Tacoma, Washington is not able to be maintained at or above 110 cfs.

It is common for drought level determination to be dependent on the duration of drought along with the pool elevation at a particular project. For the projects operated by the Tulsa District of

Table 7. Drought level determinations for upper red river basin projects.

Drought Level	Drought Duration (months)	Waurika Pool Elevation (ft NGVD29)	Texoma Pool Elevation (ft NGVD29)
1	0 to 18	951.4 to 951.4	617.0 to 617.0
2	18 to 36	951.4 to 945.2	617.0 to 612.0
3	36 to 54	945.2 to 939.7	612.0 to 607.0
4	>54	<939.7	<607.0
Bottom of Conservation		910.0	590.0

Table 8. Hedging rules for Saylorville reservoir.

Condition	Recommended Reservoir Release
Pool elevation >827 ft	release all water supply and water quality demands
Pool elevation between 826 ft and 827 ft	release 100% of water supply, maintain 175 cfs at the dam, and 245 cfs at SE 14th St
Pool elevation between 825 ft and 826 ft	release 100% of water supply, maintain 150 cfs at the dam, and 220 cfs at SE 14th St
Pool elevation between 824 ft and 825 ft	release 100% of water supply, maintain 125 cfs at the dam, and 195 cfs at SE 14th St
Pool elevation between 823.5 ft and 824 ft	release 100% of water supply, maintain 100 cfs at the dam, and 170 cfs at SE 14th St
Pool elevation between 819 ft and 823.5 ft	release 100% of water supply, no water quality releases made
Pool elevation between 816.0 ft and 819.0 ft	release 75% of water supply, no water quality releases made
Pool elevation <816 ft	release 50% of water supply, no water quality releases made

USACE, four levels of drought are used. The drought level determination for Upper Red River basin projects is shown in Table 7.

The determination of the drought level for the various districts varies widely. During this review, it was determined that standardizing the definition of drought levels is not advisable. The various USACE districts need the flexibility to make those determinations based on operating purposes, hydrologic conditions, inflow sources, and data availability.

8 DROUGHT ISSUES/DROUGHT ACTIONS

Just as the determination of drought level is highly variable throughout the districts, the issues and actions faced at the projects also vary widely. In general, low river flows downstream of projects can cause water quality and water supply issues. The water quality issues can be caused by municipal and industrial waste discharges, but can also be caused by thermal loading. For example, power generating plants at Niles, Ohio and West Pittsburgh, PA are two sources of thermal loading along the Mahoning River in the Pittsburgh District. The primary purpose of Stonewall Jackson Lake in the Pittsburgh District is the dilution of municipal and mine drainage related pollution in the lower West Fork River. This purpose could be affected by drought.

One long term consequence of drought upon agriculture is the concentration of minerals and salts in the upper soil levels which limits future crop variety and reduces yields. It is common for farmers to haul in water from outside sources during a drought for their crops and livestock.

Conservation of water during a drought is a common practice. At Saylorville Reservoir in the Rock Island, Illinois District of USACE, the water supply and water quality releases are decreased with decreasing pool elevation as shown in Table 8.

Some of the projects have specific actions or recommendations that should be followed as a drought progresses from one level to the next. For the four levels of drought used by the Tulsa District of USACE the following actions are taken:

- Drought Level 1
  - Requires reservoir control personnel to be alert for the onset of a drought while maintaining normal operating procedures
  - Reservoir Control personnel will monitor storages, withdrawals, and low flow releases and disseminate status reports within USACE and among other interested parties
- Drought Level 2
  - Requires activation of the CDMC
  - CDMC acts to insure that the various elements of the District are responding to the drought with a concerted effort and coordinates requests and actions with the appropriate state and federal agencies
  - District Commander will call an ad-hoc meeting of the IDMC within 60 days of activating the CDMC and brief the members on current and projected reservoir conditions
- Drought Level 3
  - Requires the District Commander to activate the IDMC
  - IDMC acts as the interface between the CDMC and water users within the basin
  - IDMC consolidates state and federal positions on drought actions and provides the CDMC with justifications, priorities, and suggested actions which will serve the most critical needs with the remaining project storage
- Drought Level 4
  - Requires continued coordination between the IDMC and the CDMC as described in Level 3
  - Conditions may require the use of inactive storage and water rationing

The CDMC is the USACE Drought Management Committee while the IDMC is the Interagency Drought Management Committee.

9 DROUGHT COORDINATION

The importance of frequent communication within USACE districts and among the various stakeholders is stressed in many USACE DCPs. The CDMC is formed to represent the broad range of federal interests, and the IDMC consists of other federal agencies along with state and local interests. Some of the other federal agencies involved in the coordination of drought activities include the Environmental Protection Agency, Public Health Service, Fish and Wildlife Service, U.S. Geological Survey, National Weather Service, and the various Power Administrations in charge of marketing power from federal projects. Examples of these administrations include the Bonneville Power Administration (BPA), Southeastern Power Administration (SEPA), and Southwestern Power Administration (SWPA). Numerous state and local agencies involved in drought coordination are also listed in the DCPs.

10 CONCLUSION

The review of USACE DCPs through a contract to WEST Consultants provided a comprehensive review of reservoir management by USACE throughout the United States. This review will ultimately lead to the selection of DCPs that are in need of updating and the prioritization of those updates. This prioritization will be facilitated by input from the individual districts, USACE Headquarters, and the Institute for Water Resources since the applicability, information, and context of the drought management requires all levels of USACE consideration. Additionally, this review was very timely with the information gained from this study being used to facilitate decisions regarding

Figure 2. GIS map showing coverage of DCPs at USACE projects.

project operations during the 2012 drought that occurred in the Midwestern portion of the United States.

In addition, the coverage of the DCPs was determined through the use of GIS. The locations having DCPs along with the projects covered by these DCPs were developed in ARC-GIS. This development was made available to USACE personnel through CorpsMap, the nationwide enterprise GIS implementation for USACE. Summaries of the DCPs were also linked in the GIS application. Figure 2 shows the coverage of DCPs reviewed for this study. The red points show the location of projects with DCPs reviewed for this study. Since some of the DCPs were developed for a system of projects rather than for an individual project, the green points represent the additional projects covered by the DCPs. The red dots contain the linkage to the summary reports.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Flood risk modelling for Ergene basin

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EXTENDED ABSTRACT

The surface area of Ergene Basin including Edirne, Kirklareli and Tekirdag province is approximately 26400 km^2. Topographic elevations observed at the down land are: Istranca Mountains in the North, the continuing part of the North Anatolian mountain chains and Javas in the south (Ketin 1983). The Ergene Basin has been converted to agricultural lands in lowland areas and to grasslands at higher elevations. Conifer and deciduous forests are restricted to the Istranca Mountains. Ergene Basin has a rainfall area of 10730 km^2 and yearly mean flow is about 28 m^3/s (Ordu and Demir 2007). The lowlands of the Ergene basin are subject to frequent flooding.

On 22th October 2012, excessive rain resulted in flood disaster at Corlu (Ulas). Flood caused not only negative effects on daily routine but also big financial damage. According to the governorship; amounts of rainfalls are 155.6 mm/m^2 for City Centre, 149.2 mm/m^2 for Cerkezköy, 76.6 mm/m^2 for Corlu, 128.5 mm/m^2 for Sarköy. Because of rainfalls, huge damaged occurred in Unilever Food Company (Corlu Factory). In factory, buildings have elevation as 92.2 meter and during the flood, elevation increased till 93.7 m. As a result, all area went down to flood water as about 1.5–1.8 m.

The aim of this study is to analyse the floods caused by the overflow of Ergene Basin nearby Unilever Corlu facilities and determine the possible solutions in order to prevent flooding at the facilities. In this scope, TUFLOW numerical model of SMS (Surface Water Modelling System) software, which is developed by AquaVEO, LLC was used for the various conditions of flood modelling.

In order to decrease the water levels in a possible flood, a number of enhancements in the creek system (bed, bridges and culverts etc.) were modelled and the results evaluated. First of these enhancements is enlarging the culvert flowing under the facility, however the results has shown that this enhancement has limited effect with a drop of 5 cm in the flood levels. As the next enhancement, the river bed is enlarged around the historical bridge, allowing a better flow in the area and minimizing the bridges flow restriction. This enhancement proved to be useful, with approximately 40 cm decrease on the water levels, resulting maximum water level of +94.6 m along the North wall of the facilities. Another enhancement around the historical bridge has shown

that, even though less than the historical bridge, the motorway bridges also have an important flow restriction effect. To evaluate this effect, the bridges spans are increased and connected to the enlarged channel around the historical bridge to provide as smooth flow as possible. This simulation has shown a significant improvement in decreasing the flood levels, 75 cm in total, resulting in maximum water level of +94.25 m along the North wall of the facilities. As the last enhancement, the remediation channel was modelled together with the solutions proposed in this study, at the bridge locations. This scenario, as expected provided the most favourable results decreasing the flood levels down to +92.20 m along the north wall of facility.

The modelling studies conducted for the current topography and basin system has shown that even with flood flows of 10 Years Return Period, the Unilever Facilities are under the risk of flooding, though this flooding is not expected to have a severe effect on the facilities.

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Approach to optimizing sustainable reservoir operation with uncertain inflow

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EXTENDED ABSTRACT

The Tanghe Reservoir is located in the upper basin of the Tang River in China. It is a daily regulated multipurpose reservoir, with a capacity of 707 × 106 m^3 and a drainage area of 1,228 km^2. The Tanghe dam was closed in 1969. Prior to this, little water was withdrawn from the up-stream river and the gauged inflow measured from 1950 to 1969 at the Tanghe gauging station (immediately downstream of the reservoir site) was used to describe the natural flow of the river. The release capability of reservoir is 282 $m^3 s^{-1}$ and the spillway capability is 2713 $m^3 s^{-1}$.

The reservoir is used for flood control as well as domestic and industrial water supply. It provides water for four major water users: the Liaoning Chemical Industry Group, Anshan Domestic Water Supply Company, Liaoyang Domestic Water Supply Company and Gongchan-gling Mine Industry Company. The current planned water supplies for these users are 54.8 × 106, 73 × 106, 36.5 × 106 and 18.3 × 106 m^3 each year, respectively (Yin et al., 2012). The Liaoyang water intake is located downstream of the reservoir, and no tributary exists between the reservoir and the water intake. Anshan Domestic Water Supply Company and Gongchangling Mine In-dustry Company withdraw water directly from the reservoir, while Liaoning Chemical Industry Group and Liaoyang Domestic Water Supply Company withdraw water from the Liaoyang water intake. To simplify computation, water supply was considered as the only operational aim of the reservoir. According to the plan of the reservoir, monthly water demands were fixed for re-cent years.

River inflow plays an important role in the design of reservoir operation. In previous studies, deterministic inflows (e.g., history inflows) are generally used for reservoir operation optimization (Celeste and Billib, 2009; Wang et al., 2011), which can generate suboptimal reservoir operating rules by failing to incorporate the uncertainty of inflow. The resulting operation rules of reservoir may not efficiently balance the various demands of human and environmental flows. To deal with the above problems, this study proposed a new approach to optimize reservoir operation rules.

In order to deal with the uncertain in reservoir operation, stochastic inflows are generated according to the variation of history inflows and adopted as the input of reservoir. Then, two methods including a Noisy Genetic Algorithm (NGA) (Ines and Mohanty, 2008; Yun et al., 2010) and Monte Carlo method (Wu et al., 2005) are employed to deal with stochastic characteristics of inflow. The reservoir operation is designed to maximize the water supply reliability. A four-period environmental flow release model is adopted to protect the downstream ecosystem.

The average of daily inflows in Tanghe reservoir from 1950 to 1969 was analyzed. The methods of linear regression analysis, polynomial fitting method, logarithmic fitting, power fit-ting and index fitting are used in regression analysis of reservoir inflows. It has been obtained that the inflow of Tanghe reservoir raised firstly, and then drew down. The flows totally remained in a relatively stable trend. The results of correlation test didn't show a significant trend. The correlation coefficient (R2) of polynomial form is 0.2181, which is higher than that of other types. However, the polynomial form cannot be used to describe the variation of the in-flow in the series as other stochastic methods. Besides, we calculated the average and Standard deviation of daily inflow

of Tanghe reservoir of 20 years' history inflows. It has been obtained that the average daily inflow was roughly maintained in independent and uniformly distributed as Gaussian distribution. The final optimized results imply that the NGA was a better alternative than Monte Carlo method to deal with the uncertainty of inflow in reservoir operation. Meanwhile, it is observed that water supply reliability based on the stochastic inflow is higher than deterministic inflows in previous studies.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
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Efficiency of Artificial Neural Networks (ANNs) in intelligent estimation of flood hydrograph for Shirindarreh reservoir dam in comparison with Adaptive Neuro–Fuzzy Inference System (ANFIS)

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ABSTRACT: Flood hydrographs are needed for the design of structures and management of dam reservoir. This paper presents the application of Adaptive Neuro–Fuzzy Inference System (ANFIS) and Artificial Neural Networks (ANNs) to flood hydrograph modeling of Shirindarreh reservoir dam in Iran. The results show that the Nash-Sutcliff value of ANFIS model are higher than those of the ANNs model, which indicates that the overall quality of estimation of ANFIS is better than the ANNs model.

1 INTRODUCTION

Due to its essential application to water resources and reservoir dams management, simulating of flood hydrograph into reservoir dams is one the important topics in hydrology. Intelligent computing tools such as Artificial Neural Networks (ANNs) and fuzzy logic approaches have proven to be efficient when these are individually applied to variety of problems. Recently, there has been a growing interest in combining both of those approaches, and as a result, neuro–fuzzy computing technique has evolved. This approach has been tested and evaluated in the field of signal processing and related areas. But researches have only begun evaluating the potential of this hybrid approach to hydrologic modeling studies.

Due to the ability of ANNs and neuro-fuzzy system in modeling complex nonlinear system, successful application of these models in water resource modeling and runoff prediction in catchments of water resource management have been widely reported.

Bazartsern and Hildebrandt (2003) used neuro-fuzzy and neural network models for short-term water level forecasting. Alpaslan et al. (2009) applied the ANNs, Neuro-Fuzzy and SARIMA models to predict the level change in lakes. The models were first trained based on observed data and then used to predict water level changes over the test period. The results indicate that the ANFIS model has a minimum MSE (0.0057) in comparison with others. Cobaner et al. (2009) used the Neuro-Fuzzy and ANNs models namely MLP, RBNN and GRNN to estimate suspended sediment concentration. The daily rainfall, stream flow and suspended concentration data from Mad River catchment in the USA was used as a case study. The comparison results reveal that the Neuro-Fuzzy model performs better than the other models. Aqil et al. (2007) applied the artificial neural networks and neuro-fuzzy models to the daily and hourly behavior of the runoff in the Cilalawi River, Indonesia. Three different adaptive technique were constructed and examined, namely Levenberg-Marquardt feed forward neural network, Baysian regularization feed forward network and neuro-fuzzy. A detailed comparison of the overall performance indicates that the neuro-fuzzy model performed better than others. Mahmut and Mahmud (2007) applied the neuro-fuzzy model to estimate the river flow in the River Great Meanders located in the west of Turkey. Totally

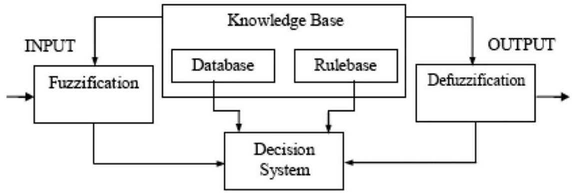

Figure 1. Fuzzy inference system structure.

5844 daily data sets collected in 1985-2000 were used to estimate the river flow. The performance of ANFIS model in training and testing sets was compared with observation and also evaluated. The results indicate that the ANFIS model can be applied successfully and provide high accuracy and reliability to river flow estimation. Aqil et al. (2007) implemented the neuro-fuzzy model to predict the flow from local source in Citarum River basin, Indonesia. They evaluated the potential of neuro-fuzzy systemas an alternative to the traditional statistical regression technique for the purpose of predicting flow from local source in the river basin. The comparison of the prediction accuracy of the neuro-fuzzy and linear regression methods indicates that the neuro-fuzzy approach was more accurate in prediction of river flow dynamics.

This paper presents the application of Adaptive Neuro–Fuzzy Inference System (ANFIS) and Artificial neural networks (ANNs) to flood hydrograph modeling, and it is demonstrated by modeling the flood hydrograph flowing to the Shirindarreh Reservoir dam located in the northern Khorasan Province, Iran.

1.1 *Fundamentals of neuro–fuzzy modeling*

Fuzzy modeling is the application of fuzzy set theory (Zadeh 1965) to the representation of the essential features of a system. The basic principle of fuzzy modeling was stated by Zadeh (1973) as follows: The use of linguistic variables in place of or in addition to numerical variables. The characterization of simple relations between variables by conditional fuzzy statement. The characterization of complex relations by fuzzy algorithms.

Figure 1 show a typical structure of a fuzzy inference system. The computation of a fuzzy inference system (FIS) generally consists of three major steps: (1) fuzzification; (2) inference (or reasoning); and (3) defuzzification. Fuzzification is the first step in the computation of a fuzzy system and it must be performed for each input variable. It is a process of mapping the crisp numbers into fuzzy domain using the membership functions of linguistic variables to compute each term's degree of validity at specific operation point of the process. The result of fuzzification is used as input for the fuzzy inference engine. Inference is the process of obtaining the outputs of a fuzzy system. The rule of inference defines an operational form of a fuzzy model. Several important rules of inference of approximate reasoning have been introduced in the literature. The compositional rule of inference is among the most often used and has many variations such as the max-product rule and max-min rule. The output of a fuzzy algorithm is a fuzzy subset, which is not the crisp number required. The process of retranslating a fuzzy output into a crisp value is termed defuzzification, in which, a defuzzification algorithm (defuzzifier) selects a best crisp value to be the output of the fuzzy system. Defuzzification can be performed using several different methods described in the literature. The most common methods include the mean of maximum and the center of area.

1.2 *Artificial Neural Networks (ANNs)*

AANs are a relatively new nonlinear statistical technique. It can be used to solve problems that are not suitable for conventional statistical methods. A neural network consists of simple synchronous processing elements, called neurons, which are inspired by biological nerve system. The most commonly used neural network structure is the feed forward hierarchical architecture. .Feed forward neural network (FFNN) has a parallel and distributed processing structure. It is composed of three layers: an input layer which is used to present data to the network, an output layer which is used to produce an appropriate response to the given input, and one or more hidden layers, which are used to act as a collection of feature detectors (Luck et al. 2001). The network topology consists of set nodes (neurons) connected by links and usually organized in a number of layers. Each node in a layer receives and processes weighted input from a previous and transmits its output to node in the following layer through links. The connection between ith and jth neuron is characterized by the weight coefficient w_{ij} and the ith neuron by the threshold coefficient. The weight coefficient reflects the degree of importance of the given connection in the network. The neural network used in this study is Multilayer Perceptron (MLP); method is adopted for training of neural network. In general, MLP is trained by error back propagation algorithm, which is one of supervised training method. It is a steepest gradient descent method that changes the weight value toward the direction for reducing the slope of error surface in weight space. Although error back propagation algorithm is a powerful learning algorithm, it has a weak point that cannot proceed with training further when it is entrapped at local minimum at error surface.

1.3 *Neuro – fuzzy system*

Neuro-fuzzy modeling refers to the way of applying various learning techniques developed in the neural network literature to fuzzy modeling or a fuzzy inference system (FIS). Neuro-fuzzy system, which combine neural network and fuzzy logic have recently gained a lot of interest in research and application The ANN provide connectionist structures and learning abilities to the fuzzy systems, whereas the fuzzy systems offer ANN a structure framework with high-level IF-THEN rule thinking reasoning.

The Chosen ANFIS model in this research was designed based on grid partition method. The model was trained with hybrid learning algorithm and gaussian1 membership function.

2 MATERIAL AND METHODS

2.1 *Study area and dataset*

To illustrate the practical application of the ANFIS and ANNs models, Shirindarreh River basin was chosen as the study area. The data derived from the Shirindarreh River basin were employed to train and validate all the models developed in this research. The Shirindarreh River basin is situated from 37°38′ to 38° 0′ north latitude and 57°57′ to 57°06′ east longitude in the northern Khorasan Province, Iran. The annual rainfall ranges from 270 to 300 mm and the temperature varies from 8 to 35°C. The total drainage area of the Shirindarreh River basin is approximately 1612.13 km^2. The hourly flood discharge data of the Brabarqalehhydrometry station were used in this research. Therefore, all the flood events recorded in this station were considered, and from this dataset, 24 flood hydrographs were chosen to train and test the models. The input data are scaled so as to lie in the range of zero to one, since the Membership Functions (MFs) of the ANFIS and transfer function of ANNs models takes values between zero and one.

2.2 *Input parameters selection*

Selecting appropriate input variables is important in a modeling procedure. The parameters required as input variables are the flood discharge values for different intervals. These parameters have a significant influence on the estimated flood discharge. Consequently, the current study analyzed different combinations of antecedent flood discharge values and also the appropriate input vector have been trained and tested. It is notable that the flood hydrograph was estimated 2, 3, 4 and 5 hours earlier using the flood discharges at 2, 3, 4 and 5 previous hours as model inputs respectively.

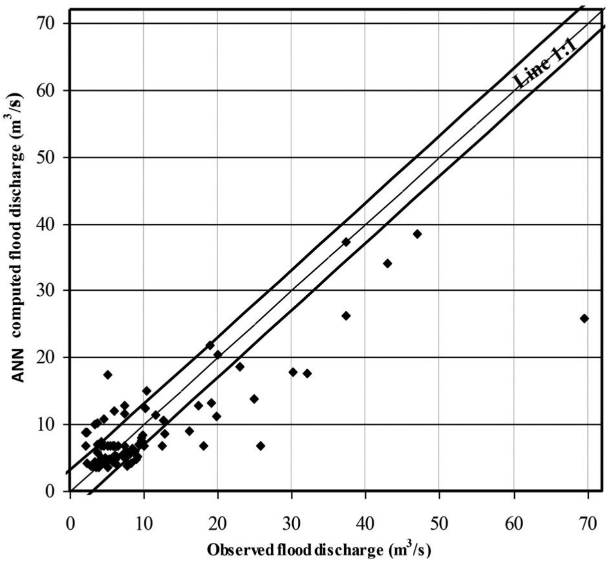

Figure 2. The variation of calculated flood discharge by ANN model against measured data.

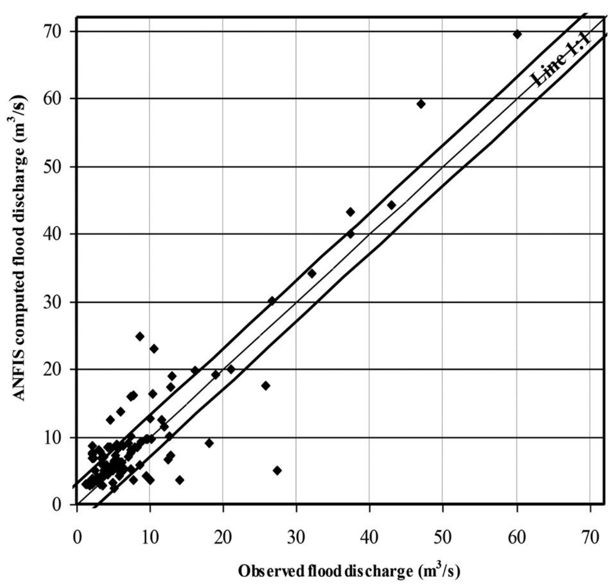

Figure 3. The variation of calculated flood discharge by ANFIS model against measured data.

In fact, in this research flood hydrograph was estimated using the discharge values that occurred at 2, 3, 4 and 5 previous hours as model inputs patterns. Three input signals were designed for each input pattern.

3 RESULTS AND DISCUSSION

Results from two models of AANs and ANFIS are presented in this section to assess and compare the degree of prediction accuracy and generalization capabilities in simulating of flood hydrograph.

Results from simulation of this signal with ANNs and ANFIS models are evaluated based on five statistical indices like R^2, RMSE, Nash-Sutcliff. The Nash-Sutcliff criterion provides an overall assessment of the efficiency of estimation. Models with NASH values close to 0.8 are generally acceptable. The results show that the Nash-Sutcliff value of ANFIS model are higher than those of the ANNs model, which indicates that the overall quality of estimation of ANFIS is better than the ANNs model. A significant improvement is observed for the ANFIS model in the peak flow prediction compared to ANNs model, as is evident from Figures 2 and 3.

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Effects of nitrogen loads from municipal wastewaters on Bothnian Bay coastal waters

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EXTENDED ABSTRACT

1 INTRODUCTION

Municipal wastewaters in Finland are treated with processes that efficiently remove phosphorus and organic matter. Traditionally, nitrogen removal has been considered less important because of the inconsiderable role of nitrogen in primary production especially in the inland waters. Cold temperature of wastewaters also impedes nitrogen removal and makes enhanced nitrogen removal challenging and expensive in Finland. Bothnian Bay, the northern part of the Baltic Sea is known to be phosphorus limited, whereas southern parts of the Baltic Sea are more nitrogen limited. In coastal waters nutrient limitation varies.

Nitrogen removal efficiency at wastewater treatment plants on the Finnish coast of Bothnian Bay varies around 20–40% and only few plants occasionally reach 40% removal efficiency in late summer. If there are no industrial areas, municipal wastewater plants are often locally largest point sources of nitrogen load in the Bothnian Bay coast. However, when there are major rivers nearby, nitrogen load from non-point sources typically exceeds the municipal wastewater load.

In this paper, we study the significance of nitrogen load from municipal wastewater treatment plants in Bothnian Bay coastal waters. A mathematical model was used to study the effect of municipal wastewaters on total nitrogen concentration in the coastal areas. Also, nutrient limitation of the Bothnian Bay coastal waters was studied through nutrient addition experiments. Both the model and nutrient addition experiments are applied in seven different locations in the Bothnian Bay coastal waters receiving municipal wastewaters.

2 METHODOLOGY

The applied mathematical model is based on information on long term average nitrogen loads from different point and diffuse sources. Nitrogen loads (W) from different sources are described by equations which have specific nitrogen response functions in the receiving water body. The modeling area was assumed to be constant in volume. The model also assumed fully mixed flow conditions. Furthermore, all processes of nitrogen cycle were combinedin one term called eigenvalue. The model was based on equation 1 presentedby Chapra (2008)

$$\frac{dc}{dt}+\lambda c=\frac{W(t)}{V} \tag{1}$$

where c = concentration; t = time in days; W = nitrogen load; V = volume of the modeling area; and λ = eigenvalue.

Nitrogen responses for different nitrogen loading sources were derived from equation 1. Altogether the total nitrogen concentration in the modeling area was modeled as a sum of the nitrogen response functions of different nitrogen loading sources. The model was applied for scenarios with varying nitrogen removal efficiency at the municipal wastewater treatment plants. Model results describe long-term mean daily nitrogen concentration in the study areas.

Nutrient addition experiments were conducted under laboratory conditions for water collected from the studied locations. There were eight experimental units in each experiment. Two of the units were manipulated with 80 $\mu g l^{-1}$ ammonium, two with 20 $\mu g l^{-1}$ phosphate and two with both ammonium and phosphate. After nutrient additions all experimental units were incubated for six days under light and temperature conditions simulating those of the sampling sites, temperature ranging from 11–18°C and lights being out 2.5–8.5 hours at night. During the experiment, the units were sampled for chlorophyll and phytoplankton. The experiment was repeated three times during one summer for each study location.

3 RESULTS

The modeling results show that enhanced nitrogen removal from municipal wastewaters could decrease total nitrogen concentrations in the coastal waters. The magnitude of the decrement in different locations is dependent on nitrogen load from other sources than municipal wastewater, volume of the modeling area, water exchange and processes of nitrogen cycle in the modeling area. Compared to the current situation of 20–40% nitrogen removal at the wastewater treatment plants, 60–70% nitrogen removal decreases total nitrogen concentration 10–100 $\mu g l^{-1}$ in the vicinity of the wastewater discharge points in summertime. At its best, this could lead to improved ecological status of the coastal waters. The decrease in the nitrogen concentration however remains quite local. The simplified modeling method naturally leads to some uncertainty in the results.

Results of the first nutrient addition experiments show variation in nutrient limitation in the studied locations. In the northernmost locations, the nutrient additions did not considerably increase chlorophyll concentrations. Contrary, in the southernmost locations, the chlorophyll concentrations increased more and nutrient limitation was more distinct. Besides study location, the magnitude of chlorophyll concentration at the start of the experiments seemed to affect the increase in chlorophyll concentrations, with low concentration at the start of the experiment leading to increase in concentration by the end of the experiment. Phytoplankton analysis showed that few species of phytoplankton, e.g. *Diatoma tenuis* (Agardh) and *Plantkonthrix agardhii* succeeded in resource competition and benefited most from the nutrient additions and experimental conditions. Phytoplankton analyses also usually indicated nutrient limitation even if the chlorophyll concentrations did not. All in all only one nutrient addition experiment showed a clear nitrogen limitation. In most of the experiments both phosphorus and nitrogen appeared to be limiting nutrients.

4 CONCLUSIONS

Results of the study have so far shown that the effects of nitrogen loads from municipal wastewater plants vary in different locations and times. The effects of nitrogen load in a water body are partly dependent on nutrient limitation. The nutrient addition experiments carried out in this study indicated varying nutrient limitation at the study sites, though the short study period is not enough for extrapolating nutrient limitations in long-term. An ecological model would further complement the results of the effects of nitrogen loads from the municipal wastewater treatment plants in the receiving Bothnian Bay coastal waters.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Estimation of nutrient loads at boreal catchments in case of limited availability of observed discharge and concentration data

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EXTENDED ABSTRACT

1 INTRODUCTION

Nutrient load estimation has been an important element in watershed management because it allows for more effective management of land use in order to minimize non-point source pollutant loads. Basic information needed for nutrient load calculations are river discharges and nutrient concentrations, which both are time and space dependent. In most cases, river discharges are readily available because of the relative ease and low cost of stream gauging (Quilbé et al., 2006). But the high cost of measuring nutrient concentration and laboratory analysis associated with it makes monitoring of concentrations difficult (Wang et al., 2011). Most studies on estimation of nutrient loads have dealt with cases where continuous discharge data over long period are available while concentrations are measured less frequent. Contrary, not much have been done in the case where both discharge and concentration data are measured less frequently as in the case of this study.

This study investigates methods that could be applied where both discharge and concentration data are measured less frequently. Conceptual hydrological model (HBV) were employed in catchments adjacent to the study catchment in order to investigate regionalization of model parameters. This parameters will then be applied in the study catchment to simulate discharge which will then enable for nutrient load estimation.

2 OBJECTIVES AND NATURE OF THE STUDY

Objectives of the study is to i) establish methods that can be used to model river discharges in situations where there is limited measurement of discharge and also to ii) evaluated different methods for load estimation. Further, iii) to determine their application in boreal environment given the cold climate conditions and typical land cover such as peatlands.

The study is still in early stage. In first stage, we use hydrological conceptual model, HBV-Light, for flow estimations. The HBV model is calibrated with catchments close to the study site where discharge measurements are available, and in order to investigate regionalization of the model parameters. In the next step, regionalized parameters will be applied in the study sites to simulate discharge from the study catchments including uncertainty analysis. This is further used for estimation of nutrient loads from the catchments against measured nutrient concentrations. Different methods of load estimation as highlighted by Li et al. (2003) and Wang et al. (2011) will be employed in estimating annual loads from the catchments.

3 PRELIMINARY RESULTS

The study site is located in Northern Finland and it encompasses the whole watersheds of Ala-Kitka, Yli-Kitka and Posio Lakes with 38 sub-catchments ($>5\,km^2$) discharging into the lakes.

Table 1. Parameter variation between the catchments for the calibration periods of 1998–2002 and 2003–2007.

Parameter	Min.	Max.	Avg.	STD.
CFMAX (mm/d°C)	1.2	2.0	2.0	0.35
SCF (−)	1.15	1.15	1.15	0.0
FC (mm)	60.0	290.0	154.38	92.65
LP (−)	0.7	1.0	0.94	0.10
BETA (−)	1.0	1.7	1.29	0.31
PERC (mm/d)	0.15	0.9	0.62	0.32
UZL (mm)	10.0	40.0	26.88	10.88
K_0 (1/d)	0.2	0.6	0.31	0.17
K_1 (1/d)	0.1	0.18	0.16	0.04
K_2 (1/d)	0.006	0.008	0.008	0.001

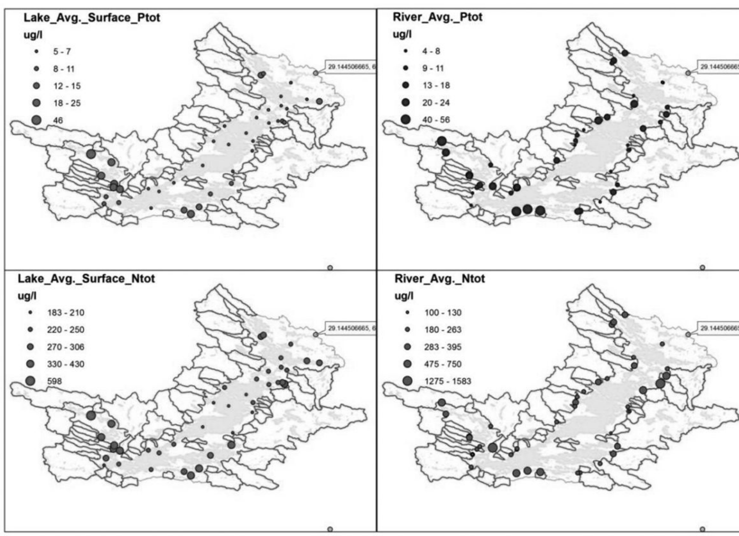

Figure 1. Average $P_{Tot.}$ and $N_{Tot.}$ concentrations in the lake and rivers discharge points.

Concentration samples are collected from each of the 38 sub-catchments discharging into the lakes at defined intervals with four of the catchments being monitored twice a week. The concentrations of nutrients from samples collected so far are shown in Figure 1. From four catchments analysed so far with HBV model, each parameter exhibits some degree of uncertainties, but the snow routine parameters appears to be well identified across the catchments while the soil routine parameters appears to have more uncertainties as they varied considerable across the catchments (Table 1). More studies will be done to investigate the correlation between the soil routine parameters and catchment attributes.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Implementation of DRASTIC method on a coastal lagoon watershed for planning purposes

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EXTENDED ABSTRACT

Drivers such as climate change, population growth and human activities put high pressure on water resources both in quantity and quality. Response of groundwater to these impacts are slower with respect to surface waters. It is expected that dependency on groundwater in terms of meeting the demands in semi-arid regions will increase in the future. Besides, remediation of the contaminated resources are prohibitively costly and often impractical (Thirumalaivasan et al. 2003) so, proper management of groundwater are of great importance.

Groundwater vulnerability has been defined as "an intrinsic property of a groundwater system that depends on the sensitivity of that system to human and/or natural impacts" (Vrba and Zaporotec, 1994), whereas its mapping is a tool for quantifying the sensitivity of the resource to its environment, and is based on the idea that some land areas are more vulnerable to groundwater contamination than others (Gogu and Dassargues 2000).

Dalyan region that drains into a complex estuarine lagoon system is located at the southwest of Turkey on the Mediterranean Sea coast (Fig. 1). The case study area is under the Mediterranean

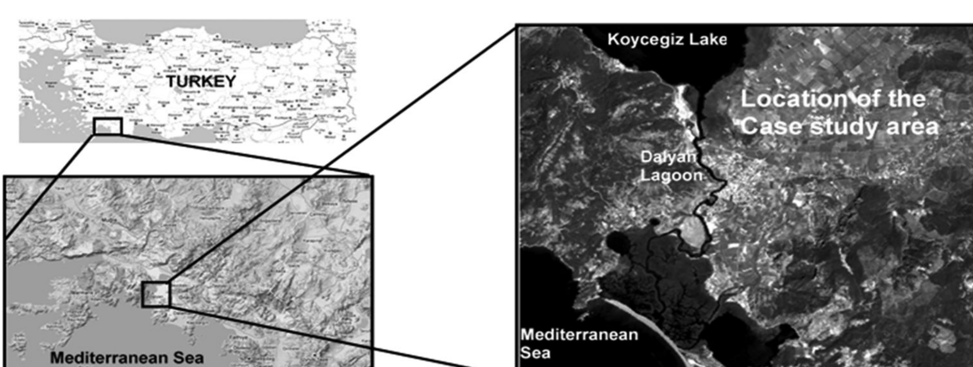

Figure 1. The case study area.

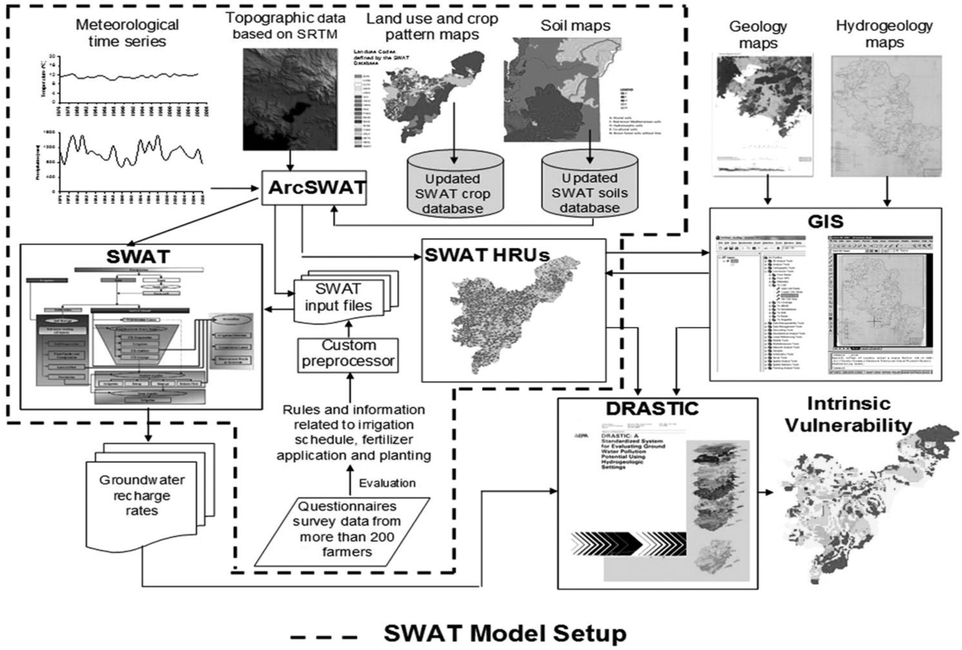

Figure 2. Procedure for vulnerability map generation.

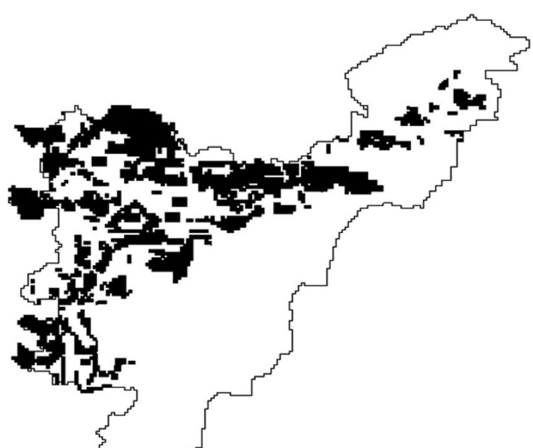

Figure 3. Sites with high priority for groundwater pollution measures.

climate. Since the lagoon's water is brackish to saline, it is not used for irrigation so that groundwater is the main source for water supply and irrigation in the case study area and an important freshwater source for the lagoon.

Since the lagoon and its watershed are within an environmental special protection area, planning the measures against water pollution, including the groundwater pollution, is crucial. In this study, we report the generation of an intrinsic groundwater vulnerability map and its assessment utilizing the DRASTIC method. Since the DRASTIC method requires recharge rates for the calculation of groundwater pollution potential index, these were obtained from hydrological simulations, where SWAT model was used. The entire procedure for generating the intrinsinc vulnerability map is illustrated by Figure 2. Further details are given by Erturk et al (2014a) and (2014b).

Once the intrinsic vulnerability maps were generated, they were overlaid with current land use maps to evaluate the groundwater pollution risk at current situation. Our analyses have shown that 46% of the case study area is under high risk of groundwater pollution and 62% of agricultural areas are located on these vulnerable high risk areas where we suggest priority for precautions against groundwater pollution (Fig. 3).

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Section 4: Decision support tools

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Drinking water protection studies in Turkey

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ABSTRACT: The most important usage area of freshwater resources is the one for drinking purposes. Although freshwater resources have enormous value for human life, they are under severe threat throughout the world due to pollution, unsustainable use, climate change and many other effects. In order to protect drinking water sources, it is a necessity to reduce erosion, control settlements and human activities around drinking water basins, take measures for point and diffuse pollution sources and prepare legal structure in line with European Union water legislation. Turkey makes many efforts on this issue. In this framework, this paper reviews drinking water protection issues in Turkey in terms of the existing institutional structure and legal framework. It also examines the details of drinking water protection studies which are conducted by the Ministry of Forestry and Water Affairs.

1 INTRODUCTION

Freshwater resources such as lakes, rivers, and groundwater aquifers are vital for the development and existence of human society. However, freshwater is a scarce commodity in view of the fact that only one percent of all water on earth is available for human consumption (WWF 2002). Nevertheless, the demand on the water supply has dramatically increased over the past few decades due to population growth, high urbanization level, rapid industrialization, and water-intensive agricultural activities. Additionally, climate change has impacted the availability of water in a negative way. On the other hand, water overuse and abuse have led to the condition of imbalance between water availability and water demand. In addition to the issue of water availability, freshwater ecosystems are under severe threat throughout the world due to pressure of human activities on land and water resources such as inadequate treatment of domestic sewage, insufficient controls on the discharge of industrial wastewater and the indiscriminate use of fertilizers and pesticides in agricultural activities. The issues related to water quantity and quality result in water problems in several parts of the world (Al Radif 1999; TWAS 2002). Over 780 million people in the world have limited access to safe drinking water and 2.5 billion lack improved sanitation. Moreover, deterioration of water quality brings about waterborne diseases resulting in the death of more than three million people each year (Prüss-Üstün et al 2008; WHO and UNICEF 2010). In this regard, wise use and protection of water resources have become essential in order to ensure that future generations will have access to affordable and safe drinking water. As a result, the sustainable use and effective management of water resources have become one of most compelling environmental challenges faced by policy-makers today.

In Turkey, the effective management of water resources has become more of an issue as well since it is situated in Middle East Region where water shortage has become a crucial problem. Although there is a general perception that Turkey is more advantageous in terms of water potential by comparison with other countries in the region, the scientific studies reveal the reverse situation. For the last two decades, annual water amount per capita in Turkey has decreased from 4000 m^3 to 1430 m^3. Based upon the renewable water resources potential and population projections, it is predicted that this number will decrease about 1000 m^3 and Turkey will become a water-poor country beyond 2030 (TÜSİAD 2008; Ardıçlıoğlu et al. 2011). In order to avoid this situation, there

Table 1. An overview of responsibilities of public institutions in drinking water management.

Institution	Main tasks and responsibilities
Ministry of Forestry and Water Affairs • General Directorate of Water Management	– To develop policies for protection and sustainable use of drinking water resources, and to monitor policy implementations – To conduct special provision determination studies for drinking water resources
Ministry of Forestry and Water Affairs • General Directorate of State Hydraulic Works	– To plan, execute and operate water resources – To supply drinking water to settlements of more than 100.000 population – To construct dams, water storages, main transmission lines, drinking water treatment plants and pump stations for domestic water supply – To perform studies for investigation, conservation and utilization of ground water as well as to allocate and register them
Ministry of Environment and Urbanization	– To identify principles and procedures for the protection of surface and ground water, and the prevention, removal and control of water pollution – To conduct monitoring and inspection studies for wastewater discharges
Ministry of Health	– To control, analyze and monitor physical, chemical and microbiological quality standards of drinking water
Bank of Provinces	– To plan and finance infrastructure systems including water distribution networks, water treatment plants, sewerage systems and wastewater treatment plants of urban settlements
Greater Municipalities • General Directorates of Water and Sewerage Administration	– To control the discharge of industrial waste water – To conduct water supply and sewerage services – To establish, operate, and maintain facilities for the water distribution, water and wastewater treatment
Municipalities	– To manage some water infrastructure systems such as drinking water distribution networks, sewerage systems, water and wastewater treatment plants
Special Provincial Administrations	– To supply drinking water and sewage system to settlements of less than 30.000 population

is an increasing awareness of the need for better protection and rational use of the water resources in Turkey.

Considering the importance of ensuring safe and clean drinking water, Turkey places special emphasis on maintaining and improving drinking water quality. In order to conserve the drinking water basins, many protection studies are conducted besides taking legal measures.

2 INSTITUTIONAL STRUCTURE

Article No. 168 of Turkish Constitution on "Exploration and Management of Natural Wealthand Resources" indicates that natural wealth and resources are under the State's authority and possession and that the right to explore and manage them belongs to the State. According to this Article, the management, protection, utilization, and supply of water resources is under the rule and disposal of the State. In this context, activities related to water supply and protection are managed through a wide variety of public institutions and organizations in Turkey. These institutions perform activities within the framework of their institutional responsibilities.

Ministry of Forestry and Water Affairs is defined as the main competent authority for Turkey's overall water resources management. In this role the Ministry has conducted studies related to the development of short, medium and long-term policies for protection and sustainable use of drinking water resources and the monitoring of policy implementations.

Apart from Ministry of Forestry and Water Affairs, other public institutions also have responsibilities about drinking water resources.

3 LEGAL FRAMEWORK

In Turkey since the 1920s a great many laws and regulations have been adopted by competent public bodies in order to protect water resources and prevent environmental pollution. Additionally, Turkey has signed several international conventions, agreements and declarations related to water issues, which have a binding force on Turkish Legislation System.

The process of Turkish water related national legislation can be discussed under three periods according to implemented approaches. In the first period covering first thirty years of Turkish Republic, framework laws related to water were enacted with the intent of putting water management onto legal grounds. The construction of individual projects and taking measures to protect public health were the determining priorities of this period. In the second period continuing from mid-1950s to the first half of the 1980s, the systematic development of water resources had gained a priority. Until 1980s, a water management oriented approach had been adopted and an ultimate attention had been paid to optimum use of water resources and public good. In the third period starting from first half of 1980s, the issue of water quality was gradually brought to the agenda because of a serious increase in water pollution in parallel with rapid urbanization and industrialization. In addition to the water quality issue, nature protection and sustainability concepts came into prominence with the impact of the Brundtland Report. Therefore, since this period, these concepts have been watched over during the preparation of the laws and regulations in order to provide a balance between development and protection. The ongoing European Union access and harmonization process also has an undeniable effect on this perception change in Turkish legal framework (ORSAM 2012).

Specific to drinking water sources and basins, several laws and regulations have came into force with the aim of defining principles not only for protecting, improving, controlling and monitoring them but also for enabling their sustainable use. National legislation of Turkey related to drinking water can be examined within four groups.

3.1 *Legislation related to protection and improvement of water resources*

"The Organization and Duties of the Ministry of Forestry and Water Affairs Statutory Decree, No.645" was published in 2011 with the aim of determining the organization, duties, authorities and responsibilities of the Ministry of Forestry and Water Affairs. One of the main duties of the Ministry is defined as policy-making regarding protection and sustainable utilization of water resources, and coordinating national water management. According to this Statutory Decree, General Directorate of Water Management is established in order to conduct the water-related studies including drinking water protection ones.

Based on its tasks and responsibilities, General Directorate of Water Management approved and adopted "Regulation on Protection of Basins and Preparation of Management Plans". The aim of this Regulation is the determination of procedures and principles for planning and protection of quantity and quality of groundwater and surface water in a holistic approach. The Regulation also includes principles of preparation of river basin management plans. Furthermore, it is stated that basin management committees will be established in each basin for providing the coordination and participation of stakeholders. These committees will have active role in preparation, implementation and monitoring of drinking water protection studies.

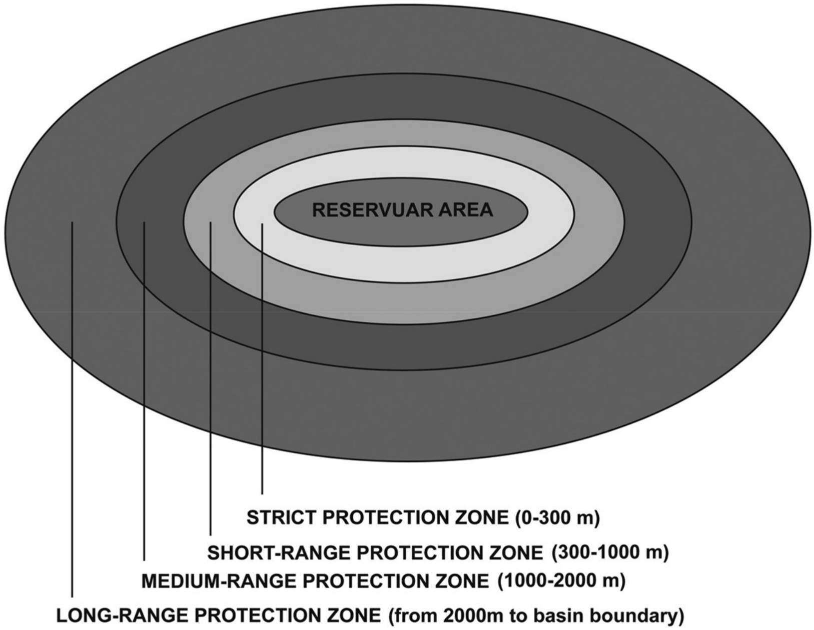

Figure 1. Protection zones determined in water pollution control regulation.

Additionally, "Regulation on Protection of Groundwater Against Pollution and Deterioration" was enacted by General Directorate of Water Management in order to determine principles for the management of groundwater quality and quantity, and to meet European Union's requirements related to groundwater. The enactment and implementation of such a regulation is crucial since groundwaters are notable drinking water sources for the regions of Turkey where surface water is limited.

3.2 *Legislation related to protection and planning of drinking water resources*

The basic framework within the Turkish Legal System regarding the protection of water resources is the "Water Pollution Control Regulation". The aim of this Regulation is to define technical and legal principles for preventing water pollution, protecting the potential of surface and ground water resources and ensuring their optimized use in harmony with the economic and social development objectives. The Regulation covers planning principles and prohibitions regarding the protection of water quality, wastewater discharge and treatment principles, and monitoring principles. Furthermore, it prescribes protection zones and land use strategies specific for reservoirs and lakes used for drinking water. Considering overall water quality and quantity related risks and the required level of water resource protection, four different protection zones (strict protection zone, short-range protection zone, medium-range protection zone and long-range protection zone) and obligatory measures for each zone are determined in the Regulation (Fig. 1). These general provisions and protection zones are in force for all drinking water reservoirs and lakes until special provisions are made for each drinking water source and its basin.

The studies regarding special provision determination are conducted for the basins where the water quality worsens although the provisions of the Water Pollution Control Regulation are implemented or where these provisions could not be implemented properly. In order to determine procedures and principles for these kinds of studies, "Communiqué on Procedures and Principles for of Special Provision Determination Studies in Basins" was published in 2009.

Another legal arrangement regarding the protection and planning of drinking water resources is "Law on the Establishment and Duties of General Directorate of Istanbul Water and Sewerage Administration, No. 2560". In this Law, it is stated that the purpose of the establishment of General Directorate of Istanbul Water and Sewerage Administration is the conduct of water supply and sewerage services, and establishment and operation of all necessary facilities for these services. Added to this Law in 1986, the Supplementary Item 6, enabled other greater municipalities to implement this Law in their metropolitan special districts. Depending on the powers specified in the Law, "Basin Protection Regulations" have been entered into force by Water and Sewerage Administrations in order to protect drinking water basins against pollution and deterioration.

Besides all these legal arrangements, General Directorate of Water Management has conducted preparatory studies for "Regulation on Protection of Drinking Water Basins" with the aim of bringing all provisions regarding drinking water under a single regulation and so reducing the problems in the implementation process.

3.3 *Legislation related to determination of quality and suitable treatment type for drinking water source*

"Regulation on Quality of Surface Waters Used or Planned to Use for Drinking Water Supply" is revised depending on Organization and Duties of the Ministry of Forestry and Water Affairs Statutory Decree, and it has been harmonized with the EU Surface Water Directive. The aim of the Regulation is to determine quality criteria and treatment principles for surface waters used or planned to use for drinking water supply. Article 7 of the Regulation put the need for the preparation of drinking water basin protection plans in order to improve water quality and to protect the water sources from pollutants.

3.4 *Legislation related to monitoring and control of tap water quality*

"Regulation on Water Intended for Human Consumption" is adopted depending on Public Sanitation Law and Law on Manufacturing, Consumption and Controlling of Foods. It was enacted by the Ministry of Health in order to define technical and legal principles of sanitary quality standards for water resources used for human consumption and of standards for production, packaging, manufacturing, selling and controlling of spring waters and drinking waters. The Regulation prescribes protection zones for spring waters in order to prevent pollution and protect the water quality.

4 DRINKING WATER PROTECTION STUDIES

As discussed earlier, Water Pollution Control Regulation defines general provisions and protection zones which are in force for all drinking water reservoirs and lakes. However, the implementation of these provisions and protection zones for all drinking water resources without considering different characteristics of these sources leads to serious problems. In order to prevent such problems, studies related to special provision determination have been conducted by Ministry of Forestry and Water Affairs with a broad participation of non-governmental organizations, local governments and local people. As for the water sources which are used for fulfilling the drinking water needs of greater municipalities, these studies can be conducted by water and sewerage administrations in close cooperation with Ministry of Forestry and Water Affairs. Although there is a need for conducting this type of study for each drinking water source and its basin, priority is given to the basins where the water quality worsen seven though the provisions of the Water Pollution Control Regulation are implemented or where these provisions could not be implemented properly.

Special provision determination studies propose to determine the most appropriate land use and protection zones for each drinking water basin through evaluation of technical and physical characteristics of the basin with the aim of not only protecting and improving the existing water quality but also pursuing the necessary balance between protection and utilization of the drinking water resource and its basin. For the drinking water basins where special provision determination studies are completed, the provisions and protection zones specified in the study become valid instead of the ones in Water Pollution Control Regulation.

In the scope of special provision determination studies, firstly, socio-economic, demographic, hydrological, hydrogeological, geological and geomorphologic structures, and existing land use are determined in order to present the current situation of the basin. As a second step, point and diffuse pollution sources are evaluated, and a new programme of monitoring is started. The water quality monitoring stations are localized in such a way that they perfectly represent the water quality of receiving environment and reservoir. Through the analysis results of samples taken from water quality monitoring stations and the outcomes of all the water quality studies, water quality is identified. Modeling is the third step of the study. By using a mathematical water quality model, the alternatives are produced for basin protection plan, and the expected impacts of different scenarios on water quality are calculated. Based on the calculations, finally, a basin protection plan is prepared in a way to include land use proposals and environmental protection measures which enable the protection and improvement of existing water quality. Additionally, special provisions and protection zones are specified in accordance with the basin protection plan.

The specified plan, provisions and protection zones are announced at basin level in order to inform stakeholders and receive their opinion. At the end of the announcement process, special provisions are arranged and finalized by taking into consideration the feedback from the stakeholders. Final form of special provisions enters into force after ministerial approval and publication in a local newspaper. In order to raise the efficiency in implementation of special provisions, they are integrated into related environmental and zoning plans. The provisions are implemented by water-user administration, and the implementations are monitored within the frame of basin protection implementation program. Reports on implementations are presented to Ministry of Forestry and Water Affairs annually.

In this framework, the special provisions have been determined for five drinking water basins up to the present and studies are still continuing for other six basins. The studies are listed below in chronological order:

- Kartalkaya Dam/Ceyhan River Basin (2009)
- Gökçe Dam/Marmara River Basin (2009)
- Eğirdir Lake/Antalya River Basin (2012)
- Porsuk Dam/Sakarya River Basin (2013)
- Atatürk Dam/Euphrates-Tigris River Basin (2013)
- Beyşehir Lake/Konya Closed Basin, Karacaören Dam/Antalya River Basin, Yuvacık Dam, Akçay Dam, Namazgah Dam/ Marmara River Basin, Sapanca Lake/Sakarya River Basin (continued)

In all of the above-mentioned studies, particular attention is paid to sustainable development approach and stakeholder participation. These studies aim at not only protecting water resources from deterioration but also ensuring sustainable water use in line with socio-economic development objectives. Additionally, stakeholder participation is defined as an indispensable principle of the studies since Turkey recognized that it is essential to establish a consensus on what is the suitable balance between environmental and economic objectives in order to achieve consistency in plan decisions. In the preparation and implementation processes of the studies, governmental institutions and non-governmental organizations work in close cooperation and local people are informed about the projects.

In view of such information, it would not be wrong to state that special provision determination studies are an effective approach to solve the dilemmas about development and natural conservation balance for drinking water basins.

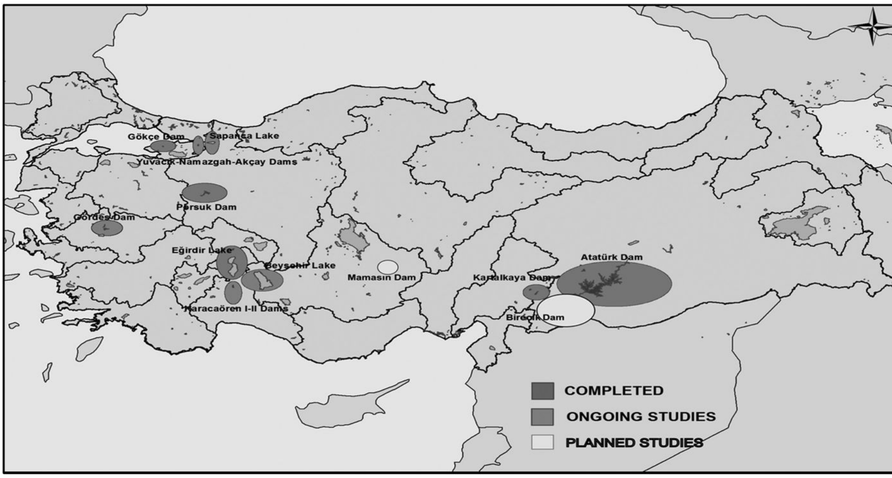

Figure 2. Studies of special provision determination in Turkey.

5 CONCLUSION

In recent years, freshwater resources have gained more significance throughout the world than ever because they are under severe threat due to unplanned urbanization, rapid industrialization, water-intensive agricultural activities and global warming. In this regard, it is crucial to find a way for the sustainable use and effective management of water resources in order to ensure that future generations have access to affordable and safe water.

Since Turkey is located in a semi-arid region, the necessity for wise use and better protection of water resources becomes more apparent (Fig. 2). Recognizing this necessity, Turkey has attempted various efforts on the harmonization of legislation, the reorganization of institutional structure, the definition of management models for treatment and disposal, and the preparation of river basin management plans.

Moreover, Turkey attaches particular importance to drinking water resources. In order to maintain and improve drinking water quality, many laws and regulations have been adopted specific to drinking water sources and basins. In addition to legal measures, many drinking water protection studies are conducted in basins where the water quality is worsening. These studies contribute to solving the issues related to development and natural conservation. Additionally, they will be of capital importance for the preparation process of river basin management plans in terms of providing input since the measures for the protection and improvement of drinking water resources are set in the Water Framework Directive as one of the important measures specified within river basin management plans. Although these plans are not realized at river basin scale, they serve as a model for implementation of an integrated and holistic planning approach in water-related planning activities. All these studies have a sustainability-oriented and participatory characteristic. Ensuring the 'sustainability' of local economic activities within the frame of protection and utilization balance is the main aim of these studies. 'Active participation' and 'capacity-building activities' are other strongly emphasized issues throughout the planning and implementation processes. In other words, these studies have acquired remarkable achievements in terms of increasing the awareness and capacity of local people and decision makers related to problems and management of planning areas, stakeholder participation in management and planning processes, and ensuring inter-sectorial coordination and cooperation.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Management of river basins by remote sensing and GIS: Küçük Menderes basin

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ABSTRACT: Water providing the rise or fall of civilizations over history known is one of the crucial compounds for human life. Protection of water resources used in domestic, agricultural and industrial purposes is still one of the main challenges for the governments as well as non-governmental organizations. Managing safe drinking water as watershed will ensure the sustainable national development. This study focused on Küçük Menderes basin which has been under stress in recent times due to human activities inland. Geographic Information Systems (GIS) technology stands as a productive tool for watershed management by means of remotely sensed satellite imagery analyzing and manipulating watershed data. Integrated GIS and remote sensing technique which analyze watershed characteristics, human settlement, forest cover, land use classification enhances basin's ecosystem. The main aim of this study is to create a frame for national watershed management plan applying remote sensing and GIS on a local area.

1 INTRODUCTION

Today's world with increasing population, scarcity of available resources and heavy industrialization create an unbearable stress on the present water sources which was formed by hydrological processes in million years. On the contrary to thought, water is not a limitless resource. Humanity will face irreversible, severe problems unless water is managed properly and efficiently.

Watersheds are comprised of multifunction landscapes and include various but interrelated agricultural and nonagricultural land units, drainage basins, and streams. A wide spectrum of hydrological processes interact with different spatial scales of type of soil and use of land, leads to landscapes consisting of areas that have a potential to intercept, generate or treat pollutants.

At the present day, technology helps to monitor and manage watersheds with two important branches: GIS and remote sensing. Remote sensing was used for the analysis of the land use conditions and the classification of the watersheds. This involved interpretation from aerial photographs as well as digital image processing of high resolution satellite data, namely Landsat images in 2006 at a scale of 1:100.000. Geographic Information Systems was used first to prepare maps representing. Watershed characteristics data were compiled and updated. These collected data were integrated into GIS environment. Then a data base model was designed for ArcGIS program which is a platform for visualizing, managing, creating and analyzing solutions through the application of geographic knowledge and GIS software.

The main objective of watershed management is to protect the environment with taking full advantage of the watershed in economic, social and aesthetic aspects. Every watershed is unique, and this uniqueness should be identified and considered in the planning, developing and implementing phases of a watershed management plan.

The present circumstances and assignment of water resources should be investigated for further management considering the watershed data. Current environmental infrastructure of region has to be taken into account like waste and sewage treatment plants. Moreover, pollutant loads and water quality of regions should be known for better analysis. All these steps summarized in Figure 1, will

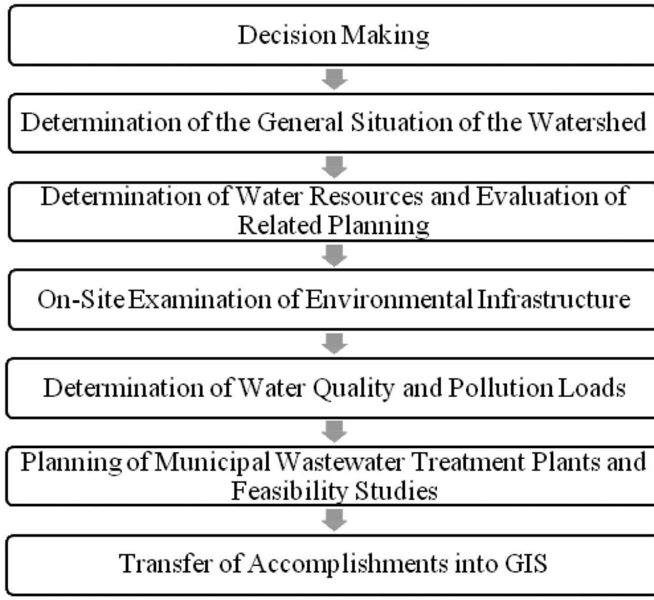

Figure 1. Watershed management steps.

provide us to construct a GIS frame for our region and help deciding about future of watersheds according to safe drinking water. All these data will be used for modeling and decision making thanks to GIS base. Lastly, short, medium and long term planning will be made considering priorities, technological and economic feasibility and sustainability.

As a brief, watershed management can be defined as the implementation of a set of resource management practices with the objective of guaranteeing water quality while ensuring the ecosystem's sustainability.

2 METHODOLOGY

Growing water needs with an increasing population, problems associated with scarcity of water resources, overconsumption and pollution of water in parallel to developing agricultural and industrial activities raised the significance of water resources management on watershed foundation in Turkey. Decision makers were focused on watershed management to find effective ways to resolve water problems. In year 2004, Water Pollution Control Act published in 2004 in Official Gazette with an issue number of 25687. In year 2009, TÜBİTAK (The Scientific and Technological Research Council of Turkey) Marmara Research Center and formerly The Ministry of Environment Forestry- General Directorate of Environmental Management, now The Ministry of Forestry and Water Affairs conduct a project entitled by "Preparation of Watershed Protection Actions Plans for 11 Watersheds in Turkey". These action-projects were aimed to be utilized in planning watersheds. These planning reports are pathfinder for constructing natural watershed management plan. With 29/6/2011 date and 645 number law General Directorate of Water Management which is authority for watershed management was founded. Today, General Directorate of Water Management studying on project named as River Watershed Management Plans.

For constructing management plans, the following factors have to be determined: Environmental pressures, water resources, environmental infrastructure, water quality and pollution loads. Besides, watershed settlement places, population, geographical and meteorological characteristics, agriculture and industry properties, mine, water sources data play key role for describing general

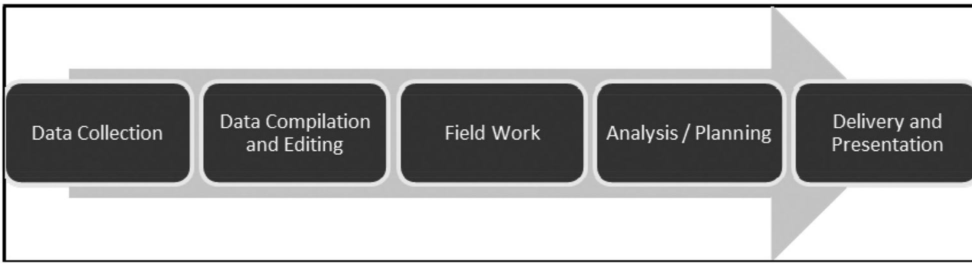

Figure 2. Steps of GIS studies.

Table 1. Authorized institutions.

Data Type	Authorized Institution
Settlement	TÜİK (Turkish Statistical Institute)
Meteorology	General Directorate Of Meteorology
Agriculture	Ministry Of Food, Agriculture And Livestock
Industry	Ministry Of Science, Industry And Technology
Mine	Ministry Of Science, Industry And Technology
Water Resources	DSİ (State Hydraulic Works)
Population	TÜİK

features of basins (or watersheds) which are crucial for the watershed management. Data were obtained from state institutes which are shown in Table 1.

As an indispensable tool for information and decision-making, GIS technology is the most essential tool for Watershed Management in Küçük Menderes Basin.

As shown in Figure 2. steps of GIS studies are summarized and explained below.

Data collection: Geographical data in the boundaries of watershed like rivers, lakes, dams, etc. were collected and digitalized.

Data compilation and editing: Collected data were re-compiled and arranged according to current settlement data, province and district boundaries.

Field work: Waste water treatment plants, solid waste disposal facilities and discharge points were visited and information was processed into collected data.

Creating data layers: Data model which rules data layers and interrelation between each other was designed for ArcGIS. In GIS environment, geodatabase was created and all collected data were integrated to system.

- Created main data layers are,
- Settlements
- Domestic waste water treatment plants
- Industrial waste water treatment plants
- Solid waste disposal facilities
- Discharge points

Analysis / Planning: After data collection, compiled and creating data layer, for defining waste water treatment plants and collectors location three different scenarios was created. The most cost effective project is depicted in Figure 6.

Delivery /Presentation: All data generated for watershed were organized according to circular of geographical information system.

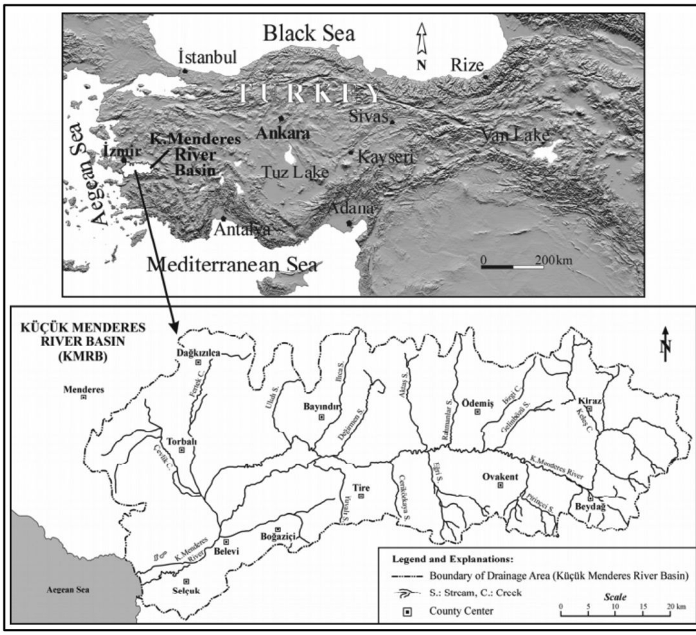

Figure 3. Küçük Menderes basin map.

Table 2. Provinces situated on the watershed and distribution in the basin.

Provinces	Total Area (ha)	Provinces Within The Basin Area (ha)	Part Of Province Into Basin Area (ha)	Distributions of Provinces Acc. To Basin (%)
İzmir	1.197.300	668.858	56	95
Aydın	158.200	25.929	16	4
Manisa	1.381.000	5.658	0,8	1

3 STUDY AREA

The Ministry of Forest and Water Affairs focused on 4 basins among 25 basins in Turkey which are at critical levels according to pollution. One of them is Küçük Menderes basin which involves İzmir, the 3rd biggest city of Turkey.

The investigated area, which represents the Küçük Menderes valley, occupies a considerable area of about 400 km^2 in the western part of Turkey. It is located between 37°55 and 38°25 N latitudes and between 27° 15 and 27° 47 E longitudes, representing the study area shown in Figure 3. By the way, geographic structure of the basin was provided from "MATRA, Strengthening the Capacity of Sustainable Groundwater Management" project. For the implementation of the Groundwater Directive (80/68/EEC) and its revision (2006/118/EC) supply supports to the MATRA project.

Nearly 3.5 million people are living in region and it is estimated that population will become over 5 million at year 2040. Settlement data of cities were provided from TÜİK that given Table 2.

The core element of the basin is water resources. There are present data on potential of surface and groundwater resources. Çevlik, DeveÇukuru, Keleº, Kemer, Kervan, Koca, Manda, Rahmanlar, Menderes, Tahtalı, Uladı, Fetrek (Viþneli), Yassı, Boğaz, Çay (DeğirmenDere), Değirmen,Döºeme, Gök, Ilıca, Kızılkaya, Koca, Fetrek (Vişneli), Aktaş are the streams and Küçük Menderes is the main river of basin. According to the data received from DSİ about river's characteristics, drainage area is 3.225 km^2, length is 129 km, total flow is 11,45 m^3/h, average water potential is 361 hm^3/year,

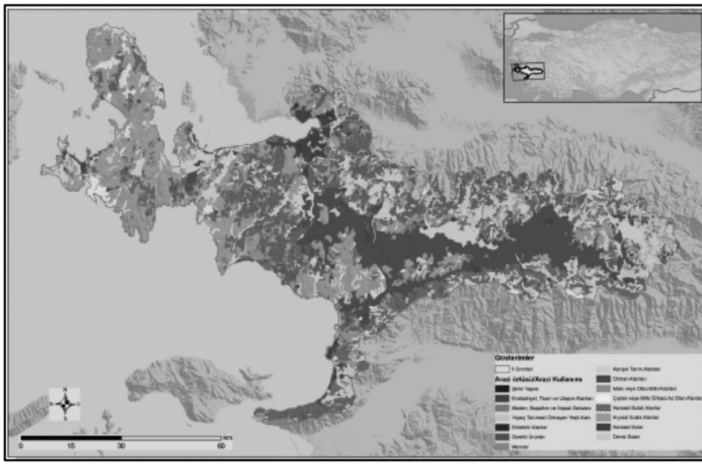

Figure 4. Küçük Menderes basin land use map.

and average rainfall is 622 mm/year. Names and areas of lakes in the basin are Belevi Lake and 140.687 m^2, Gölcük Lake and 7.206 m^2, Gebekirse Lake and 628.958 m^2 and Çağal Lake and 601.075 m^2.

4 RESULTS AND DISCUSSIONS

While human impact on the basin has intensified, the need for more rapid detection of rapid changes in land use has emerged. Considering a combination of ecological and economic development decisions, rational use of resources create the need for more rapid detection of rapid changes in land use. Küçük Menderes basin has a portion of the country's most fertile soil. In terms of product quality and product yield it has a high agricultural potential. The distribution of land use in the basin determined according to the "CORINE (Coordination of Information on the Environment)" classification with using Landsat satellite images in 2006 shown in Figure 4. CORINE is an important project within the scope of The EU (European Union), GMES (Global Monitoring for the Environment and Security) program. According to the CORINE, the distribution of land use in the basin is 41% of the agricultural, 52% of the forest and semi-natural area, 1% of water surfaces and 6% of other areas (city, transportation, mine, dumping mine).

Considering the water requirement in the watershed, reuse of treated wastewater was evaluated. In İzmir, a large part of the basin, 65% of the drinking water needs are met from ground water while 35% of the one need is met from surface waters. Sarıkız, Göksu, Menemen and Halkapınar wells constitute the majority of the water resources of İzmir. In the summer of 2008 amount of arsenic in drinking water was more than 10 microgram/L which was the limit value in TS 266 (Water Intended for Human Consumption Standard). The reason for exceeding the arsenic limit value for drinking water is drought in recent years and geological formations depending on decrease in the level of underground water. To solve the problem of arsenic, treatment plants were designed for groundwater from wells. The increasing problem of arsenic was decreased with the help of abundant rainfall and raise in groundwater and surface waters.

All municipalities regardless of the population, villages with population, organized industrial areas, other noteworthy pollution sources which discharge into receiving water resources, working and abandoned solid waste disposal sites were visited and the present infrastructure was investigated on-site.In this regard, the present situation of the municipal wastewater treatment plants, coordinates of the related places were recorded and wastewater treatment plants of individual industries and

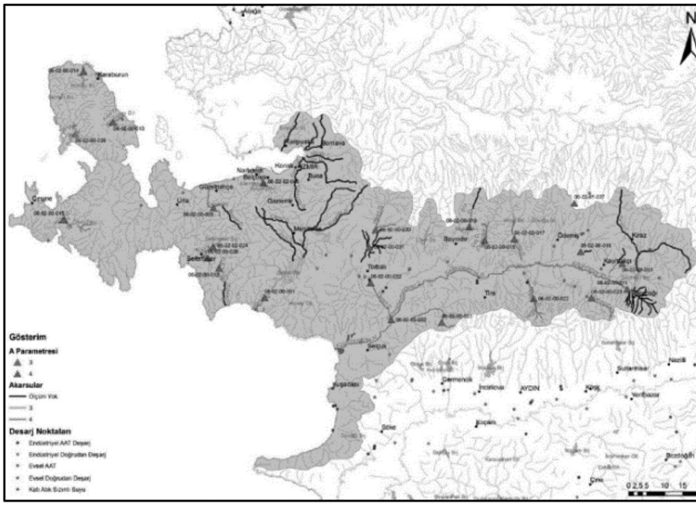

Figure 5. Water class of basin for physical inorganic pollution

organized industrial areas which discharge into receiving water bodies and which account for priority problems for the watershed were investigated. Data obtained as a consequence of fieldwork were recorded under GIS.

Within the scope of the project, 1435 settlements were visited, 192 domestic wastewater treatment plants (WWTPs), 1295 solid waste dumping areas, 29 sanitary landfills, 509 individual industrial plants with WWTP, 142 individual industrial plants without WWTPs and 70 organized industrial areas were examined on-site.For water quality classification, the data related with 2003–2009 years were obtained from DSİ measurements and analysis of water resources between years obtained by DSİ were used. As described in Water Pollution Control Act, Surface water quality classes were determined based on the quality class' criteria for terrestrial water resources. As possible as there was sufficient data in each DSİ station, water quality classes (I,II,III,IV) were determined for COD, BOD5, NH4-N, NO2-N and NO3-N which are important water quality parameters in terms of organic matter and nitrogen pollution. By the use of GIS, all these data were inserted into maps. According to classification regions, water quality is changing between 3rd and 4th degree. Figure 5 shows water quality of basin for physical inorganic pollution.

Planning of municipal WWTPs with various alternatives and feasibility studies for the planned facilities, determination of the route for wastewater collector lines and making cost analysis plays a crucial role in "Preparation of Watershed Protection Action Plans". The existing and planned WWTPs and their features were placed into GIS and illustrated on the map in Fig. 6.

In order to accomplish the planned work in time GIS technologies were effectively used. To be integrated with the system of The Ministry of Forestry and Water Affairs, all data produced within the scope of the project prepared in the GIS environment. GIS is advantageous in terms of providing a rapid completion of projects and achieving fast and accurate planning activities shown in Figure 7. Updating data has become much easier and cheaper because all data collected on watershed basis was transferred into the GIS environment.Accurate analysis of the data and information in time is provided by GIS.

5 CONCLUSION

Water resources, agricultural and industrial properties, meteorological characteristics, geographical characteristics and location form the watershed. For this reason, in this study, they were gathered

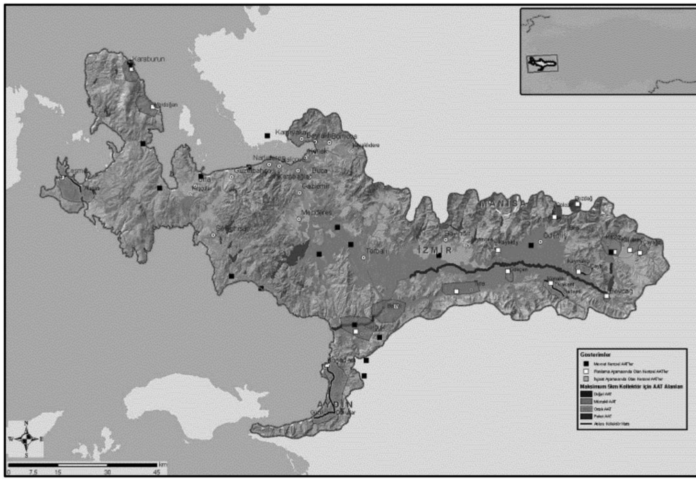

Figure 6. Planned WWTPs in Küçük Menderes basin.

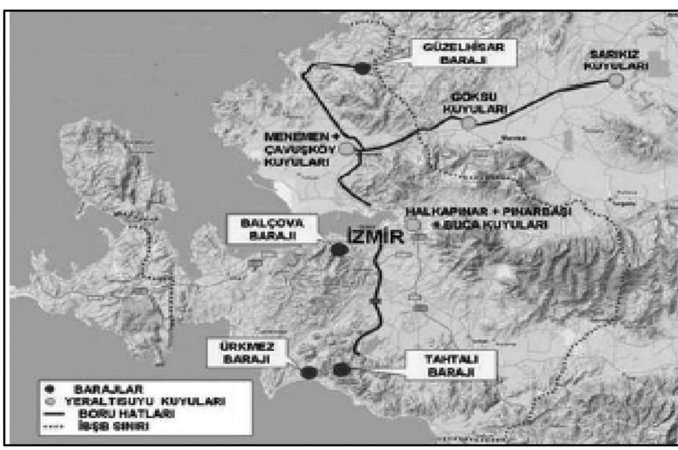

Figure 7. İzmir province, in 2009, the share of the available water resources.

and mapped through GIS tools. This project main aim is to monitor region and help to create policies according to this monitoring. It's surely seen that there is a pollution risk in Küçük Menderes basin which treats drinking water. Therefore some basic precaution applications listed below to eliminate that risk.

5.1 *Separation of domestic wastewater*

- A method of separation of solid waste landfill is used in many countries and this method can be used in waste water. This application allows the re-use for a more efficient purification and nutrient in the water and other components.
- Basic operations can be applied are gray water, black water and yellow water separation and re-use of the allocated water. So a sufficient amount of treated wastewater will turn into a valuable product. Also the collection of rainwater and re-use are considered as an alternative source of water (Regelsberger 2005).

5.2 *Rehabilitation of solid waste*

- Altering unsanitary landfill to sanitary ones.
- The preparation of the environmental and landscaping plan form unsanitary landfill to be used for various purposes.
- Preparation of groundwater quality monitoring plan for surrounding area of unsanitary landfill.
- Control the engineering design in the field of unsanitary landfill.
- For future monitoring activities, machinery and manpower needed to determine with Rehabilitation / Closure works.
- The need for necessary funding for Rehabilitation /Closure and available options.
- Implementation of landscaping project after prepared for rehabilitation and closure.

5.3 *Olive oil production facilities*

Mediterranean countries notably Spain, Greece, Turkey, Syria and Tunisia produce more than 75% of the World's olive oil production. Turkey's olive oil production ranges between 65.000–200.000 tons per year with an average of nearly 120.000 tons per year. Sustainable management of organic wastes such as black water having strong wastewater character along with strong prina and watery prina which are consequences of olive oil production process have a great importance in terms of industrial pollution control frame and greenhouses management process. Possible solutions are listed about industrial pollution arising from olive oil production in Marmara, Aegean, Mediterranean and Southeast Anatolia regions of Turkey:

- Production process and wastewater/waste quantities
- Biologic treatment technologies
- Physicochemical treatment technologies
- Transition to two phased distribution technology in production process
- Black water treatment/control

5.4 *Diffuse sources*

Unconscious usage of natural fertilizers which stems from animal husbandry and commercial fertilizer and pesticides which are component of return water of irrigation are the main sources of non-point pollution of watersheds. To prevent harmful effects, practical way is stopping nutrient rich pollution at source. It is impossible to turn effects back when pollution is spread over water sources. Another risk for this region is leakage from landfills. Main aim is to decrease amount of leakage by step by step with improving unsanitary landfills and constructing sanitary landfills solid waste plants. Septic tanks are another source for non-point sources. It is suggested parallel to rural areas population, usage of septic tanks will decrease. Nutrient loads of forest region will be controlled with erosion control and arranging near river sides.

5.5 *Groundwater management*

Management of ground water depends on inspection and monitoring groundwater in terms of quantity and quality and efficient use of water potential. It is essential to update the inventory of ground water at the local level, improve and ensure continuous monitoring. Education and awareness of the region population has to be increase in order to prevent illegal use and the unconscious shots.

5.6 *Stream beds*

For the recovery of ecological and aesthetic values of regions which are corrupted due to sand and gravel pits, there are lots of studies which are applied with success around world. These uses are listed as agriculture, forestry, recreation, fisheries and irrigation pond and nature conservation area. Topography, soil, and water features, vegetation, regional land use plans, physical, environmental and climatic data should be considered for choosing which method is applicable. (Uğur & Akpınar 2003).

To sum up, integrated GIS and remote sensing technique provides the unique opportunity to analyze and monitor safe drinking water resources.The Ministry of Forestry and Water Affairs has constituted its pathway by defining short, medium and long term goals. Especially with the effect of European Union period; harmonization of legislation, planning for implementation, enhancing the institutional capacity, defining the management models intended for treatment and disposal, setting economic instruments such as incentives and sanctions, water policies have brought into action. During the study stakeholders take participation in order to make the objective and scope of the project comprehensible and sustainable.

Also, this study is a base for national watershed management plan which will be empowered with basin protection action plans. The success of Turkey on EU membership process will be moved in practice by these plans. Basin Protection Action Plans for 25 basins in Turkey aims; protection of the water resources potential in every condition, best use of water resources, prevention of pollution, improving the quality of polluted water resources. When the action plans are implemented, the pressures on water ecosystem will be minimized.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)

Sefid-Rud watershed management and agricultural sustainable challenges downstream of Sefid-Rud dam in Iran

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ABSTRACT: Sefid-Rud Dam is the most important reservoir dam in Gilan province in Iran, and the subsistence of 250,000 rural families depends on the water of this dam. The main aim of this study was to investigate the agricultural sustainability challenges. To achieve this goal, it was necessary to consider this concept as a guiding national development document. This study attempted to address the challenges facing sustainable development in Sefid-Rud Dam downstream where the most fertile lands of Gilan province are located, and which is in crisis due to the implementation of non-expert methods and strategies. To achieve this goal, water storage data of Sefid-Rud Dam were analyzed. The results show that in 2013 the volume of water behind the dam increased by 15 percent compared to 2012, which was due to good rainfall in the upstream areas of the dam. However, this amount represents a 50 percent decline compared to previous years.

1 INTRODUCTION

Increased demand for food, which is a result of increasing population and changing consumption patterns in the country, indicates the necessity of giving more attention to the agriculture sector, as well as the soil and water of the country as the main production basis in agriculture. Lack of efficient and proper management of soil and water resources and in general the institutional mindset of the country has increased degradation of soil and water resources, which may lead to great risks for agriculture in the future (Ghanbari & Ghodousi 2008). The problem of water is one of the greatest challenges of this century. In the past, water problems were raised locally, but now these problems are raised on regional, national, and even global scales. The amount of renewable water the earth gets is equivalent to the fixed amount of water that the earth got thousands of years ago, so the amount of water per capita is highly decreasing (Abrishamchi & Tajrishy 1999).

In order to explain watershed management, it is first necessary to define the meaning of watershed: watershed is a topographic area that is drained by a river system. Watershed management is the process of formulation and implementation of appropriate measures to manage the available resources in the watershed by consideration and accommodation of interests without harming the existence of these interests. Steps of improving soil and water and renewable natural resources are very complex. Natural resource management, especially watershed management, is considered as an infrastructure of modification, development and utilization of water and soil resources for downstream areas and illustrates a comprehensive approach to sustainable development for land management of those areas. One of the most important approaches in the north areas of Iran is that many area levels have gone under water. That reduces the production and income level of many residents. On the other hand, each year the excess water from different levels of the watershed causes a lot of problems in residential areas and cities (Gholami 2011). Sustainable agriculture considers a point of view beyond mere production economy (Norman et al. 1997).

Development that is able to meet present needs of human beings without making challenges for future generations is called sustainable development. The importance of this study on sustainable development of Sefid-Rud is that 250,000 rural families are dependent on the water of this dam.

2 SUSTAINABLE WATERSHED MANAGEMENT

Sustainable management of water resources has been one of the main concerns of the present century and has been a concern of many scientists and researchers from national and international organizations. In recent years the management of integrated water resources has been addressed in different scientific sessions as one of the pillars of sustainable development in both spatial and temporal dimensions. This is because of worsening climate change and water stress which has an important tangible impact on the environment and its socio-economic role in planning on both micro and macro scales.

Today the majority of people and different sectors of natural resource management authorities are aware of these issues. The only permanent solution is to achieve proper use of water resources for agricultural land and natural resources. Surely the correct use of watershed management activities in the areas of agriculture and natural resources is feasible and would greatly improve the situation.

Water, soil and vegetation are three main factors in watershed management. Incomplete or improper administration of these resources causes environmental damage, loss of productivity, loss of revenue, and ultimately leads to an unstable region. So we have considered the best and most suitable and most natural position within these three aspects of resource management. Watershed management must emphasize water resources in an integrated manner with other natural resources such as soil, vegetation and atmosphere. The main objective in the sustainable management of watersheds is the ecological health preservation of the watershed's resources as a prerequisite for achieving sustainable economic and social development. A holistic and systematic approach to all aspects in a watershed can lead to balance in the development and growth of a community.

3 INTEGRATED WATERSHED MANAGEMENT IN SEFID-RUD BASIN

To achieve sustainable water resources and watershed management goals and to address the challenges, the term of "Integrated Watershed Management" was developed by some researchers. In this approach, the watershed is considered as a unit of planning and implementation. Supply and optimization of the use of water resources within the watershed in order to maintain ecological integrity is always a challenging debate among civil society, the private sector and the government. True and correct understanding of the watershed and watershed management depends on identifying all of the different stakeholders. To achieve it, executive public policy involves a combination of "Top-Down" and "Bottom-Up" processes; public participation is required (Jain 2004).

4 THE ROLE OF PUBLIC PARTICIPATION IN WATERSHED MANAGEMENT

Today, popular participation gradually takes its place among the organizations and authorities responsible in all fields. Participatory approaches in planning, design, implementation and evaluation of the project could be an effective solution to consider. Participation in the discussion of major issues is the aim of Partnerships. What forms of participation, such as participation of all economic, social, political, educational, and cultural interests should be raised in addition to the common purpose and integration activities. There should be an awareness and understanding of the subject by all participants. It should be recognized that participants do not necessarily know how to come together and achieve what goals are sought. We should accept the fact that participation is in essence an awareness of the issues, and this awareness is a fundamental element in the discussions. There should be a collaborative way for other topics to be discussed with open participation. The most important ones are: Feeling the need and necessity, people's will and volition and selectivity of behavior.

5 OTHER FACTORS IN WATERSHED MANAGEMENT

Watershed is the most logical and efficient unit for planning and management of natural resources. Watersheds represent geographical and ecological processes associated with surface water and move it toward an output unit. Human interferences on soil and vegetation units directly affect the amount of water, sediments and nutrients generated in the watershed. The watershed is the place of interactions of natural resources and human activities within a single geographical and biological unit. It is because of such factors that the watershed is the best unit for managing water resources and all other aspects within it (FAO 2006).

6 WATER CRISIS, A GLOBAL PROBLEM

Water presents one of the most important challenges of this century and could be the source of many conflicts. The main reason for imbalance between available water and water demand is due to the hydrological cycle and natural constraints of water resources. Another factor is the influence of human actions on water resources. There is an inherent limitation of water resources, due to effects of drought, population growth, and excessive utilization of existing resources, all of which result in a drop in groundwater and damage to environmental sustainability.

World Summit on Sustainable Development in Johannesburg in 2002, addressed implementing the goals and programs of the Rio Conference on their agenda. Five axes were chosen as the main topics: Water, Energy, Health, Agriculture and Biodiversity (WEHAB). Based on the global definition of water consumption levels, Iran is facing a water crisis (Mahmudi 2003).

7 SUSTAINABLE AGRICULTURE

Sustainable development can be defined as development that is conducted without depletion of natural resources. There have been many attempts to define sustainability. The concept of sustainable agriculture was introduced in 1987, but terms like organic agriculture, natural, ecological and low-input were used from 1940 as being synonymous with this concept.

Sustainable agriculture is considered a point of view beyond the mere production economy (Norman et al., 1997). Sustainable agriculture can be considered in both economic and social aspects (Ibrahim, 2003). This issue also needs proper management and better use of natural resources for human nutrition and to preserve environmental quality (Sedaghati 1992).

8 SEFID-RUD DAM

Sefid-Rud is one of the important rivers of Iran, and the Sefid-Rud dam is constructed at the confluence of two rivers: Qezel-Ozan and Shah-Rud. The direct distance from Sefid-Rud dam to the city of Rasht is about 75 km. This dam is one of the largest dams in Iran and is a gravity concrete dam type. Initial volume of the dam reservoir was 1765 million cubic meters, but the volume of dam reservoir is 1158 million cubic meters currently. The area of ??Sefid-Rud basin is 56,200 square kilometers, and the area of downstream lands which are irrigated by the dam's water is about 3450 square kilometers. The long term average discharge of Sefid-Rud is 4835 cubic meters, and its average sediment yield is about 48 million tons per year.

The dam supplies water for agriculture, industry and drinking of the residents downstream. The dam also controls floods of Sefid-Rud and generates hydroelectric power with the capacity of 87,500 kw, and also plays an important role in farming activity such as rice paddy. Downstream of the dam, many villages and towns benefit from its water and fertile sediments from upstream areas.

9 SURFACE WATER AND SEDIMENT YIELD

Surface water and sediment yield data analysis in general, are important aspects of integrated water resources areas. Firstly, based on the results of these studies potential sediment yield and floods are estimated. Secondly, the results of the analysis in the form of various tables, graphs and maps will provide a reference for making decisions in relation to integrated research and development (Gilan Regional Water Authority 2013).

10 CONCLUSIONS AND RECOMMENDATIONS

Agriculture and sustainable development efforts center around three main axes including food security, employment opportunity and increased income to reduce poverty and preserving natural resources and the environment (United Nations Development Program 1994).

With regard to economic and social conditions, watershed management in developing countries is different from that in developed countries. Due to the nature of watershed management programs that are interacting with many organizations, there are many difficulties for planning and implementation of watershed projects.

The ultimate aim of sustainable watershed management is design, planning and implementation of information and use of new ideas and suggestions for the sustainable management of watersheds.

Application of proper administrative strategies would be conducted to decrease the input volume of sediment in lakes of dams.

With regard to the importance of the Sefid-Rud dam, some approaches such as dredging the lake of the dam, main river and water distributing channels, and other small reservoirs downstream are necessary for sustainable agriculture. It is also essential to deepen and dredge the reservoirs located downstream of the dams to increase their effective capacity. Development and construction of gardens at steep slopes is proposed to prevent accelerated erosion (Executive Secretary Home Farmer 2013).

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)

Analysis of policy network and institutional networks cohesion in sustainable management of watersheds, case study: Taleghan region, northern Iran

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ABSTRACT

One of the keys to successful watershed management is an institutional network to facilitate co-management between varying component interests. Specifically, all stakeholders must be involved. A second key aspect is to analyze coherence between governmental and non-governmental interests. It is essential to measure social cohesion within institutional networks for successful co-management. Case study analysis of institutional network structure coherence for Dizan Village in Taleghan Region, Northern Iran, is presented.

Institutional Network Structure: An appropriate institutional network structure includes multiple levels of government and non-government interests to create natural resource policies and resolve conflicts in management options. The concept is to create an institutional network that governs natural resource management directed as sustainability. Establishment and maintenance of an institutional network is critical to success of any co-management plan. Regional policy-making must be aligned with the institutional network. A focused and coordinated activity among governmental institutions at different levels is essential.

Inefficient institutional network structures cause lack of coordination and cohesion among stakeholders. Emphasis on top-down policy making and management of natural resources at the regional or national levels to resolve political crises, is not appropriate and causes lack of stakeholder commitment. The result of such situations is over exploitation over of resources and inability to recognize dynamic processes of ecosystem.

Recently, scientists have suggested institutional network structures for the governance of natural resources instead of government management. In governance of natural resources, social issues are addressed and facilitated through creation of flexible and adaptive mechanisms and collaboration among all stakeholders.

Analyses of Institutional Network Structure Coherence – Case Study: Dizan Village in Taleghan, Northern Iran. Results indicate that the density index in the Dizan Village rangeland users' network, based on a trust and cooperation matrix, is respectively 25% and 26%. This means that the institutional network cohesion level based on trust and cooperation is weak. Thus, social capital among rangeland users in Dizan Village is low. This is one of the most important challenges in implementation any co-management. Further, as a result of the low level of cohesion among rangeland users there is limited success in implementing the rangeland management action plan. Successful rangeland management cannot be applied in this area until an effective cohesive institutional structure is established.

The degree of reciprocity (state of relations or privileges granted) based on mutual indexes equals 57.5. This indicates the degree of sustainability of the institutional network is at a medium level on natural resources in Taleghan region. This suggests that there is possibility for improvement with the establishment of an effective institutional network structure.

Also, based on trust and cooperation ties, the degree of centrality is respectively 27% and 25%, which reflects the sparse structure of the institutional network. This means that, the central

actors have only a few ties in the rangeland user's institutional network and most ties of trust and cooperation are not broad based among the stakeholders. Therefore, the level of cohesiveness in the institutional network is poor.

In conclusion, it is essential to measure social cohesion with an institutional network analysis before the implementation of co-management, then develop, implement and manage policies in order to implement co-management. Reinforcement of policy making interactions among actors at different levels is necessary to operate natural resources governance patterns in policy making to achieve sustainable management of rangelands in Taleghan. However creating coherent institutional network among different policy making actors is considered essential.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

GIS based participative decision making model for Krivaja watershed in Serbia

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EXTENDED ABSTRACT

The paper presents decision making model based on combining multi-criteria analysis, selected GIS tools and a posteriori evaluation of obtained solutions. Implementation of proposed model for given case study area in Serbia assumes application of: (1) network river basin computer model ACQUANET/K; (2) participative decision making model AHP/K and several scenario based analysis modules. Both models (1) and (2) are well known worldwide; and an extension /K for both stands after the name of Krivaja River and its watershed used as a case study. Model ACQUANET/K is described briefly because it is simplified version of MODSIM, well documented model/software which uses the same concept of treating complex water management systems. Two scenarios of water allocation on long term basis within the Krivaja watershed were defined in detail and simulated with ACQUANET/K. Existing data are carefully interpreted to create model input, while missing data are estimated in justified engineering and systems analysis manner.

Because the European Water Framework Directive imposes involvement of different stakeholders in water management, the study is extended so to provide relevant answer to the question of who should be considered as stakeholder at global and local level in this particular watershed's (water) management, but also to explore the strategy on how to reach group decisions in this typical case of 'spatial dispersion' of decision makers, i.e. interest groups and sub groups.

In relation to this, participative GIS decision making framework is created and a methodology is developed with emphasis on combining AHP/K and GIS, including an example of spatial AHP decision making to define land suitability for irrigation in selected county within the watershed. We also provide results of activities aimed to identify key stakeholders in participative decision model for this watershed and conclude that the results obtained are promising for real-life implementation in this and similar situations.

Necessity of participation of different stakeholders in the participatory GIS is discussed in detail, and paper is closed with several recommendations related to planning the strategies and operational policies which could enable such exploitation of water resources which respects existence of different interest parties, their possible conflicts, as well as economic and political environment. A key arguments are that participative decision making models combined with GIS enable a good base to come up to the answers such as how much water is available, to whom and when, and how to decide which management strategy will be most acceptable to involved stakeholders.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

An experience on increasing the awareness level and participation of local societies (Case study: Iran, Hablehroud watershed)

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ABSTRACT: Sustainable Land and Water Resources Management in Hablehroud project, which has been defined since 1997 as a joint project by the Government of I.R. Iran and the UNDP; in its second phase, aims to achieve an appropriate Watershed Comprehensive Management Model for arid and semi-arid areas through strengthening intersectional coordination among different stakeholders and implementing participation-oriented local processes.

It shall not be possible to realize such achievements without enhanced participation of all stakeholders and users of natural resources and the best strategy in this regard is intellectual investment investment in students and future generations of the watershed to promote enhanced participation of the local community. Therefore, the operational framework of this approach has been provided for training students of Hablehroud watershed in Garmsar township of Semnan province during 2013-2014 academic years. A clear path including phases and steps is provided for the implementation process of the project to raise awareness in the stakeholders. This project focused on capacity building about sustainable development. In the project, the training process, defined in a systematic and network process and the statistical evaluation results (which were collected via pre and post test) showed significant increasing in knowledge and insight about water issues and sustainable development in the audiences.

1 INTRODUCTION

According to the Johannesburg Declaration on Sustainable Development (2002), the greatest obstacle for sustainable development is that the public does not have an appropriate understanding about "sustainable development" concept. This is not just for developing countries, but also for developed ones, in different levels, too.

Capacity building and public awareness can have an effectiveness role for obviating this challenge. This fact has been properly considered by Hablehroud's project managers and planners that in this regard try to engage the participation of the local societies and prepare them for this by providing training.

The experience which is described in this paper is defined in this point of view and focused on as a trainable and target group which will be the Stakeholders and beneficiaries in the region in the near future. The project is defined for all of the students which are at the second stage of elementary schools of Garmsar, Iran. The outcomes of projects are going to be generalized as a model for the entire watershed (Hablehroud) and then for other watershed in national or international scales.

2 BACKGROUND

Before the Land Reform of 1962 when the structure of the rural community in Iran underwent a drastic change, soil and water resources used to be managed solely by the local users. As a result of the Land Reform Bill, new actors found roles to play in the socioeconomic arena of the rural life, the most significant being the central government and its affiliated agencies. These exogenous changes gradually led to the weakening of the traditional rural systems which ultimately lost their power and rigor. The following are the consequences of such ominous mistakes:

- The costs for soil and water conservation and preservation of the (not so much favorable) conditions increased year after year. This detracted to a large extent the government's attention away from its more important responsibility of investing in resource and infrastructure development.
- Farmers got into the wrong habit of looking to the government for their needs and demands, and consequently began to hold the government responsible for their misfortunes and failures.
- Increasing population led to further complication of the situation which was also coupled with technical complexities associated with the application of new technologies; hence, the opportunities that were once available for sustained and timely reforms in the traditional systems were lost.

This approach for managing land and water resources couldn't go on effectively so concurrent with fundamental events, about three decades ago, the new global approach to development shaped. As a result of this, it became clear that it was urgent to put an end to the vicious circle that contained a top-bottom planning and lack of planning at the bottom level. The local parties commonly found no opportunities to express their own needs, motivations, or ideas in formulating plans for meeting their demands, rather the plans were studied and developed at provincial or national headquarter offices and were, subsequently, executed with public funds without recognition of the pivotal role the local communities were to play.

These were the background conditions that warranted a sustainable management plan for the soil and water resources in the Hablehroud Watershed. As a pioneering project, it had to turn into an appropriate precedent of sustainable soil and water management to be replicated elsewhere. Sustainable Management of Land and Water Resources came into existence as a joint project by the Government of I.R. Iran and the UNDP in 1997. The Hablehroud Watershed with an area of 1.2 million ha was selected as a pilot area. The main objective of the project was to develop appropriate models for planning, management, execution, operation, monitoring, and evaluation of land and water resources in a number of sub-basins in the watershed so that the results obtained could be generalized and extended into a national plan for the protection and conservation of natural resources through the rural community participation in the management of watersheds across the nation.

In the second phase, the project aims to achieve an appropriate Watershed Comprehensive Management Model for arid and semi-arid areas through strengthening intersectional coordination among different stakeholders and implementing participation-oriented local processes. This target should be followed via capacity building among local experts, managers and communities to play a more active role in planning and management of land and water resources and in development of their watershed. This target needs increasing the awareness level which leads to local society's participation.

3 POSITION OF GARMSAR CITY AND HABLEHROUD RIVER

Garmsar is one of the four cities of Semnan province and is located in the west of the province (Fig. 1). Garmsar is located southeast of Tehran around 90 Kilometers away. The area of city is about 10686 Km^2.

The city is in an arid region of Iran and its water is provided mainly by Hablehroud and Rame River and also from groundwater (Fig. 2). According to agricultural activities which are the main economic activity of the city, the stated water resources are considered as the most important factors of socio – economic development.

Hablehroud is the only permanent river in Semnan province and Garmsar city. The river with mean annual discharge of 270 million cubic meters is the main source of agriculture and drinking water for Garmsar since ancient times.

Figure 1. Semnan province in the map of Iran.

4 THE FRAME OF "INCREASING THE AWARENESS LEVEL AND PARTIPATION OF LOCAL SOCIETIES" PROJECT IN HABLEHROUD

4.1 *Objectives*

- Increase the knowledge of students about Hablehroud river and Watershed
- Increase students' familiarity with the causes of the unstable situation on Hablehrud watershed such as climate change, droughts, increased water withdrawals from upstream Hablehrud River (city of Firoozkouh and Damavand), over-harvesting of agricultural water wells and underground aquifers, lack of proper nutrition
- Introduce the outcomes of the current unstable conditions such as low groundwater levels, reduced water quality and increased salinity
- Increase student motivation about the functions and roles of everyone in the community and train them in the strategies and behaviors towards sustainability such as controlling environmental degradation, increasing vegetation, reducing the surplus livestock pasture, watershed management operations, etc.

4.2 *Target group (Audience)*

The main target group (Audience) is the students and network of teachers of second stage of elementary schools in Garmsar city (Except the Ivanaki sub region).

Figure 2. A view of Hablehroud region.

4.3 *The training topics*

– Status and challenges of Hablehroud watershed in 2 categories of soil and water management
– The importance and role of soil and water, and also our needs to improve their situation in order to continue our life
– Preventive and positive behaviors in order to provide water – soil protection by considering the student options
– The importance of empathy and participation of all sectors of society in the sustainable management of water resources and soil

4.4 *The material (training, evaluating and communicating)*

- A booklet to train the trainer (one trainer in each school)
- A CD with sorted and various data for trainer such as some animations, pictures, articles
- A wall newspaper (like a poster) to introduce the main topic in a glimpse for students
- Standard pre and post test
- A Website in two languages (Farsi-English)
- A SMS center to establish a wide communication with audience

4.5 *Training model*

Due to the geographic extent of the project and the number of audience participants (around 5000), the administrative model should be defined in a way that could cover the entire wide target group. Indirectly teaching indirect methods, referred to as the snowball model, is selected for this purpose. In this way the first representatives of schools as "trainers" train directly at a workshop ("train the trainers"). This trained trainer, then, will transfer the content to each school of the project. It should be noted that the training flow will be followed by trained students to their families, but these activities are not included in the set of activities to assess the effectiveness of the project. Based on such a model, the training spreads through and covers the whole target group and beyond, to family and friends.

4.6 *Steps*

The project followed through these steps:

- Studies and formulates the subordinate documents and the framework of the project according to the Hablehroud project documents-Communicate and provide the educational system's participation
- Write, produce, edit, design and print material
- Prepare and launch communication infrastructure (Website-SMS Center)
- Hold an opening ceremony and then the workshops in the school.
- Hold the students' workshops and then running the competitions for consolidating and extending the learning
- Assess and evaluate the effects of project
- Document the activities
- Judging the received students' production under competitions and run the encouraging system (awards for selected ones)
- Compile the final report

5 ASSESS AND EVALUATE THE PROJECT EFFECTS

In this experience, after training the entire complement of students, the competitions run and tangible products received. Some of them are published in a book (Fig. 3).

For accurate assessment and evaluation of the project's effects, a statistical analysis will be done on a pretest and post-test taken on a random sample of the target groups.

Preparing the test which can measure the increasing the awareness level of audiences is a professional task and the validity of test should be checked.

The standard pre and post test is prepared through these steps:

- Define clear behavioral objectives using measurable terms
- Preparation of the draft of the test
- Check validity (validity and reliability)

In this project a random sample consisting of 210 students participated and were given pre- and post-tests. The results were analyzed in descriptive and inference frames. The test consisted of 15 questions that measured the knowledge and insight of students before and after the training process about watershed sustainable management (soil and water) according to the Likert Scale. Each question has five options and each option had its own points for the statistical analysis. Statistical analysis of pre-test and post-test data showed that overall, students' knowledge and insight were significantly increased about eight percent (7.85%).

Figure 4 shows the percentage of increasing (the difference of pre and post test results) in knowledge and insight of students under each of the 15 questions of the test. As it can be seen in the figure, the highest increase awareness occurred in Question 7 which is about the awareness of soil erosion (21%).

6 CONCLUSION AND FURTHER SUGGESTIONS

The capacity building and public awareness projects which will lead to society participation can be considered as a key for sustainable development and sustainable management of a watershed. Using the network of education system and schools for this purpose is an effective way. The snowball

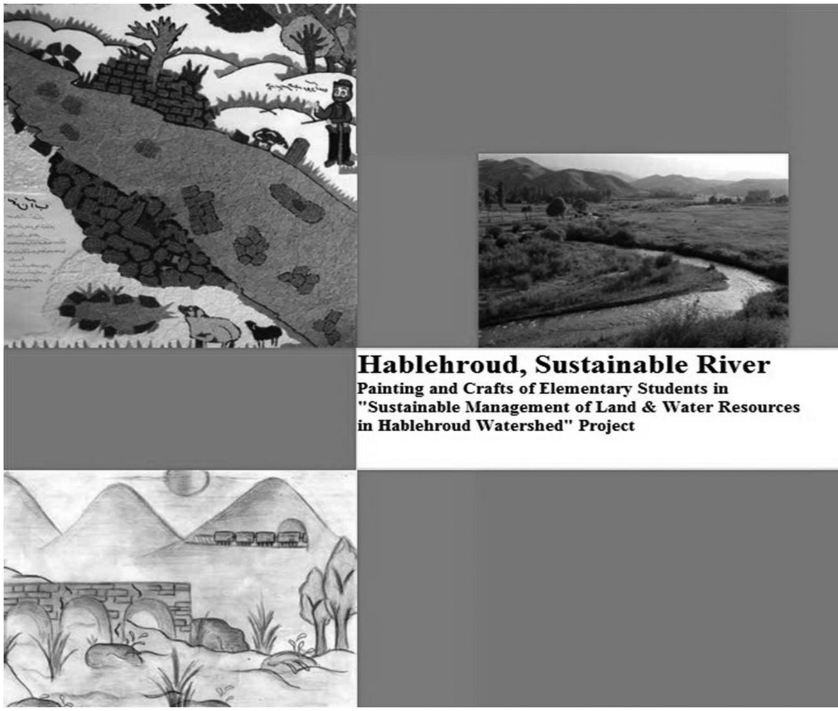

Figure 3. The cover of project book.

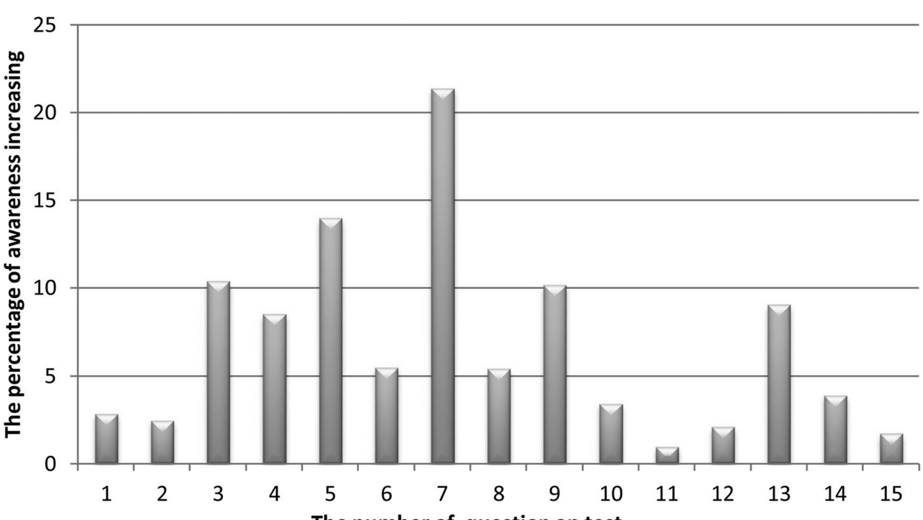

Figure 4. The percentage of awareness increasing for each question of the test.

method in which TOTs defined to promote the training is a proper model in this way. Considering the evaluation system for such projects is an important part of project planning. The model and report of increasing the awareness level for students in Hablehroud watershed can be generalized to use in other watersheds but the local properties should be noted.

Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Introduction of an integrated approach for watershed management through participatory preparation and implementation of land use plan (Case Study, Hablehroud watershed)

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EXTENDED ABSTRACT

While being considered as a complicated process, the management of a watershed area consists of different components each of which should be taken into account to assure the sustainability of the watershed.Such a systematic look at watershed area and its components as well as its inputs and outputs was the approach taken by "Sustainable Management of Land and Water Resources" Project (SMLWR), the joint Project between Iran Government and UNDP. In this regard and given the look at a basin as a dynamic and live system and the necessity of keeping the balance among the components of the system, SMLWR Project put the participatory designing and implementation of the land use plan and the integrated management plan on the agenda of its second. The process of preparation of the land use plan is included:

1- Preparing the land use plan
2- Approval of the land use plan
3- implementing of the suggested scot plans in the selected areas.

The results of this approach are introduced schematically in Figure 1.

Measuring 1.2 million hectares, Hablehroud watershed area lies between two central provinces of Iran, Tehran and Semnan. For an aeon of time, the area was affected by man's interferences. Man's manipulations could be seen all over the area. Extreme grazing in the upstream and midstream, intense soil erosion, flood, and sediment, the change in land use, especially in the upstream, unequal water distribution between the upstream and downstream, mining and excavation activities with detrimental effects on the face of the watershed area, anomalous exploitation from the underground waters, migration from villages to urban areas and hundreds of similar threats necessitate an all-inclusive and comprehensive look and the establishment of a systematic viewpoint in this regard; and SMLWR Project seeks to design and implement such an all-inclusive viewpoint in the second phase.

In this regard and given the look at this area as a dynamic and live system and the necessity of keeping the balance among the components of the system, SMLWR Project put the designing and implementation of the land use plan and the integrated management plan on the agenda of its second phase. And as the participatory approach of this project is based on the inclusion of the viewpoints of all practitioners of the management and exploitation of this watershed area, the plan was prepared and implemented in cooperation with the said practitioners. The figure 1 depicts the preparation, approval, and implementation stages of the land use plan of Hablehroud Watershed.

Meanwhile, the workshops formed in the watershed area identified indices to execute managerial plan in three criteria including water resources management, land and environment management, and socioeconomic management. And the prepared managerial plans were extracted in accordance with the improvement of the stated indices.

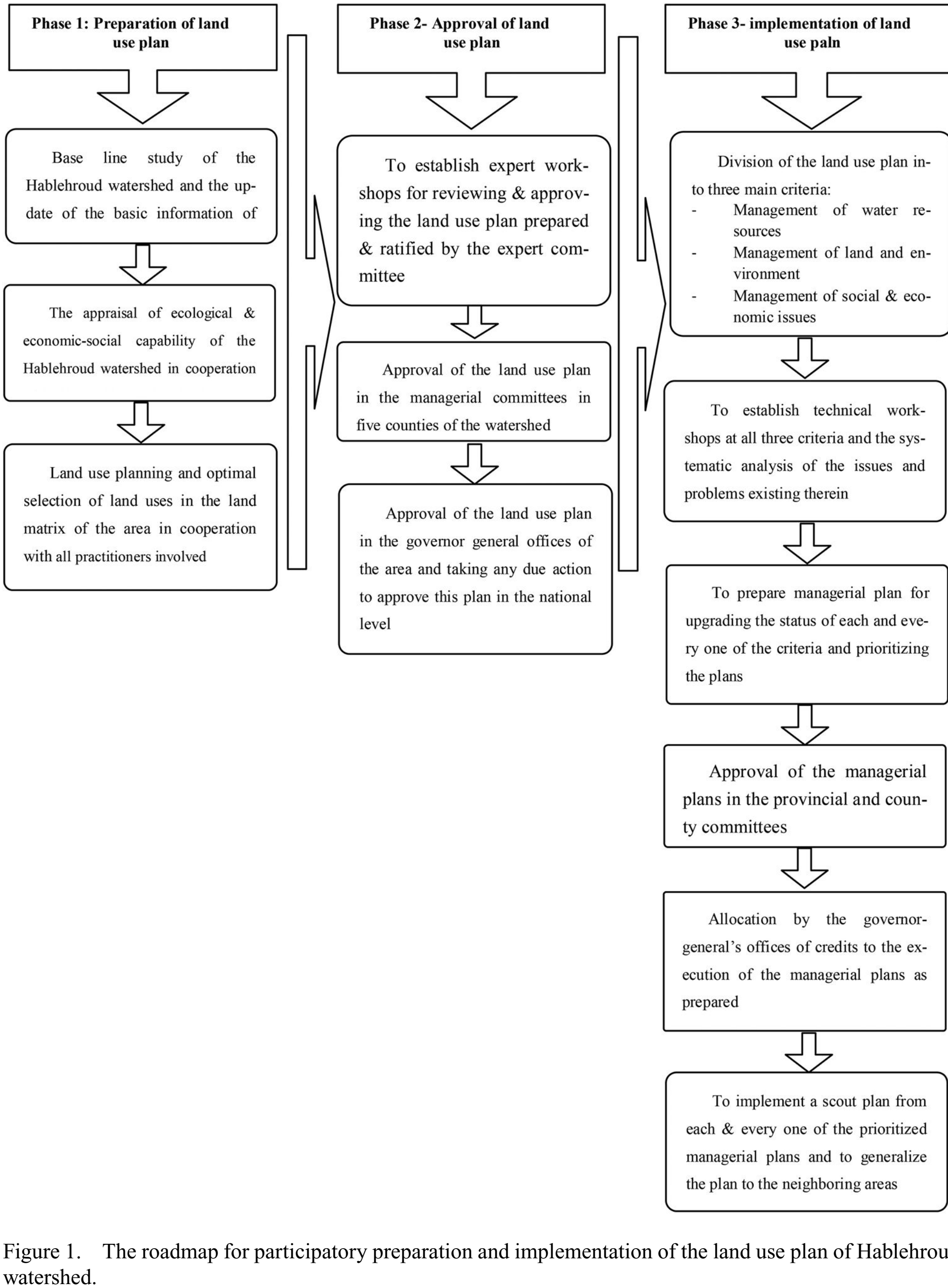

Figure 1. The roadmap for participatory preparation and implementation of the land use plan of Hablehroud watershed.

The future programs of SMLWR Project underline the discussion and forum in the bodies related to the watershed management for implementing the land use plan and integrated management plan of this watershed as well as the approval of the model at the national level as a model for the integrated management of the watershed area.

Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Network analysis and social cohesion in watershed co-management, case study: Taleghan region, northern Iran

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EXTENDED ABSTRACT

Diverse and often conflicting human issues in have been taken into consideration for decades in watershed governance. As a result, there have been problems implementing sustainable watershed management practices. A co-management approach can assist in addressing the challenges faced with comprehensive watershed management plan development and decisions in the governance process. Local stakeholders are an important component of the process of watershed co-management. Improving social cohesion and social capital (the collective benefits derived from involvement and cooperation between individuals within a group) play an important role in development and implementation of effective watershed management plans.

Social network analysis is an efficient tool for measuring social cohesion and understanding the challenges of watershed co-management. In this study, Dizan Village in the Taleghan region was selected to implement the application of an institutional network analysis in watershed co-management. First, the desired data was gathered based on a trust and cooperation matrix between all the rangeland users by using network analysis questionnaires. Then a social cohesion analysis was accomplished on the data collected. In this study, the Ucinet software was used to analyze the network data.

The results, based on trust and cooperation matrix, indicate that the density index in the rangeland users' network is respectively 25% and 26%. This means that the level of cohesion based on the two ties (trust and collaboration) is weak. Thus, social capital among rangeland users will be weak. This is one of the most important challenges in implementing the co-management plan of Dizan Village rangelands and despite low levels of cohesion among the users the successful rangeland management will not be successfully applied in this area.

Also, based on trust and cooperation ties, the degree of centrality is respectively 27% and 25%, which reflects the sparse structure of the network. This means that, the central actors have only a few ties in the rangeland user's network and most ties of trust and cooperation are not broad based among the stakeholders. Therefore, the level of cohesiveness in the institutional network is poor.

In conclusion, it is essential to measure social cohesion with an institutional network analysis before the implementation of co-management, then develop, implement and manage policies in order to implement co-management. Reinforcement of policy making interactions among actors at different levels is necessary to operate natural resources governance patterns in policy making to achieve sustainable management of rangelands in Taleghan. However creating coherent institutional network among different policy making actors is considered essential.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Land use effects to surface water quality of some watersheds in north Finland and north Turkey

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EXTENDED ABSTRACT

The surface waters must be monitored for contamination and pollution determination in drinking water watersheds. There are various chemical and biologic parameters to determine the water quality. The land use has impact on water quality. In Finland watersheds, leaching from peatland areas to surface waters is very common. In north Turkey surface water have not seen peatland effect and acidity problems, but over agricultural or industrial activities and land uses can be negative effect to water quality differ from acidity. The main objective of the study is to determine the water quality in two different basins seasonally and spatially. Secondary objective is estimating the role of land use in the water quality of these water basins.

Study area coordinates are 64.0 North-24.0 East (Finland) and 40.0 North-31.0 East (Turkey). Study area was chosen according to their different land use proportion and acidity problems. The land uses of these basins are quite different. In Finland watersheds area cover 40% peatland, while in Turkey watershed area cover 35% agricultural area determine the land use. This is mainly difference as land use. In Finland Siikajoki (4318 km^2) and Pyhäjoki (3712 km^2), in Melen watershed (Turkey) 2734 km^2 are classified as large rivers.

Water samples were collected, analyzed and obtained during different hydrological conditions in years 2009–2011. For Siikajoki and Pyhajoki rivers part of the water quality data was obtained from HERTTA database. Following analyses (alkalinity, acidity, SO_4^{2-}, Al, Fe, Mn, and colour) done according to SFS-standards in Centre for Economic, Development, Transport and the Environment of Northern Ostrobothnia (ELY-centre). During sampling, pH and electric conductivity (EC) of water were measured in field with Mettler Toledo MP120 meter. Continuous measurements of pH (half-hourly intervals) were carried out from September 2009 using pH sensors connected to an EHP-QMS data logger with internal modem, which sends data via the internet twice a day. In Melen River, part of the water quality data was obtained from Turkey State Hydraulic Works (DSI) and Istanbul Water and Sewage Administration (ISKI) during 2009–2011. HACH pH, dissolved oxygen concentration (DOC), electrical conductivity (EC), resistivity, total dissolved solids (TDS), salinity and temperature were determined at the sampling sites. Besides The samples were collected and filtered with 0.45 μm Millipore papers and acidified with supra-pure nitric acid until lower than pH 2 and were kept in polyethylene bottles. Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese,

Molybdenum, Nickel, Phosphorus, Potasium, Selenium, Silver, Sodium, Thalium, Vanadium and Zinc analyses were done according to EPA 200.7 and ISO 11885.

Before the analyses for Melen Watershed (Turkey) year was divided into four different seasons as well; winter (December–February) spring (March–May) summer (June–august) and autumn (September–November). For Siikajoki and Pyhajoki (Finland), the year was divided into four different seasons according to the amount of runoff: 1) winter (January–March) with snow accumulation and low runoff, 2) spring (April–May) with snow melt and high runoff, 3) summer (June-September) with low runoff due high evaporation, and 4) autumn (October-December) characterized by low evaporation and moderate runoff.

The relationships between water quality parameters as well as land use types of catchments were analyzed by using Spearman non-parametric correlations because of non-normal distribution of the data. The differences between sampling points in main streams were studied by using Mann-Whitney U- non-parametric test using SPSS 20.0 program.

There is a clear distinction between the two basins in terms of pH, EC, Sulfate, Iron, Aluminum, Manganese and Colour values. There is negative correlation between the pH and Aluminum, Cadmium, Iron, Sulfate and manganese. However, EC has a positive correlation between Aluminum, Manganese, nickel and cadmium. The agricultural area of Turkey has a significant positive correlation with Aluminum, Cadmium, Nickel, Iron, Sulfate, EC and Manganese, while the peatland of Finland has positive correlation only with Colour parameter. The highly risk times and times with potential risk have been determined for both watersheds. In Finland seasonal variations of acidity-related variables have been great; worst situation has been observed during spring and autumn high runoff. In Melen River has less seasonal variation.

Water quality is very important for human and all ecosystems. Agricultural and Peat areas and their activities may change by decision makers. This study is an important step for making plans of land use. Results clearly show that agriculture and peatland effect to water quality different level.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Effect of land use change on soil degradation and land use optimization

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EXTENDED ABSTRACT

Changes in land use due to human activities are a widespread problem that leads to land degradation. The conversion of natural land into cropland may decrease the rate of soil infiltration and affect soil physical characteristics that increase erosion. Soil degradation caused by land use change is known as a major threat worldwide.

The investigation of the effect of land use change on soil degradation is an important research topic. There has been increasing concern that conversion of natural lands results in ecosystem degradation, excessive soil erosion, and loss of soil and water resources. The characterization of soil loss is important to conserve ecosystems and planning management practices. Protecting the health of watershed ecosystem is a critical issue facing watershed communities and managers. Moreover, application of optimization approaches may be necessary to achieve sustainable development and prevent soil degradation in the future.

This review collates and synthesizes available findings on the effect of land use change on key soil physical properties and organic matter content. An increasing rate of land use change leads to major effects on soil physical properties. This results in accelerated environmental degradation in terms of soil erosion and reservoir sedimentation in many regions. Such changes affect soil physical properties, such as gas flux, soil erosion, soil water retention, and soil structure. Changes in land use from natural pasture lands to farmlands leads to significant changes in key soil properties including bulk density, soil structure, soil saturated hydraulic conductivity, available water content, final infiltration rate, and soil organic matter content.

The knowledge and documentation of soil erodibility is important to conserve ecosystems and planning management practices. Agriculture is one of the most common forms of human disturbance with a variety of ecological effects. Land use optimization, especially by agriculture (a major contributor to the environmental degradation), unfortunately is often regarded as necessary to achieve sustainable development. Given the concern about increasing cost of high rates of soil erosion, there is a need for analytical tools that can be easily used by researchers and environmental managers in various regions. Planning methodology to specify optimal use of scarce soil and water resources is highly important to gain the optimal benefit. A major factor in watershed-based approaches may be the ability to optimize land uses and to plan programs and policies for maximum benefits. Consequently, land use optimization that incorporates individual system components within a framework is useful for providing comprehensive analysis. This approach may assist economic efficiency by allocating limited resources to those areas that have potential to impair watershed health.

In general, quantifying and monitoring land use changes are essential to prevent soil degradation. The documentation of changes is necessary to improve land utilization in many areas. Optimization techniques have been applied to watershed resources recently. This review shows the need for strategies regarding sustainable land management that decrease the negative effects of natural land cultivation.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Sustainable watershed management through applying appropriate level of soil amendments

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ABSTRACT: Polyacrylamide (PAM) is the mostly used as soil amendment in the world. A variety of soil amendments such as have been applied for soil and water conservation. Determination of optimum level of soil amendments is important, especially in sustainable watershed management to achieve optimal health, safety and sustainability in watershed resources. Therefore, the present study aimed to determine the optimal PAM application rate under laboratory conditions. The experiments were conducted under controlled laboratory conditions with a simulated rainfall at the Soil Erosion and Rainfall Simulation Laboratory, Tarbiat Modares University, Iran. PAM treatments of 0, 0.4, 0.6, 1, 2, 3, 4 and 6 $g\,m^{-2}$ were used as experimental rates. The analyses of the results verified the optimal amounts of PAM application based on PAM residues in runoff and sediment as well as minimum soil loss at rate of 2 and 0.4 $g\,m^{-2}$, respectively.

1 INTRODUCTION

A variety of soil amendments viz. mulch, manures, composts, mineral conditioners and synthetic polymers have been applied for soil and water conservation. Determination of optimum level of soil amendments is important, especially in sustainable watershed management to achieve optimal health, safety and sustainability in watershed resources. However, determining the optimal rates of these soil amendments in environmental point of view has been less considered. The lack of adequate data has been recognized due to difficulty of determining of optimal rate. In view of the fact that many factors such as cost, availability and variability of soil physical and chemical characteristics affect the level of application. Indeed, soils respond to soil amendments applications differently, depending on soil/amendments characteristics, and even water quality. So, it is necessary to determine the optimal rates of soil amendments for particular soil as well as amendment to be practically used for similar condition. These data are therefore needed for the optimal conservation of soil and water resources in watershed scale.

The review of available literatures and documents shows that the Polyacrylamide (PAM) is the mostly used as soil amendment in the world (Shoemaker, 2009, Shin et al. 2013, Prats et al. 2014). Results also show reliable findings in soil conservation technologies. Though, determining optimal rates of PAM based on environmentally assessment of the works has been less taken into account. Therefore, the present study aimed to determine the optimal PAM application rate under laboratory conditions. The PAM is a white, odorless, and water-soluble polymer with the ability to control surface sealing and crusting, increase seedling emergence, reduce runoff and erosion, improve soil physical and chemical properties as well as reduce fertilizer and pesticide losses (Kim et al. 2013). In the fast-growing PAM soil conservation technology, knowing and surveying its

Table 1. PAM concentrations measured in outer runoff and sediment from treated plots.

PAM ($g\,m^{-2}$)	Mean and Standard Deviation of PAM Concentration in Runoff ($mg\,l^{-1}$)	Mean and Standard Deviation of PAM Concentration in Sediment ($mg\,l^{-1}$)
Control	ND*	ND*
0.4	2.579 ± 0.328	ND*
0.6	3.104 ± 0.159	ND*
1	3.439 ± 0.1.424	2.261 ± 0.905
2	3.452 ± 0.962	2.948 ± 0.892
3	4.748 ± 1.219	3.815 ± 0.2.220
4	7.093 ± 1.730	6.879 ± 1.632
6	7.501 ± 1.554	7.629 ± 0.480

*Non-Detection (Below Detection Limit (<2.07 $mg\,l^{-1}$).

residues after application in lost soil and discharged water is the first step to develop optimal PAM application rate.

2 METHODOLOGY

The experiments were conducted at the Rainfall and Soil Erosion Simulation Laboratory in Natural Resources Faculty of Tarbiat Modares University, Noor, Iran. The small boxes (0.5 × 0.5) with a steep slope (20%) were used in three replicates. The slope was selected based on the average slope of the original area i.e. Bojnourd, northeastern of Iran where the soil was collected. The simulated rainfall with intensity of 72 $mm\,h^{-1}$ and duration of 30 min and PAM treatments of 0, 0.4, 0.6, 1, 2, 3, 4 and 6 $g\,m^{-2}$ were used as experimental rates. Data were collected on runoff flow rates, sediment weights, and PAM concentration emitted in runoff and sediment samples. The PAM analytical technique was also applied based on spectrophotometer, determination of amide groups by the N-bromination method (Lu & Wu, 2001).

3 RESULTS AND DISCUSSION

The volume of runoff and weight of sediment were collected at the end of simulated rainfall with duration of 30 min. Then PAM concentration emitted in runoff and sediment samples was measured. Results of PAM concentration tracing in runoff and sediment from erosion plots measured by Spectrometer at 570 nm in three replications have been summarized in Table 1.

In the present research, the optimum application rate was selected based on decreased runoff and sediment amount and the residual of PAM amendment in outer runoff and sediment. The analysis of the results revealed the optimal amount of PAM based on its residues in runoff and sediment at rate of 2 and 0.4 $g\,m^{-2}$, respectively.

4 CONCLUSION

An optimal level of soil amendments is required to get the best effect based on conserving environment from probable unsafe amendments and to have sustainable watersheds. In the present study, an attempt was made to determine the optimal rate of PAM as soil amendment based on environmentally assessment of the work under laboratory conditions. The results showed helpful data to address environmental concerns regarding PAM application to soil erosion control, conservational and integrated watershed management. In conclusion, more extensive studies and measurement is needed toward resolving the present environmental problems due to variety soil amendments.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

The relationship between vegetation management and reduction the risk of wind erosion

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ABSTRACT: Wind erosion is a major environmental issue affecting land resources and socio-economic settings in Iran. This paper outlines a study undertaken to provide a new tool to manage wind erosion from physical and economic perspectives. The focus of this study is on exploring the economic and physical impacts of 16 vegetation-based scenarios for wind erosion management as well as conducting a trade-off analysis using the Multi-Criteria Decision Making (MCDM) technique. This involves developing a modeling system to assist decision makers in formulating scenarios, analyzing the impacts of these scenarios on wind erosion, and interpreting and suggesting appropriate scenarios for implementation in the area. The IRIFR, 1 was applied for the present condition and for the possible vegetative management scenarios. Among 16 scenarios for wind erosion management, most appropriate ones have been chosen considering the trade-offs of the outcomes.

1 INTRODUCTION

The deserts are naturally fragile ecosystems that are easily disturbed by human interventions. The disturbance in desert ecosystems results in vulnerable conditions which can be readily deteriorated by eroding factors such as water and wind. Wind force is the dominant factor controlling the soil erosion and sediment transportation rate in arid zones. Since the pedogensis process in the arid areas is very slow, soil erosion and sediment transportation in these areas are considered as critical issues (Ekhtesasi & Ahmadi 1997) Mathematical representation of detachment, transport, and deposition stages of the wind erosion process is used for modeling purposes. During the last four decades many equations and models were developed and extended (Ekhtesasi & Ahmadi 1997). Some of well-known wind erosion models are WEQ (Wind Erosion Equation), WEPS (Wind Erosion Prediction System), and RWEQ (Revised Wind Erosion Equation). To estimate the qualitative and quantitative intensity of wind erosion, the IRIFR, 1 (the Iranian Research Institute of Forests and Rangelands) model has been developed for arid areas of Iran. This model uses nine factors to estimate the wind erosion intensity.

In this study, the IRIFR, 1 model has been applied for the southern parts of the Kashan Plain in Iran. One of the main issues in this area is inadequate management of vegetation cover such as fire wood collection and overgrazing which are observed across the study area. Therefore, the aim of this study is to predict the probable impacts of the vegetation-based management scenarios in the study area.

2 MATERIAL AND METHODS

Southern part of the Kashan Plain located between 51° 28′–51° 39′E longitude and 35° 02′–35° 29′N latitude has an area of approximately 4320 km^2 (Fig. 1). This part of the plain has been affected by desertification processes and wind erosion is the dominant factor across the plain.

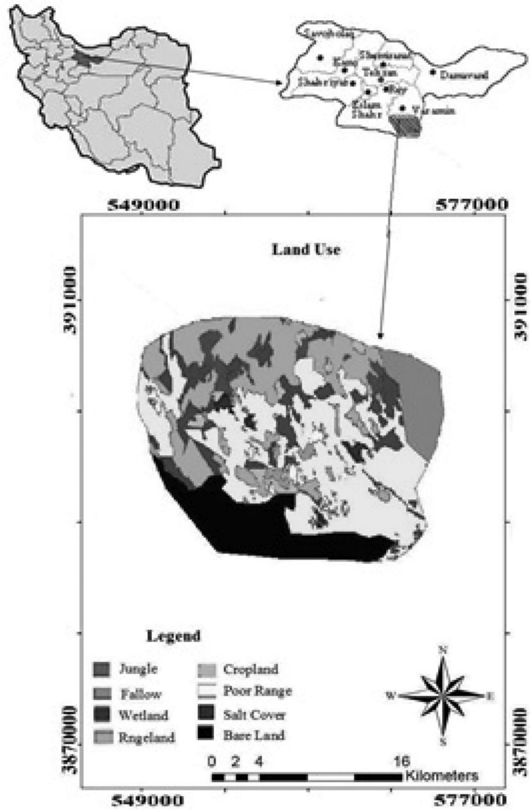

Figure 1. Location of the Kashan plain.

The IRIFR, 1 model has been applied to assess the wind erosion severity of the area. In this research, The study area was divided into some homogenous management units by overlaying of soil, vegetation density, and geomorphology map layers. The IRIFR, 1 model input map layers include geology, landforms and terrain type, wind speed and direction, soil and land cover, vegetation density, soil erosion features, soil moisture, type and distribution of sand deposits, and land use. These maps were prepared and superimposed using the ArcGIS software to estimate the wind erosion severity over each management unit. The Spearman rank correlation coefficient was calculated to evaluate the accuracy of hazard zonation. The Spearman rank correlation coefficient is usually used when the samples are not normally distributed (Mesdaghi 2004). It varies between -1 (a perfect negative correlation) and $+1$ (a perfect positive correlation). To develop management scenarios, all feasible management actions were listed and all of the possible combinations of those actions were considered. In order to determine the feasible management actions, all the planning constraints such as time, costs, labor, efficiency, and regulations were considered. The feasible management actions for the southern parts of the Kashan Plain are enclosure, seeding, seeding accompanied with enclosure, and saltbush plantation. Assuming the present condition as a base case scenario, the number of new scenarios will be $2^n - 1$ in which n is the number of management actions. The base case scenario is regarded as scenario one and the other scenarios are compared with it (Heathcote 1998). Table 1 presents the scenario development rules.

For each scenario, the land cover pattern map was synthesized using the query command of the ArcGIS software. By assuming that the other seven input maps of the IRIFR, 1 model are not

Table 1. Rules for vegetation-based scenario development for the southern part of the Kashan plain.

Management action	Suitable areas before implementation of action	Condition after implementation of actions
Enclosure	Poor & moderate rangelands	Moderate & good rangelands
Seeding	Bare lands	Poor rangelands
Seeding & enclosure	poor rangelands	Moderate rangelands
Saltbush development	Saline lands	Poor rangelands

Table 2. Vegetation-based scenarios developed to manage the wind erosion in the south of the Kashan plain.

Management action	S1	S2	S3	S4	S5	S6	S7	S8	S9	10	S11	S12	S13	S14	S15	S16
Enclosure	–	+	–	–	+	–	+	+	–	–	+	–	+	–	+	+
Seeding	–	–	+	–	+	+	–	+	–	–	–	+	–	+	+	+
Seeding and enclosure	–	–	–	+	–	+	+	+	–	+	–	–	+	+	–	+
Saltbush development	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+

changing by the management actions, the wind erosion hazard map for each scenario was created. Table 2 presents sixteen vegetation-based scenarios developed for the study area by combining all different management actions.

The extent of wind erosion hazard classes for each scenario has been compared with the classes of the present condition (base case scenario). The Kappa index of agreement was used for comparison purposes. Several criteria and indices can be used to select the best scenario among various scenarios. Usually a set of criteria which include the public attitude and values are suggested (Heathcote 1998). However, in this study, the physical and economic criteria were used. Differences between wind erosion hazard maps at the present condition and after implementation of each scenario have been used as the physical index. To this end, the ordinal values of wind erosion hazard classes have been multiplied by their extent and summed up to obtain the value of the physical index. Since the implementation of each scenario will result into changes in the dry mass production, total gross margin and establishment costs were used as two indices of economic criteria. Total gross margin is described as the gross income minus the variable costs associated with an enterprise/activity (Norman et al. 2002).

$$G = \sum_{j=1}^{m} \left(P_j Y_j - C_j\right) A_j \tag{1}$$

Where, G is total gross margin; P_j is price of crop j (Iranian Rials per production unit, kg); Y_j is yield of crop j per unit area (ha); C_j running cost of crop j (Iranian Rials per unit area); m is number of crops, and A_j is the area under crop j. The values of input parameters used in the economic calculations were obtained from the previous rangeland management studies conducted in the study area (Tehran Natural Resources Bureau 1999).

For vegetation-based scenarios the establishment costs are identified as labor cost and seed price. The establishment costs of each management scenario have been calculated by Eq. 2

$$E = \sum_{i=1}^{n} d_i \left(A_i - \overline{A}_i\right) \tag{2}$$

Table 3. Distribution of wind erosion hazard classes for the present condition in the southern parts of the Kashan plain.

Hazard class	Very low	Low	Moderate	High	Sum
Area (ha)	22896	59184	295920	54000	4320000
Area (%)	5.3	13.7	68.5	12.5	100

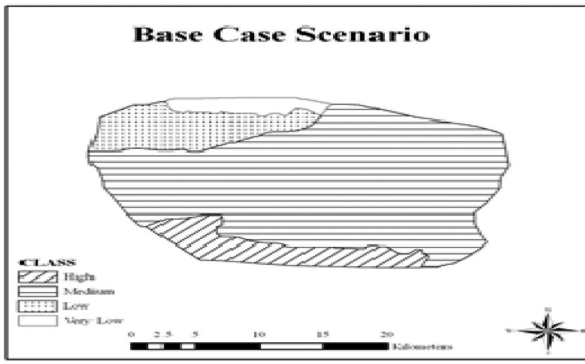

Figure 2. Wind erosion hazard map of the southern parts of the Kashan plain for the present condition.

where, E is establishment costs; d_i is the cost of the management activity i; A_i is the area of activity i; $\bar{A}_i$ is the area of activity i for base case scenario; and n is the number of management actions. Therefore, the costs of each management scenario are the sum of all actions' costs.

The linear scale transformation has been used to convert the original index values into standardized index values. There are various methods of linear scale transformation (Sadoddin 2006). In this study, the method of maximum standardization has been applied. In this method, to standardize a benefit effect, the value of each index is divided by the highest value of the index across different scenarios. For instance, to standardize the gross margin index, its value for each scenario is divided by the highest value of the index across different scenarios. For a cost effect, such as wind erosion (the physical index) and establishment costs (an economic index) Equation 3 has been used:

$$\text{score}_{\text{standardized}} = 1 - \frac{\text{score}_i - \text{score}_{\min}}{\text{score}_{\max}} \quad (3)$$

The Delphi method has been used to assign weights to the indices. For this purpose, a panel of six experts in natural resources management have been addressed and requested to weigh the indices on a given scale of 0 to 1. After gathering the responses, they have been collated and returned back to the contributors and requested to revisit the weights in case of inconsistency. This process is repeated until a consensus is reached on the weights assigned to the criteria. Multiple Criteria Decision Making (MCDM) technique has then been applied to evaluate the scenarios. For each scenario, the standardized score of indices have been multiplied by their corresponding weights and summed up to provide a criterion for evaluation purpose. The scenarios with higher total sum of weighted scores have been identified as the best ones. For visual comparison of the index values associated with each scenario, segment diagram presentation was utilized. A sensitivity analysis has been carried out to determine the dependency of results to the weights of the indices. (Knack 1996).

3 RESULTS

The input parameters of the IRIFR, 1 model were estimated and summed up to predict the wind erosion severity of management units across the management scenarios and their respective wind erosion hazard maps were then synthesized. For instance, Table 3 and Figure 2 show the extent of wind erosion hazard classes of the study area for the present condition and the wind erosion hazard map, respectively.

4 CONCLUSION

Based on the IRIFR, 1 model, land use type and vegetation density are the two important parameters controlling the wind erosion rate and hazard. Therefore, selection and implementation of best land use types and management practices are necessary to control wind erosion in a region. Using a scenario-based approach is a straightforward and efficient way to choose the best land use type over an area. Since each management scenario may have some positive and negative physical and/or economic impacts, a MCDM approach has been applied to trade off the impacts and chooses best scenario/s.

To develop the scenarios, the technical limitations related to the management actions have been considered. It was also assumed that there are no serious ecological and social limitations for implementation of the management actions. In other words, all of the scenarios were considered to be feasible. The sensitivity analysis indicated that the results of the MCDM are not significantly affected by the different perspectives. The result of the sensitivity analysis indicated that four scenarios of S16, S13, S8, and S7 were among best scenarios regardless of the weighting perspectives. These four scenarios are identical with the scenarios which were chosen by the Delphi approach as best scenarios. This indicates the robustness of the approach implemented in this study.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

The study on water erosion in Amameh watershed using observed sediment data and EPM

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ABSTRACT: The estimation of erosion and sedimentation rates in a watershed has always been an interesting subject for planners and researchers in the field of erosion and sedimentation. Employing several empirical models and techniques is prevalent due to the shortage of measured and recorded data in Iran, although application of these models is not always followed by appropriate, logical, and expected results because of various reasons. The present investigation is intended to explore the condition of water erosion and production of sediments in Amameh watershed using EPM empirical method and comparing its results with the observed sedimentation data in this region. According to data intermediate analysis, compared to the observed sedimentation data, the results of estimation of sedimentation rate showed that the rate of relative error has been 117.7% in EPM empirical method.

1 INTRODUCTION

Soil erosion is a natural process and generally aggravated by human intervention, and exceeds the rate of soil regeneration; it is the most widely recognized and most common form of land degradation and, therefore, a major cause of falling productivity (Stocking and Murnaghan 2001). Soil erosion affects the earth and its inhabitants directly and indirectly (Toy et al. 2002). The approximately actual estimation of erosion and sedimentation rate in a region is an important issue in which the quality of its estimation has been noticed by researchers. Lack of accurate data about rate of erosion and sedimentation in many countries makes using of estimation models of erosion and sedimentation inevitable, but such models do not always result in logical and close to actual responses (Ahmadi 1995).

Methods for estimating sediment yield were first developed for the analysis of the effects of agricultural practices using empirical models to evaluate soil erosion and sediment yield in watersheds without statistical data. Empirical models have been and are still used because of their simple structure and ease of application. One of the most important problems with empirical models of soil erosion is their lack of accuracy in processing the huge numbers of data which should be digitalized by GIS system and analyzed by mathematical models. MPSIAC is an empirical model to estimate the quantity and quality of sediment. In fact quantifying and digitalizing the sediment data is an important breakthrough in sediment assessment models development (Nearing et al. 1999).

The current research was carried out in Amameh watershed, and the EPM empirical method was performed there and the given results were compared with the observed sedimentation data in Amameh sedimentation measurement station.

2 MATERIALS AND METHOD

2.1 *The studied region*

The studied area is geographically situated in Tehran province, Iran, among northern latitudes (35°52′01″–35°56′49″) and eastern longitudes (51°32′31″–51°38′37″) (Fig. 1). This watershed is

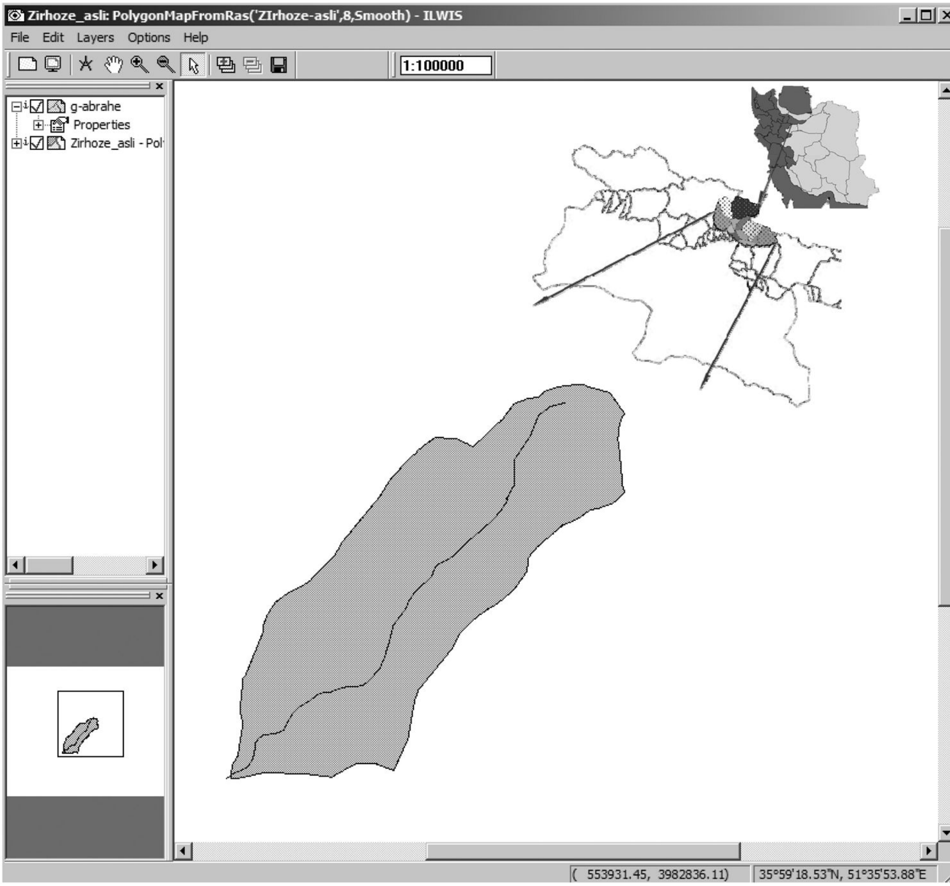

Figure 1. The location of Amameh watershed, Tehran province, Iran.

drained to Latian Dam Lake with the main river, named Amameh. Total area of this watershed is 3801 hectares, and the elevation of this region ranges from 1750 to 3855 m with average height of 2687 m above sea level. The average slope of the watershed is 49.64% and the aspect of hillside is mainly westward. The average annual precipitation is about 865 mm and the average annual temperature is 5.32°C in this area. The regional climate is of higher mountainous type in 2000 m height above sea level, and this climate is of semi- humid and highly cold type in the region with height lower than 2000 m above sea level. With regard to geologic properties the main part of this watershed is covered by Karaj formation and the soils are classified in two main orders: entisol and inceptisol. The main land use type over the watershed is range land with perennial shrubs such as *Astragalus* sp.

2.2 *Methodology*

EPM method was introduced in an international conference on water system in 1988 (Gavrolovich 1988). This model can estimate the amount of soil erosion and sediment yield of a watershed, and soil erosion maps can also be drawn. The model calculates the erosion sensitivity coefficient by mean of equation (1):

$$Z = Y.\ Xa\ (\Psi + I^{0.5}) \quad (1)$$

In which the 4 basic specifications are: erosion coefficient of watershed Ψ), the coefficient of land use (Xa), the coefficient of soil and rock sensitivity to erosion (Y), and the average slope (I).

According to Z values of each unit and the relevant table, erosion sensitivity values are classified. The volume of special erosion is calculated using equation (2):

$$Wsp = T.\ H.\ \pi.\ Z^{1.5} \tag{2}$$

In which: Wsp is the average annual special erosion in terms of cubic meter in square kilometers, H is the average annual rain in the auriferous area in terms of millimeters, and T is Thermal index which is calculated by equation (3):

$$T = (t/10 + 0.1)^{0.5} \tag{3}$$

In which: t is the average annual temperature in area in terms of Celsius. To estimate the volume of erosion EPM model applies the (R_u) coefficient to turn erosion to sedimentation by equation (4):

$$R_u = 4\,(P \times D)^{0.5} / (L + 10) \tag{4}$$

In which: R_u is sedimentation coefficient in watershed. L is the length of the watershed which is the same as the length of the straight line that joins the two ends of watershed. P is perimeter of watershed in terms of kilometers. D is the average elevation difference in the area which is calculated by equation (5):

$$D = D_{ar} - D_o \tag{5}$$

In which: D_o is the elevation of the outlet of watershed from sea level and D_{ar} is the average elevation of watershed from sea level in term of kilometers. The equation (6) calculates the amount of special sedimentation:

$$G\ sp = Wsp\ .Ru \tag{6}$$

In which: G sp is the annual special sedimentation in terms of cubic meter in kilometer. And finally the equation (7) can be used to determine the total volume of annual sedimentation:

$$G\ s = Gsp\ .A \tag{7}$$

In which: Gs = the annual total sedimentation in terms of cubic meter by kilometer and A is the area of watershed in square kilometers.

To estimate the rate of sedimentation of the watershed based on the measured data of suspended sediment load, sediment rating curve using the technique proposed by Johnson (1980) was employed.

3 RESULTS

3.1 *Calculation of soil erosion density*

Soil erosion density coefficient (Z-factor) and its classified map were produced using a GI system. The map of erosion features was prepared initially by means of "Landsat" satellite images. A rocks sensitivity map was produced according to the geologic map and the slope map was calculated from the digital elevation model (DEM). Overlapping the erosion features map, rocks sensitivity map and slope map, the homogeneous units map was prepared. Afterwards, according to tables

Table 1. The areas of soil erosion density classes.

Soil erosion density classes		Very low	Low	Average	High	Very high	Total
EPM	Area (ha)	580.54	287.66	302.21	1953.17	675.28	3798.86
model	Percent	15.28	7.57	7.96	51.41	17.78	100.00

Table 2. The stages of calculation of the rate of erosion and sediment yield in EPM model.

Calculation of erosion density coefficient and specific erosion

Study area	Soil & rock factor (Y)	Land Use factor (Xa)	Erosion Coefficient (ϕ)	Mean Slope (I)	Erosion density (Z)	Mean precipitation (mm)	Mean temperature (°C)	T factor	Specific Erosion (WSP)
Amameh wateshed	0.83	0.46	0.60	49.64	0.46	864.99	5.32	0.80	667.93

Calculation of specific and total sediment yield

Study area	Mean elevation (m)	Minimum height (m)	Height difference (m)	watershed perimeter (km)	watershed area (km^2)	watershed length (km)	Sediment yield coefficient	Specific Sediment yield	Total Sediment yield
Amameh wateshed	2687.0	1750.0	0.94	29.51	38.01	29.51	0.94	628.6	23894.4

derived from EPM method, erosion intensity coefficient (Z-factor) in each homogeneous unit was computed using 4 factors including soil and rock erosion coefficient, lands use, erosion status, and the mean slope. The soil erosion density map was derived for Amameh watershed based on classification of values of the erosion density coefficient (Z-factor) within descriptive classification of erosion density orders in five levels comprised of very low, low, average, high, and very high (Table 1).

4 THE RESULTS OF ESTIMATION OF SOIL EROSION AND SEDIMENT YIELD

To estimate the amount of soil erosion and sediments yield in Amameh watershed, the average rate of each of these values for total watershed was computed based on the calculated values of erosion density coefficient to any homogeneous unit; and also the rates of specific soil erosion, sedimentation coefficient, specific sediment yield, and total soil erosion and sediment yield were calculated based on model equations and using GI system (Table 2).

Based on the observed data of sediment load in Kamarkhani gage, average annual specific and total sediment yield of the river was calculated based on the sediment rating curve (Table 3).

5 DISCUSSION

The results of the present research indicate that compared to the observed sedimentation data, application of EPM model for estimation of watershed erosion and sediment yield in Amameh watershed shows significant difference. In contrast, the derived rate of sediment yield sediment rating curve, the relative error percentage is 117.7% for EPM model (Table 4).

Table 3. Sediment data analysis based on sediment rating curve.

hydrometric station	Elevation from sea level (m)	Area of upstream watershed (sq.km)	Annual mean discharge (m^3/s)	Annual runoff volume (MCM)	Sediment yield based on sediment rating curve (tons/year)			
					Specific suspended sediment yield	Specific sediment yield	Total suspended sediment	Total sediment yield
Kamarkhani	1890	37	0.58	18.23	257.91	296.60	9542.55	10973.93

Table 4. Comparison between the estimated and observed sediment yield of study area.

	Observed sediment yield	Estimated sediment yield	Relative error (percentage)
Sediment value (tons/year)	10973.93	23894.46	117.7

The high rate of relative error value in EPM model can be attributed to the non-localized nature of this model and difference in conditions of the area of origination of this model in contrast with the studied region. These findings comply with the studies conducted by Koopaei (1997) and Shahbazi (2000). On the other hand, although the recorded sediment data in hydrometric stations and especially in Kamarkhani station are usually related to non-flooding periods while the major part of sediments in this watershed has been also collected during flooding periods, the rates of sediments should be cautiously estimated according to curve parameter-based techniques in those watersheds, which lack confident data (Arab Khedri et al. 1998). With respect to results of this study, it was identified that EPM model is not relatively appropriate for estimation of erosion and sedimentation in Amameh watershed, so it is suggested that the efficiency of other experimental models be explored in this region.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Assessing water quality in small islands. The Santa Cruz (Galapagos) case study

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ABSTRACT: Galapagos islands are one of most important biodiversity hot spot in the world, whose importance was recognized also by UNESCO in the World Heritage list. Despite the great effort for their conservation, the increasing human pressure and the consequent pollution, in particular of the water resources, are threatening the environment and the health of the inhabitants. The results of the cooperation project "Health protection and prevention of anthropic pollution risks" are presented here. The main water pollution sources in the island of Santa Cruz were identified, an extensive water monitoring was carried out and public local authorities were supported to improve water resources management.

1 WATER QUALITY ISSUES IN GALAPAGOS ISLANDS

The Galapagos Islands, located across the equator about 1000 km far from the Ecuadorian coastline, are an archipelago composed by 250 islands, out of which only four are inhabited. The archipelago is often defined as a "living museum and showcase of evolution" and has been inserted in the UNESCO Worlds Heritage list in 1978 in order to protect its fragile ecosystem (UNESCO, 2014). Despite the high attention toward their protection, these islands are alarmingly endangered by the introduction of alien species and by the increasing population and touristic activities (Grenier & De Miras 1994). In fact, the number of inhabitants has doubled in the last 20 years (e.g. from 9.000 in 1990 to 25.000 in 2010; Leon & Salazar 2013) and the number of tourist increased from 82.000 in the year 2002 to 204.000 in 2014 (PNG 2014).

In particular, in the island of Santa Cruz the anthropic activities, even if concentrated in small urban areas, generated a considerable level of contamination of water and soil with severe impacts on both the environment and the local population's health (Liu & d'Ozouville 2013). For this reason, public administrations of the island recently recognized the importance of protecting the scarce water resources from further contamination and promoted several studies and collaborations specifically addressing natural resources quality assessment (d'Ozouville & Merlen 2007). Within this framework, the University Ca' Foscari of Venice started in the 2011 the technical cooperation project "Health protection and prevention of anthropic pollution risks", with the overall objective of supporting the sustainable development of the Galapagos archipelago. In particular, a pilot case study in the Santa Cruz island was developed with the aim of identifying the main water pollution sources and supporting public local authorities in the improvement of water resources management. In this manuscript, both the project and the preliminary outcomes are presented. Results will be used to provide advices for the implementation of alternative strategies for water resources and health protection.

2 WATER QUALITY ASSESSMENT IN SANTA CRUZ ISLAND

The first phase of the project aimed at performing a preliminary assessment of the water quality based on existing data collected by several authorities/institutes. In order to achieve this objective a technical committee involving public local authorities with competences on water was organised. Successively, all available data were homogenised and organised within a geodatabase. This activity allowed obtaining a first indication of the water quality in the island of Santa Cruz, highlighting data needs and gaps. The following step was the organization of a monitoring campaign in cooperation with local authorities. It was aimed at creating a baseline of monitoring data useful for water quality assessment and representing the reference condition for further monitoring activities. The monitoring focused on the main water supply sources for domestic purposes and on a small semi-enclosed basin with brackish waters, called *Laguna de las Ninfas*. The latter also represents one of the main recreational areas for the local population, particularly affected by pollution issues due to domestic and hotels' wastewater discharge. The third, on-going, phase of the project, aims at completing the assessment of water quality.

Monitoring results showed that contamination of potential sources of drinking water is mainly related to BOD (Biological Oxygen Demand) and oil & greases, both up 10 times higher than regulatory thresholds, as well as salinity (most often in the range of 1-4 PSU instead of max 0.5 PSU). Similar results were found also for water and sediment taken from *Laguna des las Ninfas*. These results prove the occurrence of an extensive organic contamination in the waters of the Santa Cruz Island.

3 CONCLUSION

The present project represents a first step in the implementation of a monitoring plan that should continue in future and could be replicated in the other populated islands of the archipelago (i.e. San Cristobal, Isabela and Floreana). Results will be used to support sustainable planning processes and to define specific interventions for water pollution reduction. A further step is represented by the implementation of a Decision Support System for local stakeholders based on the geodatabase of water quality data.

ACKNOWLEDGEMENT

The described activities were carried within the project *Tutela della salute e prevenzione dai rischi di inquinamento antropico* funded by the Veneto Region (Italy) in the framework of the direct initiatives for the development of international cooperation.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)

Economic value of water in arid regions: Greenhouse culture application

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ABSTRACT: New cultures practices such as greenhouse culture have an important role in optimum consumption of water resources especially in arid regions. The purpose of this article is to estimate the water demand for these cultures.

At this study, 95 beneficiaries were selected randomly out of 153 and data were collected accordingly. Based on the results, there is negative relationship between water price and water consumption. Demand elasticity estimation reveals that greenhouse producers' sensitivity to water price changes is high (almost 12.83 percent).

This article shows that efficient use of technologies such as greenhouse cultivation has very significant role in controlling the optimum consumption of water that in turns will improve the position of water value among consumers. Considering the result that the water consumption level for greenhouse cultures in the study area is located in the second economic region, supporting greenhouse productions can lead to a optimum use of water input in agricultural sector.

1 INTRODUCTION

In production sectors such as agriculture, water is considered as a middle input or as a production input (Chambers 1988). According to many authors, water input has the most influential effect in production cycle (Musavi et al. 2007). This study aims to assess the productivity of water exploitation using it as a production function and to compare it with other effective inputs. It is focused on water demand and water demand elasticity in modern cultures practices and their role in productivity. Water productivity is generally regarded in terms of net water return for each water unit (Molden et al. 2010). When water exploitation is justified in an efficient manner it can help to prevent waste. It can also be used to develop policies that avoid negative effects on a region's productivity. It should be noted that a production function estimation is a parametric method (econometrics) used to approach productivity territory and generally most investigations are aimed at 'water productivity' in titles like suitable agricultural water pricing, economic water price, agricultural water demand, water market, policies and water management, and agricultural optimal water allocation, so many of them in the literature are closely related (Hexem & Heady 1987, Soltani & Zibaei 1996, Hoseinzad & Salami 1999). Studies have recognized that alternation provides a suitable cultivation pattern to lower water consumption. However, management of many factors at the same time, as mentioned earlier is a way to achieve optimum productivity from a water supply (Shajari et al. 2007). Taking into account production function, research has determined that the real economic value of water is far above that generally used in production. Meanwhile researcher attempted to determine an economic price for agricultural water demand due to strict conditions determining water allocation using production function for various crops (Kulshreshtha Suren & Devi 1991).

Results of short-period elasticity in an investigation entitled 'rural water pricing and drought management' presented a situation that needed a 40% increment in water price in order to attain a 10% decrease in water consumption (Moncur 1987). Water price in Pakistan was calculated with regards to water transportation efficiency and production function approaches (Chakravorty & Roumasset 1991). Another study evaluated effects of pricing strategies on consumption levels and re-allocation of water. A conclusion was drawn that identified pricing strategy as not the only way to control water consumption in agriculture and due to a lack of decrease in consumption level that is particularly evident at lower priced water. Given these results, determining that consumption would decrease according to an increment in price; it would seem that this premise could be implemented to put pressure on income and employment in the agricultural sector (Berbel & Gomez-Limon 2000). In most developing countries in which governmental subside is still given to water for agriculture, a pricing strategy for optimum water allocation and implementation of state-of-the-art technologies to control water consumption are proven to be fruitful (Speelman et al. 2009). The point of view put forward in a paper that considered data from a 50-year period in irrigated plains in the United States is that management has an undeniable role in increasing irrigation efficiency. The view presented in that paper is that between water over-exploitation and farmers' age, there was a strong positive relation and between water over-exploitation and with size of farm there was a negative relation (Lilienfeld & Asmild 2007). This point of view leads to a couple of important considerations. Some researchers have claimed that water price is an effective tool available to facilitate optimum water allocation and to achieve optimum consumption therefore revising methods for water pricing is essential. In Water pricing with attention to economic factors such as value according to demand and marginal cost need to be highlighted. However, some investigations explain the unsuitability of the pricing method as a means to control water consumption and to bring low water price elasticity as the reason for, and emphasize the necessity of competitive market creation for optimum pricing. This paper stresses the importance and sensitivity of water productivity in the new technologies such as greenhouse cultures. Greenhouse cultures are an important crop for the provincial economy in arid regions; it also makes a significant contribution to the national export.

2 STUDY AREA

Located in one of the most arid regions in the world, Iran has an annual average precipitation rate of 252 millimeters, approximately one third of the global average. Exacerbating the severity of water shortages, as much as 70 per cent of precipitation is lost to evaporation. Estimates suggest that lower-than-average precipitation in 2013 caused a 30 per cent reduction in the volume of water in resourves across the country, with only five exceeding 90 per cent capacity (Lehane, 2014).

This research was implicated in Yazd province (Fig. 1). Yazd province with the area of 131,551 km^2 is situated at an oasis where the Dasht-e Kavir desert and the Dasht-e Lut desert meet. The city itself is sometimes called "the bride of the Kavir" because of its location, in a valley between Shir Kuh, the tallest mountain in the region at 4,075 m above sea level, and Kharaneq. The city proper is located at 1,203 m above sea-level, and covers 16,000 km^2. According to the administrative division rules, the Yazd province is divided into 9 counties. Yazd is the driest major province in Iran, with an average annual rainfall of only 60 millimeters. The climate of this region is defined as arid and semi-arid. Its climate has very low annual precipitation and frequent drought producing

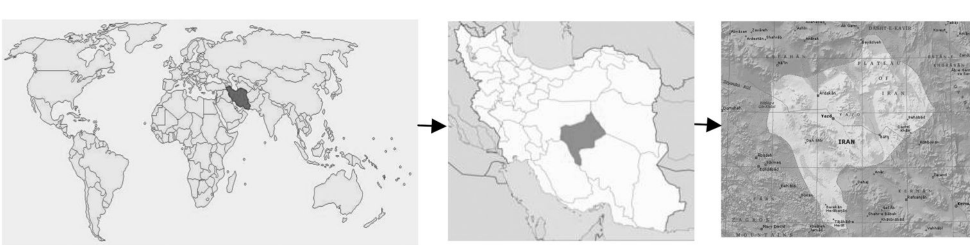

Figure 1. Location of study area in the world map, Iran, and Yazd province.

fragile conditions for agriculture. These problems all affect agricultural production in the region. Over 30% of the region's cultivated area is devoted to greenhouse cultures and this represents a significant sector of the local economy and it has a vital role in many peoples' livelihoods.

3 MATERIALS AND METHODS

According to production and distribution theories, production growth is gained through two ways. Firstly, production is gained through more inputs but in current technological framework. Secondly, the important part of production growth could be achieved according to high technological and efficient ways and more influential inputs (productivity approach) are brought into work. Currently, with regard to input limitation and day-after-day growth in population, using the first approach faces many obstacles in a long run. So nowadays, productivity is one of those which considered the most prominent role toward economic growth regarding input sources scarcity. Two methods are put forward in order to calculate productivity (hoseinzad, 2004): 1- Econometrics (parametric method), 2- Non- parametric method. In former, a production and a cost or benefit function is acquired using techniques of econometrics which shows production structure. In the latter one, by means of mathematical scheduling (input-output way) and productivity index the structure is formed.

Productivity, more generally, is calculated by production function. Also in this study the same method is considered. According to production function, the amount of one output's production relates to various inputs which would be framed as follow:

$$y_i = f(l, f, p, s, m, w, \dots)$$

where $\boldsymbol{y}$ is the amount of production of the specific output and in bracket parameters are the bundles of production factors. Level of participation for each input in the production cycle is acquired through edge production of the input. The more output gains through one input, the more important that input is. Accordingly, edge value of every input in the production cycle, is taken as the economic value or shadow value of that input (Hoseinzad 2004). Principle of efficient manner of consumption of inputs rules us to consume each input till the value of it in the production cycle becomes equal to the cost of it (Chambers 1988). Hence, calculation of production function for each input leads to the calculation of final productivity of the specific input. Indeed by means of production function and calculating production elasticity, the fluctuation of production in agricultural product (consumer of inputs) could be traced for each fluctuation in consumption of input (for any reason like input value alternation).

In order to calculate the efficient production function which is fit with the environment and crops of the region, first various functions like linear, cap Douglas, extended secondary function, extended third function, transcendental and trans-log were estimated. Generally, extended secondary production function, were selected against other functions according to R-square adjusted, Akaike and Schwarz and beside the number of significant numbers results (Table 1).

In addition to production elasticity in the function is related to the amount of consumption of inputs, and the first derivate does have no limitation for signs. Moreover, the function shows three area of production and mutual links between inputs are also included (Hoseinzad & Salami 1999). This function is also compatible with the technical function of production and the links

Table 1. Different functional forms and corresponding significant numbers.

Functional form.	Trans-log	Transcendental	Extended third function	Extended secondary function	Cap Douglas	Linear
Significant numbers	8	19	19	21	5	5

between outputs and inputs. From the existence of extended secondary function is fitted between the functions the most, this function was considered as the production function of the study. In order to calculate marginal product (edge production) first of all the edge production must be calculated. If the extended secondary function is like Equation-1, so the edge production is derived from Equation-2 as followed:

$$y = \alpha + \sum_{i=1}^{n} \beta_i x_i + (1/2)\sum_{i=1}^{n} \gamma_{ii} (x_i)^2 + \sum_{i=1}^{n} \sum_{j=2}^{n} \gamma_{ij} x_i x_j \quad (1)$$

where x_I and x_j are ith and jth inputs, γ_{ij} and β_i are estimated correlations. n is also the number of inputs.

$$MP_i = \beta_i + \gamma_{ii} x_i + \sum_{j=2}^{n} \gamma_{ij} x_j \quad (2)$$

where MP_i is the marginal product of its input. So production elasticity of input is calculated from Equation-3:

$$E_p = (\beta_i + \gamma_{ii} x_i + \sum_{j=2}^{n} \gamma_{ij} x_j)(\frac{x_i}{y}) = \frac{MP}{AP} \quad (3)$$

where E_p shows the input's production elasticity, y shows total production and AP shows average product. Equation 2 and 3 illustrate that in addition to input's consumption, the level of consumption from other inputs affect production elasticity and edge production.

Also, to determine the total value of input's related output for ith case using MP_i, Equation 4 could be suggested:

$$VMP_i = P_y \times MP_i = P_i \quad (4)$$

where VMP is marginal value product for its input, Py is product's price and Pi is input's price. So marginal value product of water (VMP_w) is calculated from the multiplication of product's price (P_y) and marginal product of water (MP_w) as presented here:

$$PY .MP_W = VMP_W \qquad VMP_W = P_W \quad (5)$$

Here Pw is the economic value of water (or VMP_W). Water demand function, represents the economic value of water and marginal value product of water (VMP_W). It explains that manufacturer should consume water till water unit price (one cubic meter) results in more final production value. In another words, the optimum use of water is proven to be when water's related marginal value product of water (VMP_w) equals to the water's price (P_w). (Equation 5). Demand elasticity is obtained from demand equations. Demand elasticity is useful to identifying the pricing changes basis one percent increasing in water pricing. Water pricing elasticity (E) calculates from Equation-6:

$$E= dw/dp * p/w \quad (6)$$

In Equation -6, (d_w/d_p) is slope of water demand function (water demand function is elicited from Equation -4), (p) is average of water pricing in the case study and w is average of water consumption in the crop.

The optimal consumption level for each input (i.e. water) is determined by investigating the production elasticity (Ep) obtained from Equation (3) and the relationship of these items with economic areas. The first economic area represents the production is less than optimal ($E > 1$). In

Table 2. Relationship between optimal consumption level, production elasticity (E_p) and economic areas.

Production Elasticity (E_P)	Consumption Level	Economic areas
$E > 1$	Below optimum	First
$0 < E < 1$	Optimum	Second
$E < 0$	Over Optimum	Third

other word farmers must more consume of that inputs in their production cycle. Second economic area is only logical area of production ($0 < E < 1$). The third area of production is not logical as every unit over – consumption results in lower production not more production (Koopahi 2007). Second area Table 2, displays the situation of optimal consumption level in three categories (Below optimum, Optimum, Over Optimum).

Here in this study, we have taken into account some parameters like labor size (N), fertilizer (K), animal manure (Kh), Seeds (SE), pesticides (P) and water (W). Statistical society consists of 135 hectare Cucumber greenhouses in Yazd province in 2013–2014 crop years. 95 beneficiaries were selected randomly out of 153 beneficiaries and data collected of them. Questionnaires were distributed among beneficiaries. This volume of beneficiaries, were selected for a more precise and accurate results.

4 RESULTS AND DISCUSSION

As mentioned above, in this study using different forms of production scenarios, various production functions such as linear, Kap Douglas, secondary extended function, third extended function, transcendental and trans-log were used and with respect to different criteria and technical links of inputs and production level, secondary extended function was chosen as the most suitable form. SHAZAM software was used for estimating production function. Effectual correlations from inputs in the production cycle for cucumber are brought here in Table 3.

As explained earlier, using calculated production function leads to marginal product (MP), average product (AP) for imported inputs in the equation and then from the ratio of MP to AP, related production elasticity (E) for each input could be estimated (From Equation 2 and 3). Results for each parameter are brought here in Table 4.

If estimated elasticity is placed into 3rd production-area, productivity of input's consumption will be estimated. Table 5. plots the Productivity against water Consumption.

Likewise, as illustrated bellow, marginal value product of water (VMP_W) is elicited from Equation 4.

$$P_W = -69.34 - 0.0000051264884W \tag{7}$$

Using this equation (Pw) and basis on Equation -6, we can reach to demand elasticity estimation. Demand elasticity estimates almost 12.83 percent. In Equation -6, the (dw/dp) is slope of water demand function that already we can obtain this amount from above equation. In this case study the average of water price (p) gets about 987470 Rials (98747 Toman) for cucumber production from one hectare of greenhouse units per year. In here water price is the total costs that were paid by farmers. Based on the author's research, the average of water consumption (w) achieved 15,000 cubic meters per hectare per year.

Table 3. Estimation of effectual correlations estimations for inputs in the production cycle for cucumber.

Parameter	Estimated correlation	t parameter
Number of workers (N)	1.6145*	3.708
Fertilizer's consumption (K)	62.662	1.713
Animal manure consumption (KH)	−16.197*	−3.142
Pesticides consumption (p)	132.55*	3.771
Number of seed consumption(SE)	−0.25336***	−10.39
Annual water consumption (W)	0.075940	2.419
Number of workers * number of workers (N^2)	0.0026444	1.419
Fertilizer's consumption * Fertilizer's consumption (K^2)	−3.3583	−2.392
Animal manure consumption * Animal manure consumption (KH^2)	−0.12332	−1.074
Pesticides consumption * Pesticides consumption (P^2)	−2.7965	−0.9509
Number of seed consumption * Number of seed consumption(SE^2)	−0.000028947***	11.12
Annual water consumption * Annual water consumption (W^2)	−0.000050657**	0.5229
Number of workers * Fertilizers' consumption (NK)	0.14120	0.9901
Number of workers * Animal manure consumption (NKH)	−0.094702	−2.109
Number of workers * Pesticides consumption (NP)	−0.046525	−0.7551
Number of workers * Number of seed consumption(NSE)	0.000023668	0.3950
Number of workers * Annual water consumption (NW)	−0.00089816	−1.362
Fertilizers' consumption * Animal manure consumption (KKH)	1.3335*	3.705
Fertilizers' consumption * Pesticides consumption (KP)	15.803*	3.139
Fertilizers' consumption * Number of seed consumption (KSE)	−0.023446**	−6.601
Fertilizers' consumption * Annual water consumption (KW)	−0.092173	−0.8033
Animal manure consumption * Pesticides consumption (KHP)	−3.4741*	−3.231
Animal manure consumption * Number of seed consumption (KHSE)	−0.0062445**	6.941
Animal manure consumption * Annual water consumption (KHW)	0.010958	2.121
Pesticides consumption * Number of seed consumption(PSE)	0.028939**	−7.469
Pesticides consumption * Annual water consumption (PW)	0.033988	2.465
Pesticides consumption * Annual water consumption (SEW)	−0.000028233*	−4.236
Distance from center (Constant)	324.77*	3.787

***, **, * mean 1%, 5% and 10% significant level, respectively.
R-Square = 0.9776 R-Square adjusted = 0.6757 Durbin-Watson = 2.5043
Von Neumann ratio = 2.2546 Jarque-Bera normality
Test-CHI–Square(2 DF) = 0.5641 P-value = 0.754

Table 4. Final production, average production and production elasticity for each input in cucumber production.

Related inputs	AP	MP	E
Labor	2.317	−1.6145	−0.696
Animal manure	62.45	−10.62	−0.170
Fertilizer	170.21	81.057	0.476
Pest management	159.03	−25.65	−0.161
Seed	0.83527	0.35	0.419
Water	1.03906	0.28904	0.278

Table 5. Comparing various inputs in production cycle according to productivity of consumption versus water input.

cucumber	E_N	E_K	E_{KH}	E_P	E_{SE}	E_W
Estimated value	−0.69	0.476	−0.17	−0.161	0.77	0.278
Economic area	Third	Second	Third	Third	Second	Second
Consumption level	Over optimum	Optimum	Over optimum	Over optimum	Optimum	Optimum

5 CONCLUSIONS

Equation 4 shows the economic value of water for cucumber production. The equation explains the suitable place of water in agriculture for cucumber greenhouse owners as a situation in which marginal value product of water (VMP_W) is equal to its related cost. Thus, there is a negative relationship between water consumption and water price. Demand function results in this study with emphasis on the relationship between price and consumption confirm previous studies (Moncur 1987, Berbel & Gomez-Limon 2000) This reflects that appropriate pricing policies are as the consumption lever that improve the consumption efficiency.

Water demand function displays that producers of greenhouse should continue amount of water consumption until that the cost of water consumption (for one cubic meter) increases economic value of water the minimum amount of water price. So, the optimal amount of water consumption is where the marginal value product of water (VMP_W) is equal to the price of water.

According to Table 4, the production elasticity average for water input ($E_W = 0.278$) represents the production is located in second economic area. Production in the second area is only the logic area of production (Koopahi 2007). In this area, with increasing the inputs consumption, the final production and average production both is decreased. Marginal product (1.03906) and average product (0.28904) for water input is obtained. Both of them are positive and marginal product is less than average product. The production elasticity (E_w) represents optimal water consumption in greenhouse cultures.

According to Equation 6, demand elasticity estimation revealed that greenhouse producers' sensitivity to agriculture water price changes is high and almost 12.83 percent.

This figure shows that greenhouse cucumber crop has high consumption sensitivity toward water pricing changes. In other words, it should be noted that the increase of one percent in water price will reduce water demand by 12.83 percent. Demand elasticity is the relationship between water price paid and the amount of water consumed by farmers (demand for water). Because of water consumption in greenhouse cultures is located in second area; we can conclude that increase of water pricing is detriment of greenhouse productions and it has no a role in optimum consumption of water. Therefore, as a result, the research stipulates that the required (just needed or the equivalent amount of water/crop yield) volume of water is used for production but if the price increases, water will not be used for that pricing because elasticity is high. Demand elasticity estimation at this study was important because it helps firms model the potential change in demand due to changes in price of the water. A firm grasp of demand elasticity helps to guide firms toward more optimal competitive behavior.

As a conclusion, the rational approach implies that the required volume for production should be kept at a lower price while any amount exceeding that, must be higher in order to prevent water wastage.

This study proves that water consumption level in greenhouse cultures is considered to be based on econometric criteria. Therefore, replacing traditional with new ones by state has a significant role to achieve this success in the study area (Islami et al. 2013) and ultimately is effective to improve productivity in arid areas of Iran and agricultural growth in this region.

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Sustainable Watershed Management – Gönenç, Wolflin & Russo (Eds.)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-00018-6

Indices rate determines effective measures for economic evaluation of watershed projects

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ABSTRACT: Comprehensive watershed management plans must be realistic and yet have an insightful perspective on various aspects nationally and regionally. A general conservation area (soil, water would only cover, etc.) can prevent erosion, sediment transport, flood risk and drought damage, and sustainability of the water regime of rivers causes geometric characteristics and optimal utilization of available resources.

For the purposes of valuation and economic evaluation of the physical and economic impacts of projects and also to provide an appropriate framework, the selection of compatible and indicators needs to be determined in addition to determining the benefits, physical and economic effects of the economic efficiency of projects as well as manner conducting them.

The aim of this work is to provide a framework for economic evaluation of watershed projects so it's possible to apply ecosystem-friendly choices at lower costs and provide more future revenue. Physical impact assessment and economic feasibility study of watershed management action and the effects of economic data are converted based on the index (B/C), the estimated cost of the project is executed, and the bases of its profits are used.

Evaluation shows that rehabilitation of watershed with discount rate of 15 percent during a period of 30 years will be justified economically in lands with low and relative productivity, and implementing soil conservation activities in mountainous rangelands and hilly badlands with high soil erosion will have a positive net present value. Also, developing new springs, the potential of their irrigation, conserving lands, roads and buildings against flood hazard and conserving reservoirs against sediment deposition consists of 48, 20 and 7 percent of total benefits of NPV in rehabilitated watershed.

In this study we conducted a field investigation of the Projects, the set of indicators and identified their projects' valuation methods, and compared the costs and benefits of watershed management projects. This included the physical implications (of projects), financial and economic consequences (increased production and income of residents in the areas of direct and indirect impact), environmental impacts (changes in ground water quality, soil erosion, biodiversity, water levels surface and groundwater, wildlife habitat, soil salinity and alkalinity, etc.) and various assessments mentioned including environmental, social, economic, and distribution and presentation of case studies.

1 INTRODUCTION

Land destruction has undesirable economic, social and bioenvironmental consequences for efficiency, distribution of income and environment that may play a major role in national and international economy and stable development of agriculture. This is why evaluation of costs of soil erosion and land destruction are the cases which agricultural economics and environmental researchers have considered. The researchers have proposed that aerologists, agricultural experts and economists should operate in a group for studying economic consequences of land destruction. Some economists believe that if damage of soil of environment is not compensated, it will be dangerous and its future benefits should be reduced. Therefore, it is seen that economic evaluation and evaluation of costs of soil erosion and soil preservation actions are necessary in Iran so the consequences can be used in future planning. Annually, we were wasting tons of soil by erosion in the country and in order to prevent some part of it, watershed operations are done. As a result, for fulfilling these plans, some considerable costs are used everywhere in the country. Therefore, evaluation of this operation is necessary for finding the consequences of these activities to improve future activities in the fields of watershed and their effect on solving economic-social and bioenvironmental problems of a region. For evaluating operation of soil preservation projects, primary conditions of the region should be studied before fulfilling the plan. These should be studied after operation while comparing accomplished actions and predicted operations' results based on proposed cases in the natural environment. Then, the assimilated effect of every operation with regard to decrease of running water and sediment and also qualitative and quantitative changes of plant cover is looked at by statistics. Economic and social comparisons should be performed using suitable data of economic and social effects caused by watershed operation in the region and the costs of operation.

The main purpose of this research is to study and evaluate the effectiveness of soil preservation activities considering the time and local situation of revived watersheds emphasizing natural, economic and social effects in the country. Therefore, effects and value of negative and positive changes caused by it are studied, recognized and analyzed. Another purpose of this study is to study, recognize, improve and provide new methods of evaluating bioenvironmental and economic effects of revived watersheds. In this research, technical and economic evaluation of brushwood hydrology under the Zidasht area in Taleqan watershed is studied.

2 PRESENTATION OF CONCEPTS

2.1 *What is a watershed?*

A watershed is the area of slope land that all running water of raining on it is received by a river, effluent, lake or a watering place. In other words, it is a topographic area that is drained by a river network. In the above definition, the physical feature of watershed area is emphasized, although, in new definitions, wider concepts are involved so that a watershed, usually counted for a hydrologic unit, is considered as physical-biological unit and in many cases, it is considered as social-economic unit and political rights for the planning and natural sources department.

2.2 *Definition of watershed management*

Watershed management and correct usage of watershed lands are based on preplanned programs such as restraining erosion and regulating floodwaters and sediment and reforming plant cover, etc. In other words, watershed operation is scientific management of watershed area that uses various sciences and experiments while considering economic and social issues and preservation of soil and water sources in watershed areas and the role of people.

2.3 *Necessity of watershed operation*

1) The benefits that we gain by operating soil preservation policies and control of erosion within a framework of watershed operation plans. Continuation of life on earth is not provided without soil. This issue is a more concrete aspect for humans. Namely, our food is provided from soil. Our coverage depends on soil typically, and the air that we breathe has a root in soil.
2) The loss that we bear for not considering soil preservation and watershed operation includes destructive floodwater, drought, disappearance of forests and rangelands, dam reservoirs filled

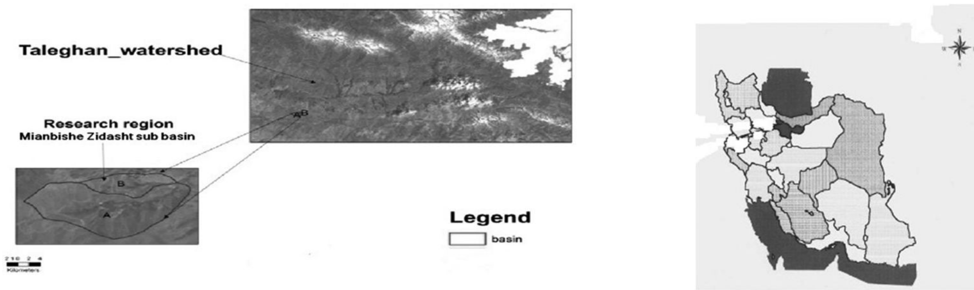

Figure 1. The situation of Mianbishe basin.

Table 1. Biological operations of soil preservation and usage status of lands in 1995–2011.

Period of studying	Road & building (Hectare)	Implant of graft in waterways (Hectare)	Banket & afforesting (Hectare)	Water agriculture (Hectare)	Gardens (Hectare)	Rock lands (Hectare)	Rangelands (Hectare)
1995	4.18	0	0	7	2.14	45.82	90.17
2011	4.36	3.39	14.42	8	2.14	45.62	71.36

with sediments, decrease of underground waters level, becoming dry of pools and ponds in sediment accumulation and low depth of them, and serious damage in human and animal environment. Nowadays, one of the important indicators of development in developed countries is the issue of soil preservation essentially. We can gain this goal by watershed operations for soil preservation and erosion control.

3 THE CASE STUDY WATERSHED AREA

Taleqan watershed is one of subareas of Sefidrood watershed at central Alborz height (Fig. 1). Minimum annual rainfall of watershed is 667 mm that causes flow of 480 million sqm water in discharging watershed. Taleqan dam having 96000 hectares watershed and 420 million sqm reservoir has been constructed on Taleqan River for providing Tehran with drinkable water and irrigation of agricultural lands of Ghazvin. Soil erosion has been annually evaluated as a minimum of 13 tons per hectare according to studies for the last decade. The limit of studied area is hydrologic unit of medium-wood under Zidasht area located at Taleqan area and includes an area of 149 hectares. This mountainous watershed area having height of 2350 meters and the most slope in 20–40 and 40–60 classes is about 61 hectares. According to raining gradient, hydrologic unit of medium-wood receives 571 mm atmospheric falls. Geognosy of this unit has formed by eosin plutonic formation, green Tuff rock of Karaj, sandstone and Neogene's conglomerate and types of erosions are mechanical erosion, erodible, surface erosion, furrow erosion and ditch erosion. In 1995, estimation of sediment production was 9.83 tons per hectares at this hydrology unit. Biological-mechanical actions have been evaluated in Table 1 and 2.

4 METHODOLOGY

According to available information, various techniques of evaluation can be used. In this study we will use direct prices of market (commercial) for some costs and benefit items and also types of

Table 2. Mechanical operations of soil preservation, number, volume and controlled sediment.

Structural Type of sedimentation	Number	Medium volume of structure (sqm)	Average volume of sediment (sqm)	Proportion of volume/structure to sediment
Dry Folding Check Dam	94	874.43	1612.76	1.844
Check Dam	19	1153	4492.8	3.896
Mortar & Rock Check Dam	9	217.69	616	2.83
Gabion Check Dam	1	1	12	12
123	123	2244.03	6733.56	9979.2

Table 3. Evaluation of cost and benefit items in NVP evaluation.

Item	Evaluation of amount (value)
Increase of wood biomass	31 \$/ha/yr
Increase of grass biomass	258 \$/ha/yr
Preventing from sedimentation of Taleghan dam reservoir	86 \$/ha/yr
Bioenvironmental value of carbonic Tarsib	42 \$/ha/yr
Preventing from floodwater in farmlands, gardens and roads	266 \$/ha/yr
Production potential of new source water	635 \$/ha/yr
Cost of land opportunity with relative efficiency	53 \$/ha/yr
Cost of middle wood watershed reclamation and reform	1400 \$/ha
Cost maintenance and preservation period of revived watershed	90 \$/ha/yr

indirect techniques for some other costs and benefit items. In this study, the following methods have been used for evaluating effects of soil preservation operations, described briefly.

Method of superseded cost:The logic inserted in this evaluation method of cost is a special harm and under studying and also its evaluation by using equal or superseded cost. For example, if we evaluate or estimate danger of soil erosion in a farmland, it is necessary to evaluate loss of nutrient materials caused by erosion and replace equal cost by available method of market.

Method of efficiency change:In this method, the lost production is evaluated and compared with prices of market. For example, if purpose of evaluating economic value is the efficiency of lost product due to soil erosion at a place, physical efficiency of products is compared with soil erosion and without soil erosion and then the change in amount of product is gained.

Benefit and cost items: Three important items of lands opportunity cost, cost of reclamation stage and costs of maintenance period and six important items of benefit that are studied as SC effects in analysis of cost and benefit. These are: production of rangeland biomass, production of wooden biomass, bioenvironmental value of carbonic precipitation, value of decrease of Taleqan reservoir dam sedimentation, irrigation potential gained by new sources and preservation of Taleqan farmlands and main road against floodwater and sedimentation. Results are shown in Table 3.

After defining cost and benefit parameters and their evaluation, we need to select a criterion and rules of decision making for evaluation and comparison of economic benefit of projects. There are different criteria for this analysis and evaluation, and within them, there are common criteria such as net present value (NPV), internal return rate (IRR), proportion of benefit/cost (B/C) and proportion of cost to net fund. In the present research, we selected NPV method for analysis of the subject. NPV unlike other criteria such as IRR and B/C, is a reliable criterion because it is not vulnerable for providing ambiguous consequences and it is decreased in form of difference

Table 4. NPV ($/ha) estimates for base case scenario (by annual benefit and cost flow, different opportunity costs of land, 15% discount rate).

YEAR	NB (OCL = 0) (t)	NB (OCLS) (t)	NB (OCLP) (t)	NPV (A) (t)	NPV (B) (t)	NPV (C) (t)
T	A))	C))	C))	D))	E))	F))
1	−371	−424	−1595.00	−322.61	−368.70	−1386.96
2	939	886	−285.00	710.02	669.94	−215.50
3	939	886	−285.00	617.41	582.56	−187.39
4	939	886	−285.00	536.88	506.57	−162.95
5	939	886	−285.00	466.85	440.50	−141.70
6	1197	1144	−27.00	517.50	494.58	−11.67
7	1197	1144	−27.00	450.00	430.07	−10.15
8	1197	1144	−27.00	391.30	373.98	−8.83
9	1197	1144	−27.00	340.26	325.20	−7.68
10	1197	1144	−27.00	295.88	282.78	−6–67
11–30	24566.00	23506.00	86.00	1900.44	1818.44	6.65
Total	33936	32346	−2874	5903.9189	5555.992	−2132.8402

In Table 4, the following notations were used.
a: annual amount consists of 11 to 30 years. To calculate summation it should be multiplied by 20 times
b: decimal summations are rounded
t: time duration
OCL: opportunity cost of land
NB (OCL = 0) (t): Net Benefit without discount rate when opportunity cost of land is assumed zero.
NB (OCLS) (t): Net Benefit without discount rate when opportunity cost of land has a relative productivity.
NB (OCLP) (t): Net Benefit without discount rate when opportunity cost of land has productivity.
calculated based on (A) $NPV = NPV_t^A$
calculated based on (B) $NPV = NPV_t^B$
calculated based on (C) $NPV = NPV_t^C$

between total present value of benefit and the decreased amount of costs during life of the project is defined. Evaluation of investment value of every project is precise and determined based on NPV. According to this criterion, the projects with positive NPV are accepted and the projects with negative NPV are not acceptable. In addition, selection reference for projects with mutual relation is exclusive. (Kitinger 1982)

$$NPV = \frac{\sum_{t=0}^{T} B_t}{(1+d)^t} - \frac{\sum_{t=0}^{T} C_t}{(1+d)^t} = \sum_{t=0}^{T} \left[(B_t - C_t)(1+d)^{-t} \right]$$

where NPV = amount (net present value), Ct = cost at time during years (t = 1, 2... T)

5 RESULTS

Evaluations of net benefits (NB) and amounts of net present value (NPV) for triple choices with hypothesis of cost of different land opportunities are shown in Table 4. The revived regions with zero cost of land opportunity have an annual positive net return during the project and positive NPV. NPV = 5904 $ per hectare and B/C = 3.8 are evaluated. As cost of land opportunity provides an important balance between revived watersheds and other costs, when cost of land opportunity is zero, positive NP and NPV are formally predicted and evident.

6 DISCUSSION

We are faced with two fundamental issues for this analysis.The first issue is the lack of necessary data. If we are looking for planning and stable use of watershed areas and also useful efficiency of lands, we should only consider gathering, organizing and analyzing biophysics, economic social data that are between field's researchers. The second issue is related to quantification and evaluation of cost and benefit items that are used in CBA. In fact, problems of bioenvironmental issues and ecosystem services are common cases of most projects in CBA. Because, at such processes, all cost and benefit items are not quantified and their analysis based on monetary expressions seems difficult. Pricing all values of an ecosystem in watersheds has not many records in the world. Wide positive effects versus few negative effects occur in a watershed area after reclamation; evaluation of all of them is not possible. Some effects cannot be measured physically. Rials evaluation cannot be performed for many functions of an ecosystem. Also, amounts and measures are evaluated less while evaluating qualitative features of a project. In such conditions, qualitative discussions for better decisions should be analyzed quantitatively to complete the evaluation. In addition, the research method may be one of the problems of evaluation for environmental evaluation. Evaluation methods of watersheds do not have a methodology in the country. In this research, evaluation methods and their methodology are provided, and three methods including superseded selection, increase or change of efficiency and preventing the possibility of incurring danger or harm are used. Change of efficiency and its increase due to SC activities such as increase of agricultural products, increase of wooden and grass biomass or increase of water production due to development of new sources and or amount of absorbed carbonic due to plant cover that each caused change toward last conditions are evaluated by method of efficiency change. The cost beyond watersheds reclamation such as decrease of controlled sediments was evaluated by superseded method and in fact, effect of last action has been evaluated in this method and decrease of sediments is superseded by reservoir of provided dam at last. But value of watershed operations for decrease of floodwater is in fact prediction of future possible dangers occurring. Value of performed actions is compared with value of possible harms in the future. Losses of last floodwater and percent force of floodwater and simulation of danger can value this method more precisely. By providing these three methods, it seems that more operations should be followed for evaluation methods in estate watersheds.

Revived watersheds help to preserve bed flow of waterways and rivers. At the studied watershed, providing new sources and improvement of hydrologic conditions of waterways are the most important effects of plant cover reclamation, along with other activities. For example, in middleholt watershed along with development of new sources, these new sources of water provide drinking water for administrative and tourism building, available gardens and handmade forests used for reclamation of watersheds. At present analysis CBA, we have just evaluated potential economic value of new sources. More access to water especially at drought season causes decrease of cost of water collecting by villagers, farmers and ranchmen. Because rural families spend considerable work and time for collecting water and its transfer in Iran, more and better access to water has important economic value. Consequently, analysis of access to improvement of the welfare of families residing in watershed regions, related to hydrology improvements that have been created due to revived watersheds, is an important subject for future research.

Different applications of lands and their reclamation in watersheds have complicated relations with each other. In this research, it was determined that output value of reclamation was compared with value of present usage and superseded project was proposed and performed. The applicable lands with suitable production cannot be allocated to reclamation and preservation, and if farm lands change to gardens, it will be acceptable for local people socially and economically. Change of these lands to forest and rangeland in watersheds of the country seems impossible for local societies socially and economically. Also, the type of application and efficiency of production of changed lands in reclamation of watersheds for other economic activities are important components for evaluating NPV. Our analysis shows that net present value toward changes in benefit items in the future and rate of social fall have more fluctuation. Two important concepts can be gained from this subject. At first, suitable management plans should be selected for supporting benefit items in revived watersheds in the country. Second, it should be properly studied which factor causes local people to value future benefits less so that future benefits can be evaluated more and cooperate with local beneficiaries for principled management of sources and stimulation of their motivation.

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This proceedings volume contains papers & extended abstracts presented at the International Conference on Sustainable Watershed Management (SuWaMa14). The Conference was the second in a series of Sustainable Watershed Management Conferences. The objective of the Conference Series is to present and discuss advanced environmental models and contemporary decision support tools for the sustainable use and development of watersheds.

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Suite 300, Boca Raton, FL 33487
Schipholweg 107C
2316 XC Leiden, NL
2 Park Square, Milton Park
Abingdon, Oxon OX14 4RN, UK

ISBN 978-1-138-00018-6

9 781138 000186

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